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# Information technology — Coding of audio-visual objects —

## Part 10: Advanced video coding

*Technologies de l'information — Codage des objets audiovisuels —*

*Partie 10: Codage visuel avancé*

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# Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 14496-10 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and information* in collaboration with ITU-T.

This part of ISO/IEC 14496 is technically aligned with ITU-T Rec. H.264 but is not published as identical text.

This fourth edition cancels and replaces the third edition which has been technically revised.

ISO/IEC 14496 consists of the following parts, under the general title *Information technology — Coding of audio-visual objects*:

— *Part 1: Systems*

— *Part 2: Visual*

— *Part 3: Audio*

— *Part 4: Conformance testing*

— *Part 5: Reference software*

— *Part 6: Delivery Multimedia Integration Framework (DMIF)*

— *Part 7: Optimized reference software for coding of audio-visual objects* [Technical Report]

— *Part 8: Carriage of ISO/IEC 14496 contents over IP networks*

— *Part 9: Reference hardware description* [Technical Report]

— *Part 10: Advanced video coding*

— *Part 11: Scene description and application engine*

— *Part 12: ISO base media file format*

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— *Part 13: Intellectual Property Management and Protection (IPMP) extensions*

— *Part 14: MP4 file format*

— *Part 15: Advanced Video Coding (AVC) file format*

— *Part 16: Animation Framework eXtension (AFX)*

— *Part 17: Streaming text format*

— *Part 18: Font compression and streaming*

— *Part 19: Synthesized texture stream*

— *Part 20: Lightweight Application Scene Representation (LASeR) and Simple Aggregation Format (SAF)*

— *Part 21: MPEG-J Graphics Framework eXtensions (GFX)*

— *Part 22: Open Font Format*

— *Part 23: Symbolic Music Representation*

— *Part 24: Audio and systems interaction*

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# 0 Introduction

This clause does not form an integral part of this International Standard.

## 0.1 Prologue

This subclause does not form an integral part of this International Standard.

As the costs for both processing power and memory have reduced, network support for coded video data has diversified, and advances in video coding technology have progressed, the need has arisen for an industry standard for compressed video representation with substantially increased coding efficiency and enhanced robustness to network environments. Toward these ends the ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG) formed a Joint Video Team (JVT) in 2001 for development of a new International Standard.

## 0.2 Purpose

This subclause does not form an integral part of this International Standard.

This International Standard was developed in response to the growing need for higher compression of moving pictures for various applications such as videoconferencing, digital storage media, television broadcasting, internet streaming, and communication. It is also designed to enable the use of the coded video representation in a flexible manner for a wide variety of network environments. The use of this International Standard allows motion video to be manipulated as a form of computer data and to be stored on various storage media, transmitted and received over existing and future networks and distributed on existing and future broadcasting channels.

## 0.3 Applications

This subclause does not form an integral part of this International Standard.

This International Standard is designed to cover a broad range of applications for video content including but not limited to the following:

| | |
|---|---|
| CATV | Cable TV on optical networks, copper, etc. |
| DBS | Direct broadcast satellite video services |
| DSL | Digital subscriber line video services |
| DTTB | Digital terrestrial television broadcasting |
| ISM | Interactive storage media (optical disks, etc.) |
| MMM | Multimedia mailing |
| MSPN | Multimedia services over packet networks |
| RTC | Real-time conversational services (videoconferencing, videophone, etc.) |
| RVS | Remote video surveillance |
| SSM | Serial storage media (digital VTR, etc.) |

## 0.4 Publication and versions of this specification

This subclause does not form an integral part of this International Standard.

This specification has been jointly developed by ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group. It is published as technically-aligned twin text in both organizations ITU-T and ISO/IEC.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 1 refers to the first approved version of this International Standard.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 2 refers to the integrated text containing the corrections specified in the first technical corrigendum.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 3 refers to the integrated text containing both the first technical corrigendum (2004) and the first amendment, which is referred to as the "Fidelity range extensions".

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ITU-T Rec. H.264 | ISO/IEC 14496-10 version 4 refers to the integrated text containing the first technical corrigendum (2004), the first amendment (the "Fidelity range extensions"), and an additional technical corrigendum (2005).

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 5 refers to the integrated version 4 text with its specification of the High 4:4:4 profile removed.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 6 refers to the integrated version 5 text after its amendment to support additional colour space indicators.

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 7 refers to the integrated version 6 text after its amendment to define five new profiles intended primarily for professional applications (the High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, CAVLC 4:4:4 Intra, and High 4:4:4 Predictive profiles) and two new types of supplemental enhancement information (SEI) messages (the post-filter hint SEI message and the tone mapping information SEI message).

ITU-T Rec. H.264 | ISO/IEC 14496-10 version 8 (the current specification) refers to the integrated version 7 text after its amendment to specify scalable video coding in three profiles (Scalable Baseline, Scalable High, and Scalable High Intra profiles).

## 0.5 Profiles and levels

This subclause does not form an integral part of this International Standard.

This International Standard is designed to be generic in the sense that it serves a wide range of applications, bit rates, resolutions, qualities, and services. Applications should cover, among other things, digital storage media, television broadcasting and real-time communications. In the course of creating this Specification, various requirements from typical applications have been considered, necessary algorithmic elements have been developed, and these have been integrated into a single syntax. Hence, this Specification will facilitate video data interchange among different applications.

Considering the practicality of implementing the full syntax of this Specification, however, a limited number of subsets of the syntax are also stipulated by means of "profiles" and "levels". These and other related terms are formally defined in clause 3.

A "profile" is a subset of the entire bitstream syntax that is specified by this International Standard. Within the bounds imposed by the syntax of a given profile it is still possible to require a very large variation in the performance of encoders and decoders depending upon the values taken by syntax elements in the bitstream such as the specified size of the decoded pictures. In many applications, it is currently neither practical nor economic to implement a decoder capable of dealing with all hypothetical uses of the syntax within a particular profile.

In order to deal with this problem, "levels" are specified within each profile. A level is a specified set of constraints imposed on values of the syntax elements in the bitstream. These constraints may be simple limits on values. Alternatively they may take the form of constraints on arithmetic combinations of values (e.g. picture width multiplied by picture height multiplied by number of pictures decoded per second).

Coded video content conforming to this International Standard uses a common syntax. In order to achieve a subset of the complete syntax, flags, parameters, and other syntax elements are included in the bitstream that signal the presence or absence of syntactic elements that occur later in the bitstream.

## 0.6 Overview of the design characteristics

This subclause does not form an integral part of this International Standard.

The coded representation specified in the syntax is designed to enable a high compression capability for a desired image quality. With the exception of the transform bypass mode of operation for lossless coding in the High 4:4:4 Intra, CAVLC 4:4:4 Intra, and High 4:4:4 Predictive profiles, and the I_PCM mode of operation in all profiles, the algorithm is typically not lossless, as the exact source sample values are typically not preserved through the encoding and decoding processes. A number of techniques may be used to achieve highly efficient compression. Encoding algorithms (not specified in this International Standard) may select between inter and intra coding for block-shaped regions of each picture. Inter coding uses motion vectors for block-based inter prediction to exploit temporal statistical dependencies between different pictures. Intra coding uses various spatial prediction modes to exploit spatial statistical dependencies in the source signal for a single picture. Motion vectors and intra prediction modes may be specified for a variety of block sizes in the picture. The prediction residual is then further compressed using a transform to remove spatial correlation inside the transform block before it is quantised, producing an irreversible process that typically discards less important visual information while forming a close approximation to the source samples. Finally, the motion vectors or intra

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prediction modes are combined with the quantised transform coefficient information and encoded using either variable length codes or arithmetic coding.

Scalable video coding is specified in Annex G of this specification allowing the construction of bitstreams that contain sub-bitstreams that conform to this specification. For temporal bitstream scalability, i.e., the presence of a sub-bitstream with a smaller temporal sampling rate than the bitstream, complete access units are removed from the bitstream when deriving the sub-bitstream. In this case, high-level syntax and inter prediction reference pictures in the bitstream are constructed accordingly. For spatial and quality bitstream scalability, i.e. the presence of a sub-bitstream with lower spatial resolution or quality than the bitstream, NAL units are removed from the bitstream when deriving the sub-bitstream. In this case, inter-layer prediction, i.e., the prediction of the higher spatial resolution or quality signal by data of the lower spatial resolution or quality signal, is typically used for efficient coding.

Otherwise, the coding algorithm as described in the previous paragraph is used.

### 0.6.1 Predictive coding

This subclause does not form an integral part of this International Standard.

Because of the conflicting requirements of random access and highly efficient compression, two main coding types are specified. Intra coding is done without reference to other pictures. Intra coding may provide access points to the coded sequence where decoding can begin and continue correctly, but typically also shows only moderate compression efficiency. Inter coding (predictive or bi-predictive) is more efficient using inter prediction of each block of sample values from some previously decoded picture selected by the encoder. In contrast to some other video coding standards, pictures coded using bi-predictive inter prediction may also be used as references for inter coding of other pictures.

The application of the three coding types to pictures in a sequence is flexible, and the order of the decoding process is generally not the same as the order of the source picture capture process in the encoder or the output order from the decoder for display. The choice is left to the encoder and will depend on the requirements of the application. The decoding order is specified such that the decoding of pictures that use inter-picture prediction follows later in decoding order than other pictures that are referenced in the decoding process.

### 0.6.2 Coding of progressive and interlaced video

This subclause does not form an integral part of this International Standard.

This International Standard specifies a syntax and decoding process for video that originated in either progressive-scan or interlaced-scan form, which may be mixed together in the same sequence. The two fields of an interlaced frame are separated in capture time while the two fields of a progressive frame share the same capture time. Each field may be coded separately or the two fields may be coded together as a frame. Progressive frames are typically coded as a frame. For interlaced video, the encoder can choose between frame coding and field coding. Frame coding or field coding can be adaptively selected on a picture-by-picture basis and also on a more localized basis within a coded frame. Frame coding is typically preferred when the video scene contains significant detail with limited motion. Field coding typically works better when there is fast picture-to-picture motion.

### 0.6.3 Picture partitioning into macroblocks and smaller partitions

This subclause does not form an integral part of this International Standard.

As in previous video coding Recommendations and International Standards, a macroblock, consisting of a 16x16 block of luma samples and two corresponding blocks of chroma samples, is used as the basic processing unit of the video decoding process.

A macroblock can be further partitioned for inter prediction. The selection of the size of inter prediction partitions is a result of a trade-off between the coding gain provided by using motion compensation with smaller blocks and the quantity of data needed to represent the data for motion compensation. In this International Standard the inter prediction process can form segmentations for motion representation as small as 4x4 luma samples in size, using motion vector accuracy of one-quarter of the luma sample grid spacing displacement. The process for inter prediction of a sample block can also involve the selection of the picture to be used as the reference picture from a number of stored previously-decoded pictures. Motion vectors are encoded differentially with respect to predicted values formed from nearby encoded motion vectors.

Typically, the encoder calculates appropriate motion vectors and other data elements represented in the video data stream. This motion estimation process in the encoder and the selection of whether to use inter prediction for the representation of each region of the video content is not specified in this International Standard.

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### 0.6.4 Spatial redundancy reduction

This subclause does not form an integral part of this International Standard.

Both source pictures and prediction residuals have high spatial redundancy. This International Standard is based on the use of a block-based transform method for spatial redundancy removal. After inter prediction from previously-decoded samples in other pictures or spatial-based prediction from previously-decoded samples within the current picture, the resulting prediction residual is split into 4x4 blocks. These are converted into the transform domain where they are quantised. After quantisation many of the transform coefficients are zero or have low amplitude and can thus be represented with a small amount of encoded data. The processes of transformation and quantisation in the encoder are not specified in this International Standard.

## 0.7 How to read this specification

This subclause does not form an integral part of this International Standard.

It is suggested that the reader starts with clause 1 (Scope) and moves on to clause 3 (Definitions). Clause 6 should be read for the geometrical relationship of the source, input, and output of the decoder. Clause 7 (Syntax and semantics) specifies the order to parse syntax elements from the bitstream. See subclauses 7.1-7.3 for syntactical order and see subclause 7.4 for semantics; i.e., the scope, restrictions, and conditions that are imposed on the syntax elements. The actual parsing for most syntax elements is specified in clause 9 (Parsing process). Finally, clause 8 (Decoding process) specifies how the syntax elements are mapped into decoded samples. Throughout reading this specification, the reader should refer to clauses 2 (Normative references), 4 (Abbreviations), and 5 (Conventions) as needed. Annexes A through E also form an integral part of this International Standard.

Annex A specifies eleven profiles (Baseline, Main, Extended, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra), each being tailored to certain application domains, and defines the so-called levels of the profiles. Annex B specifies syntax and semantics of a byte stream format for delivery of coded video as an ordered stream of bytes. Annex C specifies the hypothetical reference decoder and its use to check bitstream and decoder conformance. Annex D specifies syntax and semantics for supplemental enhancement information message payloads. Finally, Annex E specifies syntax and semantics of the video usability information parameters of the sequence parameter set.

Annex G specifies scalable video coding (SVC). The reader is referred to Annex G for the entire decoding process for SVC, which is specified there with references being made to clauses 2-9 and Annexes A-E. Subclause G.10 specifies three profiles for SVC (Scalable Baseline, Scalable High, and Scalable High Intra).

Throughout this specification, statements appearing with the preamble "NOTE -" are informative and are not an integral part of this International Standard.

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# Information technology — Coding of audio-visual objects —

# Part 10:
# Advanced video coding

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## 1 Scope

This part of ISO 14496 specifies advanced video coding for the coding of audio-visual objects.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

- ITU-T Recommendation T.35 (2000), *Procedure for the allocation of ITU-T defined codes for non-standard facilities*.
- ISO/IEC 11578:1996, Annex A, *Universal Unique Identifier*.
- ISO/CIE 10527:1991, *Colorimetric Observers*.

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1** **access unit**: A set of *NAL units* always containing exactly one *primary coded picture*. In addition to the *primary coded picture*, an access unit may also contain one or more *redundant coded pictures*, one *auxiliary coded picture*, or other *NAL units* not containing *slices* or *slice data partitions* of a *coded picture*. The decoding of an access unit always results in a *decoded picture*.

**3.2** **AC transform coefficient**: Any *transform coefficient* for which the *frequency index* in one or both dimensions is non-zero.

**3.3** **adaptive binary arithmetic decoding process**: An entropy *decoding process* that derives the values of *bins* from a *bitstream* produced by an *adaptive binary arithmetic encoding process*.

**3.4** **adaptive binary arithmetic encoding process**: An entropy *encoding process*, not normatively specified in this International Standard, that codes a sequence of *bins* and produces a *bitstream* that can be decoded using the *adaptive binary arithmetic decoding process*.

**3.5** **alpha blending**: A process not specified by this International Standard, in which an *auxiliary coded picture* is used in combination with a *primary coded picture* and with other data not specified by this International Standard in the *display process*. In an alpha blending process, the samples of an *auxiliary coded picture* are interpreted as indications of the degree of opacity (or, equivalently, the degrees of transparency) associated with the corresponding *luma* samples of the *primary coded picture*.

**3.6** **arbitrary slice order (ASO)**: A *decoding order* of *slices* in which the *macroblock address* of the first *macroblock* of some *slice* of a *slice group* may be less than the *macroblock address* of the first *macroblock* of some other preceding *slice* of the same *slice group* or, in the case of a *picture* that is coded using three separate colour planes, some other preceding *slice* of the same *slice group* within the same colour plane, or in which the *slices* of a *slice group* of a picture may be interleaved with the *slices* of one or more other *slice groups* of the *picture* or, in the case of a *picture* that is coded using three separate colour planes, with the *slices* of one or more other *slice groups* within the same colour plane.

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3.7 **auxiliary coded picture**: A *picture* that supplements the *primary coded picture* that may be used in combination with other data not specified by this International Standard in the *display process*. An auxiliary coded picture has the same syntactic and semantic restrictions as a monochrome *redundant coded picture*. An auxiliary coded picture must contain the same number of *macroblocks* as the *primary coded picture*. Auxiliary coded pictures have no normative effect on the *decoding process*. See also *primary coded picture* and *redundant coded picture*.

3.8 **B slice**: A *slice* that may be decoded using *intra prediction* or *inter prediction* using at most two *motion vectors* and *reference indices* to *predict* the sample values of each *block*.

3.9 **bin**: One bit of a *bin string*.

3.10 **binarization**: A set of *bin strings* for all possible values of a *syntax element*.

3.11 **binarization process**: A unique mapping process of all possible values of a *syntax element* onto a set of *bin strings*.

3.12 **bin string**: A string of *bins*. A bin string is an intermediate binary representation of values of *syntax elements* from the *binarization* of the *syntax element*.

3.13 **bi-predictive slice:** See *B slice***.**

3.14 **bitstream**: A sequence of bits that forms the representation of *coded pictures* and associated data forming one or more *coded video sequences*. Bitstream is a collective term used to refer either to a *NAL unit stream* or a *byte stream*.

3.15 **block**: An MxN (M-column by N-row) array of samples, or an MxN array of *transform coefficients*.

3.16 **bottom field**: One of two *fields* that comprise a *frame*. Each row of a *bottom field* is spatially located immediately below a corresponding row of a *top field*.

3.17 **bottom macroblock (of a macroblock pair)**: The *macroblock* within a *macroblock pair* that contains the samples in the bottom row of samples for the *macroblock pair*. For a *field macroblock pair*, the bottom macroblock represents the samples from the region of the *bottom field* of the *frame* that lie within the spatial region of the *macroblock pair*. For a *frame macroblock pair*, the bottom macroblock represents the samples of the *frame* that lie within the bottom half of the spatial region of the *macroblock pair*.

3.18 **broken link**: A location in a *bitstream* at which it is indicated that some subsequent *pictures* in *decoding order* may contain serious visual artefacts due to unspecified operations performed in the generation of the *bitstream*.

3.19 **byte**: A sequence of 8 bits, written and read with the most significant bit on the left and the least significant bit on the right. When represented in a sequence of data bits, the most significant bit of a byte is first.

3.20 **byte-aligned**: A position in a *bitstream* is byte-aligned when the position is an integer multiple of 8 bits from the position of the first bit in the *bitstream*. A bit or *byte* or *syntax element* is said to be byte-aligned when the position at which it appears in a *bitstream* is byte-aligned.

3.21 **byte stream**: An encapsulation of a *NAL unit stream* containing *start code prefixes* and *NAL units* as specified in Annex B.

3.22 **can**: A term used to refer to behaviour that is allowed, but not necessarily required.

3.23 **category**: A number associated with each *syntax element*. The category is used to specify the allocation of *syntax elements* to *NAL units* for *slice data partitioning*. It may also be used in a manner determined by the application to refer to classes of *syntax elements* in a manner not specified in this International Standard.

3.24 **chroma**: An adjective specifying that a sample array or single sample is representing one of the two colour difference signals related to the primary colours. The symbols used for a chroma array or sample are Cb and Cr.

NOTE – The term chroma is used rather than the term chrominance in order to avoid the implication of the use of linear light transfer characteristics that is often associated with the term chrominance.

3.25 **coded field**: A *coded representation* of a *field*.

3.26 **coded frame**: A *coded representation* of a *frame*.

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**3.27** **coded picture**: A *coded representation* of a *picture*. A coded picture may be either a *coded field* or a *coded frame*. Coded picture is a collective term referring to a *primary coded picture* or a *redundant coded picture*, but not to both together.

**3.28** **coded picture buffer (CPB)**: A first-in first-out buffer containing *access units* in *decoding order* specified in the *hypothetical reference decoder* in Annex C.

**3.29** **coded representation**: A data element as represented in its coded form.

**3.30** **coded slice data partition NAL unit**: A *NAL unit* containing a *slice data partition*.

**3.31** **coded slice NAL unit**: A *NAL unit* containing a *slice* that is not a *slice* of an *auxiliary coded picture*.

**3.32** **coded video sequence**: A sequence of *access units* that consists, in decoding order, of an *IDR access unit* followed by zero or more non-IDR *access units* including all subsequent *access units* up to but not including any subsequent *IDR access unit*.

**3.33** **component**: An array or single sample from one of the three arrays (*luma* and two *chroma*) that make up a *field* or *frame* in 4:2:0, 4:2:2, or 4:4:4 colour format or the array or a single sample of the array that make up a *field* or *frame* in monochrome format.

**3.34** **complementary field pair:** A collective term for a *complementary reference field pair* or a *complementary non-reference field pair*.

**3.35** **complementary non-reference field pair**: Two *non-reference fields* that are in consecutive *access units* in *decoding order* as two *coded fields* of opposite parity where the first *field* is not already a paired *field*.

**3.36** **complementary reference field pair**: Two *reference fields* that are in consecutive *access units* in *decoding order* as two *coded fields* and share the same value of the frame_num *syntax element*, where the second *field* in *decoding order* is not an *IDR picture* and does not include a memory_management_control_operation *syntax element* equal to 5.

**3.37** **context variable**: A variable specified for the *adaptive binary arithmetic decoding process* of a *bin* by an equation containing recently decoded *bins*.

**3.38** **DC transform coefficient**: A *transform coefficient* for which the *frequency index* is zero in all dimensions.

**3.39** **decoded picture**: A *decoded picture* is derived by decoding a *coded picture*. A *decoded picture* is either a decoded *frame*, or a decoded *field*. A decoded *field* is either a decoded *top field* or a decoded *bottom field*.

**3.40** **decoded picture buffer (DPB)**: A buffer holding *decoded pictures* for reference, output reordering, or output delay specified for the *hypothetical reference decoder* in Annex C.

**3.41** **decoder**: An embodiment of a *decoding process*.

**3.42** **decoding order**: The order in which *syntax elements* are processed by the *decoding process*.

**3.43** **decoding process**: The process specified in this International Standard that reads a *bitstream* and derives *decoded pictures* from it.

**3.44** **direct prediction**: An *inter prediction* for a *block* for which no *motion vector* is decoded. Two direct *prediction* modes are specified that are referred to as spatial direct *prediction* and temporal *prediction* mode.

**3.45** **display process**: A process not specified in this International Standard having, as its input, the cropped decoded *pictures* that are the output of the *decoding process*.

**3.46** **decoder under test (DUT)**: A *decoder* that is tested for conformance to this International Standard by operating the *hypothetical stream scheduler* to deliver a conforming *bitstream* to the *decoder* and to the *hypothetical reference decoder* and comparing the values and timing of the output of the two *decoders*.

**3.47** **emulation prevention byte**: A *byte* equal to 0x03 that may be present within a *NAL unit*. The presence of emulation prevention bytes ensures that no sequence of consecutive *byte-aligned bytes* in the *NAL unit* contains a *start code prefix*.

**3.48** **encoder**: An embodiment of an *encoding process*.

**3.49** **encoding process**: A process, not specified in this International Standard, that produces a *bitstream* conforming to this International Standard.

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**3.50** **field**: An assembly of alternate rows of a *frame*. A *frame* is composed of two *fields*, a *top field* and a *bottom field*.

**3.51** **field macroblock**: A macroblock containing samples from a single *field*. All *macroblocks* of a *coded field* are field macroblocks. When *macroblock-adaptive frame/field decoding* is in use, some *macroblocks* of a *coded frame* may be field macroblocks.

**3.52** **field macroblock pair**: A *macroblock pair* decoded as two *field macroblocks*.

**3.53** **field scan**: A specific sequential ordering of *transform coefficients* that differs from the *zig-zag scan* by scanning columns more rapidly than rows. Field scan is used for *transform coefficients* in *field macroblocks*.

**3.54** **flag**: A variable that can take one of the two possible values 0 and 1.

**3.55** **frame**: A *frame* contains an array of *luma* samples in monochrome format or an array of *luma* samples and two corresponding arrays of *chroma* samples in 4:2:0, 4:2:2, and 4:4:4 colour format. A *frame* consists of two *fields*, a *top field* and a *bottom field*.

**3.56** **frame macroblock**: A *macroblock* representing samples from the two *fields* of a *coded frame*. When *macroblock-adaptive frame/field decoding* is not in use, all macroblocks of a *coded frame* are frame macroblocks. When *macroblock-adaptive frame/field decoding* is in use, some macroblocks of a *coded frame* may be frame macroblocks.

**3.57** **frame macroblock pair**: A *macroblock pair* decoded as two *frame macroblocks*.

**3.58** **frequency index**: A one-dimensional or two-dimensional index associated with a *transform coefficient* prior to an *inverse transform* part of the *decoding process*.

**3.59** **hypothetical reference decoder (HRD)**: A hypothetical *decoder* model that specifies constraints on the variability of conforming *NAL unit streams* or conforming *byte streams* that an encoding process may produce.

**3.60** **hypothetical stream scheduler (HSS)**: A hypothetical delivery mechanism for the timing and data flow of the input of a *bitstream* into the *hypothetical reference decoder*. The HSS is used for checking the conformance of a *bitstream* or a *decoder*.

**3.61** **I slice**: A *slice* that is not an *SI slice* that is decoded using *intra prediction* only.

**3.62** **informative**: A term used to refer to content provided in this International Standard that is not an integral part of this International Standard. Informative content does not establish any mandatory requirements for conformance to this International Standard.

**3.63** **instantaneous decoding refresh (IDR) access unit**: An *access unit* in which the *primary coded picture* is an *IDR picture*.

**3.64** **instantaneous decoding refresh (IDR) picture**: A *coded picture* in which all *slices* are *I* or *SI slices* that causes the *decoding process* to mark all *reference pictures* as "unused for reference" immediately after decoding the IDR picture. After the decoding of an IDR picture all following *coded pictures* in *decoding order* can be decoded without *inter prediction* from any *picture* decoded prior to the IDR picture. The first *picture* of each *coded video sequence* is an IDR picture.

**3.65** **inter coding**: Coding of a *block*, *macroblock*, *slice*, or *picture* that uses *inter prediction*.

**3.66** **inter prediction**: A *prediction* derived from decoded samples of *reference pictures* other than the current *decoded picture*.

**3.67** **interpretation sample value**: A possibly-altered value corresponding to a decoded sample value of an *auxiliary coded picture* that may be generated for use in the *display process*. Interpretation sample values are not used in the *decoding process* and have no normative effect on the *decoding process*.

**3.68** **intra coding**: Coding of a *block, macroblock*, *slice*, or *picture* that uses *intra prediction*.

**3.69** **intra prediction**: A *prediction* derived from the decoded samples of the same decoded *slice*.

**3.70** **intra slice**: See *I slice*.

**3.71** **inverse transform**: A part of the *decoding process* by which a set of *transform coefficients* are converted into spatial-domain values, or by which a set of *transform coefficients* are converted into *DC transform coefficients*.

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**3.72** **layer**: One of a set of syntactical structures in a non-branching hierarchical relationship. Higher layers contain lower layers. The coding layers are the *coded video sequence*, *picture*, *slice*, and *macroblock* layers.

**3.73** **level**: A defined set of constraints on the values that may be taken by the *syntax elements* and variables of this International Standard. The same set of levels is defined for all *profiles*, with most aspects of the definition of each level being in common across different *profiles*. Individual implementations may, within specified constraints, support a different level for each supported *profile*. In a different context, level is the value of a *transform coefficient* prior to *scaling*.

**3.74** **list 0 (list 1) motion vector**: A *motion vector* associated with a *reference index* pointing into *reference picture list 0* (*list 1*).

**3.75** **list 0 (list 1) prediction**: *Inter prediction* of the content of a *slice* using a *reference index* pointing into *reference picture list 0* (*list 1*).

**3.76** **luma**: An adjective specifying that a sample array or single sample is representing the monochrome signal related to the primary colours. The symbol or subscript used for luma is Y or L.

NOTE – The term luma is used rather than the term luminance in order to avoid the implication of the use of linear light transfer characteristics that is often associated with the term luminance. The symbol L is sometimes used instead of the symbol Y to avoid confusion with the symbol y as used for vertical location.

**3.77** **macroblock**: A 16x16 *block* of *luma* samples and two corresponding *blocks* of *chroma* samples of a *picture* that has three sample arrays, or a 16x16 *block* of samples of a monochrome *picture* or a *picture* that is coded using three separate colour planes. The division of a *slice* or a *macroblock pair* into macroblocks is a *partitioning*.

**3.78** **macroblock-adaptive frame/field decoding**: A *decoding process* for *coded frames* in which some *macroblocks* may be decoded as *frame macroblocks* and others may be decoded as *field macroblocks*.

**3.79** **macroblock address**: When *macroblock-adaptive frame/field decoding* is not in use, a macroblock address is the index of a macroblock in a *macroblock raster scan* of the *picture* starting with zero for the top-left *macroblock* in a *picture*. When *macroblock-adaptive frame/field decoding* is in use, the macroblock address of the *top macroblock* of a *macroblock pair* is two times the index of the *macroblock pair* in a *macroblock pair raster scan* of the *picture*, and the macroblock address of the *bottom macroblock* of a *macroblock pair* is the macroblock address of the corresponding *top macroblock* plus 1. The macroblock address of the *top macroblock* of each *macroblock pair* is an even number and the macroblock address of the *bottom macroblock* of each *macroblock pair* is an odd number.

**3.80** **macroblock location**: The two-dimensional coordinates of a *macroblock* in a *picture* denoted by ( x, y ). For the top left *macroblock* of the *picture* ( x, y ) is equal to ( 0, 0 ). x is incremented by 1 for each *macroblock* column from left to right. When *macroblock-adaptive frame/field decoding* is not in use, y is incremented by 1 for each *macroblock* row from top to bottom. When *macroblock-adaptive frame/field decoding* is in use, y is incremented by 2 for each *macroblock pair* row from top to bottom, and is incremented by an additional 1 when a macroblock is a *bottom macroblock*.

**3.81** **macroblock pair**: A pair of vertically contiguous *macroblocks* in a *frame* that is coupled for use in *macroblock-adaptive frame/field decoding*. The division of a *slice* into macroblock pairs is a *partitioning*.

**3.82** **macroblock partition**: A *block* of *luma* samples and two corresponding *blocks* of *chroma* samples resulting from a *partitioning* of a *macroblock* for *inter prediction* for a *picture* that has three sample arrays or a *block* of *luma* samples resulting from a *partitioning* of a *macroblock* for *inter prediction* for a monochrome *picture* or a *picture* that is coded using three separate colour planes.

**3.83** **macroblock to slice group map**: A means of mapping *macroblocks* of a *picture* into *slice groups*. The macroblock to slice group map consists of a list of numbers, one for each coded *macroblock*, specifying the *slice group* to which each coded *macroblock* belongs.

**3.84** **map unit to slice group map**: A means of mapping *slice group map units* of a *picture* into *slice groups*. The map unit to slice group map consists of a list of numbers, one for each *slice group map unit*, specifying the *slice group* to which each coded *slice group map unit* belongs.

**3.85** **may**: A term used to refer to behaviour that is allowed, but not necessarily required. In some places where the optional nature of the described behaviour is intended to be emphasized, the phrase "may or may not" is used to provide emphasis.

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**3.86** **memory management control operation**: Seven operations that control *reference picture marking*.

**3.87** **motion vector**: A two-dimensional vector used for *inter prediction* that provides an offset from the coordinates in the *decoded picture* to the coordinates in a *reference picture*.

**3.88** **must**: A term used in expressing an observation about a requirement or an implication of a requirement that is specified elsewhere in this International Standard. This term is used exclusively in an *informative* context.

**3.89** **NAL unit**: A syntax structure containing an indication of the type of data to follow and *bytes* containing that data in the form of an *RBSP* interspersed as necessary with *emulation prevention bytes*.

**3.90** **NAL unit stream**: A sequence of *NAL units*.

**3.91** **non-paired field**: A collective term for a *non-paired reference field* or a *non-paired non-reference field*.

**3.92** **non-paired non-reference field:** A decoded *non-reference field* that is not part of a *complementary non-reference field pair*.

**3.93** **non-paired reference field**: A decoded *reference field* that is not part of a *complementary reference field pair*.

**3.94** **non-reference field**: A *field* coded with nal_ref_idc equal to 0.

**3.95** **non-reference frame**: A *frame* coded with nal_ref_idc equal to 0.

**3.96** **non-reference picture**: A *picture* coded with nal_ref_idc equal to 0. A *non-reference picture* is not used for *inter prediction* of any other *pictures*.

**3.97** **note**: A term used to prefix *informative* remarks. This term is used exclusively in an *informative* context.

**3.98** **opposite parity**: The *opposite parity* of *top* is *bottom*, and vice versa.

**3.99** **output order**: The order in which the *decoded pictures* are output from the *decoded picture buffer*.

**3.100** **P slice**: A *slice* that is not an *SP slice* that may be decoded using *intra prediction* or *inter prediction* using at most one *motion vector* and *reference index* to *predict* the sample values of each *block*.

**3.101** **parameter**: A *syntax element* of a *sequence parameter set* or a *picture parameter set*. Parameter is also used as part of the defined term *quantisation parameter*.

**3.102** **parity**: The parity of a *field* can be *top* or *bottom*.

**3.103** **partitioning**: The division of a set into subsets such that each element of the set is in exactly one of the subsets.

**3.104** **picture**: A collective term for a *field* or a *frame*.

**3.105** **picture parameter set**: A *syntax structure* containing *syntax elements* that apply to zero or more entire *coded pictures* as determined by the pic_parameter_set_id *syntax element* found in each *slice header*.

**3.106** **picture order count**: A variable having a value that is non-decreasing with increasing *picture* position in output order relative to the previous *IDR picture* in *decoding order* or relative to the previous *picture* containing the *memory management control operation* that marks all *reference pictures* as "unused for reference".

**3.107** **prediction**: An embodiment of the *prediction process*.

**3.108** **prediction process**: The use of a *predictor* to provide an estimate of the sample value or data element currently being decoded.

**3.109** **predictive slice**: See *P slice*.

**3.110** **predictor**: A combination of specified values or previously decoded sample values or data elements used in the *decoding process* of subsequent sample values or data elements.

**3.111** **primary coded picture**: The coded representation of a *picture* to be used by the *decoding process* for a bitstream conforming to this International Standard. The primary coded picture contains all *macroblocks* of the *picture*. The only *pictures* that have a normative effect on the *decoding process* are primary coded pictures. See also *redundant coded picture*.

**3.112** **profile**: A specified subset of the syntax of this International Standard.

**3.113** **quantisation parameter**: A variable used by the *decoding process* for *scaling* of *transform coefficient levels*.

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**3.114** **random access**: The act of starting the decoding process for a *bitstream* at a point other than the beginning of the stream.

**3.115** **raster scan**: A mapping of a rectangular two-dimensional pattern to a one-dimensional pattern such that the first entries in the one-dimensional pattern are from the first top row of the two-dimensional pattern scanned from left to right, followed similarly by the second, third, etc. rows of the pattern (going down) each scanned from left to right.

**3.116** **raw byte sequence payload (RBSP):** A syntax structure containing an integer number of *bytes* that is encapsulated in a *NAL unit*. An RBSP is either empty or has the form of a *string of data bits* containing *syntax elements* followed by an *RBSP stop bit* and followed by zero or more subsequent bits equal to 0.

**3.117** **raw byte sequence payload (RBSP) stop bit:** A bit equal to 1 present within a *raw byte sequence payload (RBSP)* after a *string of data bits*. The location of the end of the *string of data bits* within an *RBSP* can be identified by searching from the end of the *RBSP* for the *RBSP stop bit*, which is the last non-zero bit in the *RBSP*.

**3.118** **recovery point**: A point in the *bitstream* at which the recovery of an exact or an approximate representation of the *decoded pictures* represented by the *bitstream* is achieved after a *random access* or *broken link*.

**3.119** **redundant coded picture**: A coded representation of a *picture* or a part of a *picture.* The content of a redundant coded picture shall not be used by the *decoding process* for a *bitstream* conforming to this International Standard. A *redundant coded picture* is not required to contain all *macroblocks* in the *primary coded picture*. Redundant coded pictures have no normative effect on the *decoding process*. See also *primary coded picture*.

**3.120** **reference field**: A *reference field* may be used for *inter prediction* when *P*, *SP*, and *B slices* of a *coded field* or *field macroblocks* of a *coded frame* are decoded. See also *reference picture*.

**3.121** **reference frame**: A *reference frame* may be used for *inter prediction* when *P*, *SP*, and *B slices* of a *coded frame* are decoded. See also *reference picture*.

**3.122** **reference index**: An index into a *reference picture list*.

**3.123** **reference picture**: A *picture* with nal_ref_idc not equal to 0. A *reference picture* contains samples that may be used for *inter prediction* in the *decoding process* of subsequent *pictures* in *decoding order*.

**3.124** **reference picture list**: A list of *reference pictures* that is used for *inter prediction* of a *P, B,* or *SP slice.* For the *decoding process* of a *P* or *SP slice,* there is one reference picture list. For the *decoding process* of a *B slice*, there are two reference picture lists.

**3.125** **reference picture list 0**: A *reference picture list* used for *inter prediction* of a *P*, *B*, or *SP slice*. All *inter prediction* used for *P* and *SP slices* uses reference picture list 0. Reference picture list 0 is one of two *reference picture lists* used for *inter prediction* for a *B slice*, with the other being *reference picture list 1*.

**3.126** **reference picture list 1**: A *reference picture list* used for *inter prediction* of a *B slice*. Reference picture list 1 is one of two lists of *reference picture lists* used for *inter prediction* for a *B slice*, with the other being *reference picture list 0*.

**3.127** **reference picture marking**: Specifies, in the bitstream, how the *decoded pictures* are marked for *inter prediction*.

**3.128** **reserved**: The term reserved, when used in the clauses specifying some values of a particular *syntax element*, are for future use by ITU-T | ISO/IEC. These values shall not be used in *bitstreams* conforming to this International Standard, but may be used in future extensions of this International Standard by ITU-T | ISO/IEC.

**3.129** **residual**: The decoded difference between a *prediction* of a sample or data element and its decoded value.

**3.130** **run**: A number of consecutive data elements represented in the decoding process. In one context, the number of zero-valued *transform coefficient levels* preceding a non-zero *transform coefficient level* in the list of *transform coefficient levels* generated by a *zig-zag scan* or a *field scan*. In other contexts, run refers to a number of *macroblocks*.

**3.131** **sample aspect ratio**: Specifies, for assisting the display process, which is not specified in this International Standard, the ratio between the intended horizontal distance between the columns and the intended vertical distance between the rows of the *luma* sample array in a *frame*. Sample aspect ratio is expressed as *h*:*v*, where *h* is horizontal width and *v* is vertical height (in arbitrary units of spatial distance).

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**3.132** **scaling**: The process of multiplying *transform coefficient levels* by a factor, resulting in *transform coefficients*.

**3.133** **sequence parameter set**: A *syntax structure* containing *syntax elements* that apply to zero or more entire *coded video sequences* as determined by the content of a seq_parameter_set_id *syntax element* found in the *picture parameter set* referred to by the pic_parameter_set_id *syntax element* found in each *slice header*.

**3.134** **shall**: A term used to express mandatory requirements for conformance to this International Standard. When used to express a mandatory constraint on the values of *syntax elements* or on the results obtained by operation of the specified *decoding process*, it is the responsibility of the *encoder* to ensure that the constraint is fulfilled. When used in reference to operations performed by the *decoding process*, any *decoding process* that produces identical results to the *decoding process* described herein conforms to the *decoding process* requirements of this International Standard.

**3.135** **should**: A term used to refer to behaviour of an implementation that is encouraged to be followed under anticipated ordinary circumstances, but is not a mandatory requirement for conformance to this International Standard.

**3.136** **SI slice**: A *slice* that is coded using *intra prediction* only and using quantisation of the *prediction* samples. An SI slice can be coded such that its decoded samples can be constructed identically to an *SP slice*.

**3.137** **skipped macroblock**: A *macroblock* for which no data is coded other than an indication that the *macroblock* is to be decoded as "skipped". This indication may be common to several *macroblocks*.

**3.138** **slice**: An integer number of *macroblocks* or *macroblock pairs* ordered consecutively in the *raster scan* within a particular *slice group*. For the *primary coded picture*, the division of each *slice group* into slices is a *partitioning*. Although a slice contains *macroblocks* or *macroblock pairs* that are consecutive in the *raster scan* within a *slice group*, these *macroblocks* or *macroblock pairs* are not necessarily consecutive in the *raster scan* within the *picture*. The *macroblock addresses* are derived from the first *macroblock address* in a slice (as represented in the *slice header*) and the *macroblock to slice group map*, and, when a *picture* is coded using three separate colour planes, a colour plane identifier.

**3.139** **slice data partitioning**: A method of *partitioning* selected *syntax elements* into *syntax structures* based on a *category* associated with each *syntax element*.

**3.140** **slice group**: A subset of the *macroblocks* or *macroblock pairs* of a *picture*. The division of the *picture* into slice groups is a *partitioning* of the *picture*. The partitioning is specified by the *macroblock to slice group map*.

**3.141** **slice group map units**: The units of the *map unit to slice group map*.

**3.142** **slice header**: A part of a coded *slice* containing the data elements pertaining to the first or all *macroblocks* represented in the *slice*.

**3.143** **source**: Term used to describe the video material or some of its attributes before encoding.

**3.144** **SP slice**: A *slice* that may be coded using *intra prediction* or *inter prediction* with quantisation of the *prediction* samples using at most one *motion vector* and *reference index* to *predict* the sample values of each *block*. An SP slice can be coded such that its decoded samples can be constructed identically to another SP slice or an *SI slice*.

**3.145** **start code prefix**: A unique sequence of three *bytes* equal to 0x000001 embedded in the *byte stream* as a prefix to each *NAL unit*. The location of a start code prefix can be used by a *decoder* to identify the beginning of a new *NAL unit* and the end of a previous *NAL unit*. Emulation of start code prefixes is prevented within *NAL units* by the inclusion of *emulation prevention bytes*.

**3.146** **string of data bits (SODB)**: A sequence of some number of bits representing *syntax elements* present within a *raw byte sequence payload* prior to the *raw byte sequence payload stop bit*. Within an SODB, the left-most bit is considered to be the first and most significant bit, and the right-most bit is considered to be the last and least significant bit.

**3.147** **sub-macroblock**: One quarter of the samples of a *macroblock*, i.e., an 8x8 *luma block* and two corresponding *chroma blocks* of which one corner is located at a corner of the *macroblock* for a *picture* that has three sample arrays or an 8x8 *luma block* of which one corner is located at a corner of the *macroblock* for a monochrome *picture* or a *picture* that is coded using three separate colour planes.

**3.148** **sub-macroblock partition**: A *block* of *luma* samples and two corresponding *blocks* of *chroma* samples resulting from a *partitioning* of a *sub-macroblock* for *inter prediction* for a *picture* that has three sample arrays

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or a *block* of *luma* samples resulting from a *partitioning* of a *sub-macroblock* for *inter prediction* for a monochrome *picture* or a *picture* that is coded using three separate colour planes.

**3.149** **switching I slice**: See *SI slice*.

**3.150** **switching P slice**: See *SP slice*.

**3.151** **syntax element**: An element of data represented in the *bitstream*.

**3.152** **syntax structure**: Zero or more *syntax elements* present together in the *bitstream* in a specified order.

**3.153** **top field**: One of two *fields* that comprise a *frame*. Each row of a *top field* is spatially located immediately above the corresponding row of the *bottom field*.

**3.154** **top macroblock (of a macroblock pair)**: The *macroblock* within a *macroblock pair* that contains the samples in the top row of samples for the *macroblock pair*. For a *field macroblock pair*, the top macroblock represents the samples from the region of the *top field* of the *frame* that lie within the spatial region of the *macroblock pair*. For a *frame macroblock pair*, the top macroblock represents the samples of the *frame* that lie within the top half of the spatial region of the *macroblock pair*.

**3.155** **transform coefficient**: A scalar quantity, considered to be in a frequency domain, that is associated with a particular one-dimensional or two-dimensional *frequency index* in an *inverse transform* part of the *decoding process*.

**3.156** **transform coefficient level**: An integer quantity representing the value associated with a particular two-dimensional frequency index in the *decoding process* prior to *scaling* for computation of a *transform coefficient* value.

**3.157** **universal unique identifier (UUID)**: An identifier that is unique with respect to the space of all universal unique identifiers.

**3.158** **unspecified:** The term unspecified, when used in the clauses specifying some values of a particular *syntax element*, indicates that the values have no specified meaning in this International Standard and will not have a specified meaning in the future as an integral part of this International Standard.

**3.159** **variable length coding (VLC)**: A reversible procedure for entropy coding that assigns shorter bit strings to *symbols* expected to be more frequent and longer bit strings to *symbols* expected to be less frequent.

**3.160** **VCL NAL unit**: A collective term for *coded slice NAL units* and *coded slice data partition NAL units*.

**3.161** **zig-zag scan**: A specific sequential ordering of *transform coefficient levels* from (approximately) the lowest spatial frequency to the highest. Zig-zag scan is used for *transform coefficient levels* in *frame macroblocks*.

## 4 Abbreviations

For the purposes of this International Standard, the following abbreviations apply.

CABAC Context-based Adaptive Binary Arithmetic Coding

CAVLC Context-based Adaptive Variable Length Coding

CBR Constant Bit Rate

CPB Coded Picture Buffer

DPB Decoded Picture Buffer

DUT Decoder under test

FIFO First-In, First-Out

HRD Hypothetical Reference Decoder

HSS Hypothetical Stream Scheduler

IDR Instantaneous Decoding Refresh

LSB Least Significant Bit

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| | |
|---|---|
| MB | Macroblock |
| MBAFF | Macroblock-Adaptive Frame-Field Coding |
| MSB | Most Significant Bit |
| NAL | Network Abstraction Layer |
| RBSP | Raw Byte Sequence Payload |
| SEI | Supplemental Enhancement Information |
| SODB | String Of Data Bits |
| SVC | Scalable Video Coding |
| UUID | Universal Unique Identifier |
| VBR | Variable Bit Rate |
| VCL | Video Coding Layer |
| VLC | Variable Length Coding |
| VUI | Video Usability Information |

# 5 Conventions

NOTE – The mathematical operators used in this Specification are similar to those used in the C programming language. However, integer division and arithmetic shift operations are specifically defined. Numbering and counting conventions generally begin from 0.

## 5.1 Arithmetic operators

The following arithmetic operators are defined as follows.

| | |
|---|---|
| + | Addition |
| – | Subtraction (as a two-argument operator) or negation (as a unary prefix operator) |
| * | Multiplication |
| $x^y$ | Exponentiation. Specifies x to the power of y. In other contexts, such notation is used for superscripting not intended for interpretation as exponentiation. |
| / | Integer division with truncation of the result toward zero. For example, 7/4 and –7/–4 are truncated to 1 and –7/4 and 7/–4 are truncated to –1. |
| ÷ | Used to denote division in mathematical equations where no truncation or rounding is intended. |
| $\frac{x}{y}$ | Used to denote division in mathematical equations where no truncation or rounding is intended. |
| $\sum_{i=x}^{y} f(i)$ | The summation of f( i ) with i taking all integer values from x up to and including y. |
| x % y | Modulus. Remainder of x divided by y, defined only for integers x and y with x >= 0 and y > 0. |

When order of precedence is not indicated explicitly by use of parenthesis, the following rules apply:

- multiplication and division operations are considered to take place before addition and subtraction;
- multiplication and division operations in sequence are evaluated sequentially from left to right;
- addition and subtraction operations in sequence are evaluated sequentially from left to right.

## 5.2 Logical operators

The following logical operators are defined as follows:

x && y Boolean logical "and" of x and y

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x || y Boolean logical "or" of x and y

! Boolean logical "not"

x ? y : z If x is TRUE or not equal to 0, evaluates to the value of y; otherwise, evaluates to the value of z

## 5.3 Relational operators

The following relational operators are defined as follows:

> Greater than

>= Greater than or equal to

< Less than

<= Less than or equal to

= = Equal to

!= Not equal to

When a relational operator is applied to a syntax element or variable that has been assigned the value "na" (not applicable), the value "na" is treated as a distinct value for the syntax element or variable. The value "na" is considered not to be equal to any other value.

## 5.4 Bit-wise operators

The following bit-wise operators are defined as follows:

& Bit-wise "and". When operating on integer arguments, operates on a two's complement representation of the integer value. When operating on a binary argument that contains fewer bits than another argument, the shorter argument is extended by adding more significant bits equal to 0.

| Bit-wise "or". When operating on integer arguments, operates on a two's complement representation of the integer value. When operating on a binary argument that contains fewer bits than another argument, the shorter argument is extended by adding more significant bits equal to 0.

x >> y Arithmetic right shift of a two's complement integer representation of x by y binary digits. This function is defined only for positive integer values of y. Bits shifted into the MSBs as a result of the right shift have a value equal to the MSB of x prior to the shift operation.

x << y Arithmetic left shift of a two's complement integer representation of x by y binary digits. This function is defined only for positive integer values of y. Bits shifted into the LSBs as a result of the left shift have a value equal to 0.

## 5.5 Assignment operators

The following arithmetic operators are defined as follows:

= Assignment operator.

++ Increment, i.e., $x$++ is equivalent to $x = x + 1$; when used in an array index, evaluates to the value of the variable prior to the increment operation.

Decrement, i.e., $x$–– is equivalent to $x = x - 1$; when used in an array index, evaluates to the value of the variable prior to the decrement operation.

+= Increment by amount specified, i.e., x += 3 is equivalent to x = x + 3, and x += (-3) is equivalent to x = x + (-3).

–= Decrement by amount specified, i.e., x –= 3 is equivalent to x = x – 3, and x –= (-3) is equivalent to x = x – (-3).

## 5.6 Range notation

The following notation is used to specify a range of values

x = y .. z x takes on integer values starting from y to z inclusive, with x, y, and z being integer numbers.

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## 5.7 Mathematical functions

The following mathematical functions are defined as follows:

$$\text{Abs}( x ) = \begin{cases} x & ; \quad x >= 0 \\ -x & ; \quad x < 0 \end{cases} \tag{5-1}$$

Ceil( x ) the smallest integer greater than or equal to x. (5-2)

$$\text{Clip1}_Y( x ) = \text{Clip3}( 0, ( 1 << \text{BitDepth}_Y ) - 1, x ) \tag{5-3}$$

$$\text{Clip1}_C( x ) = \text{Clip3}( 0, ( 1 << \text{BitDepth}_C ) - 1, x ) \tag{5-4}$$

$$\text{Clip3}( x, y, z ) = \begin{cases} x & ; \quad z < x \\ y & ; \quad z > y \\ z & ; \quad \text{otherwise} \end{cases} \tag{5-5}$$

Floor( x ) the greatest integer less than or equal to x. (5-6)

$$\text{InverseRasterScan}( a, b, c, d, e ) = \begin{cases} (a \% (d / b)) * b; & e == 0 \\ (a / (d / b)) * c; & e == 1 \end{cases} \tag{5-7}$$

Log2( x ) returns the base-2 logarithm of x. (5-8)

Log10( x ) returns the base-10 logarithm of x. (5-9)

$$\text{Median}( x, y, z ) = x + y + z - \text{Min}( x, \text{Min}( y, z ) ) - \text{Max}( x, \text{Max}( y, z ) ) \tag{5-10}$$

$$\text{Min}( x, y ) = \begin{cases} x & ; \quad x <= y \\ y & ; \quad x > y \end{cases} \tag{5-11}$$

$$\text{Max}( x, y ) = \begin{cases} x & ; \quad x >= y \\ y & ; \quad x < y \end{cases} \tag{5-12}$$

$$\text{Round}( x ) = \text{Sign}( x ) * \text{Floor}( \text{Abs}( x ) + 0.5 ) \tag{5-13}$$

$$\text{Sign}( x ) = \begin{cases} 1 & ; \quad x >= 0 \\ -1 & ; \quad x < 0 \end{cases} \tag{5-14}$$

$$\text{Sqrt}( x ) = \sqrt{x} \tag{5-15}$$

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## 5.8 Variables, syntax elements, and tables

Syntax elements in the bitstream are represented in **bold** type. Each syntax element is described by its name (all lower case letters with underscore characters), its one or two syntax categories, and one or two descriptors for its method of coded representation. The decoding process behaves according to the value of the syntax element and to the values of previously decoded syntax elements. When a value of a syntax element is used in the syntax tables or the text, it appears in regular (i.e., not bold) type.

In some cases the syntax tables may use the values of other variables derived from syntax elements values. Such variables appear in the syntax tables, or text, named by a mixture of lower case and upper case letter and without any underscore characters. Variables starting with an upper case letter are derived for the decoding of the current syntax structure and all depending syntax structures. Variables starting with an upper case letter may be used in the decoding process for later syntax structures mentioning the originating syntax structure of the variable. Variables starting with a lower case letter are only used within the subclause in which they are derived.

In some cases, "mnemonic" names for syntax element values or variable values are used interchangeably with their numerical values. Sometimes "mnemonic" names are used without any associated numerical values. The association of values and names is specified in the text. The names are constructed from one or more groups of letters separated by an underscore character. Each group starts with an upper case letter and may contain more upper case letters.

NOTE – The syntax is described in a manner that closely follows the C-language syntactic constructs.

Functions are described by their names, which are constructed as syntax element names, with left and right round parentheses including zero or more variable names (for definition) or values (for usage), separated by commas (if more than one variable).

A one-dimensional array is referred to as a list. A two-dimensional array is referred to as a matrix. Arrays can either be syntax elements or variables. Subscripts or square parentheses are used for the indexing of arrays. In reference to a visual depiction of a matrix, the first subscript is used as a row (vertical) index and the second subscript is used as a column (horizontal) index. The indexing order is reversed when using square parentheses rather than subscripts for indexing. Thus, an element of a matrix s at horizontal position x and vertical position y may be denoted either as s[ x, y ] or as $s_{yx}$.

Binary notation is indicated by enclosing the string of bit values by single quote marks. For example, '01000001' represents an eight-bit string having only its second and its last bits equal to 1.

Hexadecimal notation, indicated by prefixing the hexadecimal number by "0x", may be used instead of binary notation when the number of bits is an integer multiple of 4. For example, 0x41 represents an eight-bit string having only its second and its last bits equal to 1.

Numerical values not enclosed in single quotes and not prefixed by "0x" are decimal values.

A value equal to 0 represents a FALSE condition in a test statement. The value TRUE is represented by any other value different than zero.

## 5.9 Text description of logical operations

In the text, a statement of logical operations as would be described in pseudo-code as

```
if( condition 0 )
  statement 0
else if ( condition 1 )
  statement 1
…
else /* informative remark on remaining condition */
  statement n
```

may be described in the following manner:

... as follows / ... the following applies.

- If condition 0, statement 0
- Otherwise, if condition 1, statement 1
- …
- Otherwise (informative remark on remaining condition), statement n

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Each "If...Otherwise, if...Otherwise, ..." statement in the text is introduced with "... as follows" or "... the following applies" immediately followed by "If ... ". The last condition of the "If...Otherwise, if...Otherwise, ..." is always an "Otherwise, ...". Interleaved "If...Otherwise, if...Otherwise, ..." statements can be identified by matching "... as follows" or "... the following applies" with the ending "Otherwise, ...".

In the text, a statement of logical operations as would be described in pseudo-code as

```
if( condition 0a  &&  condition 0b )
  statement 0
else if ( condition 1a  ||  condition 1b )
  statement 1
…
else
  statement n
```

may be described in the following manner:

... as follows / ... the following applies.

- If all of the following conditions are true, statement 0
  - condition 0a
  - condition 0b
- Otherwise, if any of the following conditions are true, statement 1
  - condition 1a
  - condition 1b
- …
- Otherwise, statement n

In the text, a statement of logical operations as would be described in pseudo-code as

```
if( condition 0 )
  statement 0
if ( condition 1 )
  statement 1
```

may be described in the following manner:

When condition 0, statement 0

When condition 1, statement 1

## 5.10 Processes

Processes are used to describe the decoding of syntax elements. A process has a separate specification and invoking. All syntax elements and upper case variables that pertain to the current syntax structure and depending syntax structures are available in the process specification and invoking. A process specification may also have a lower case variable explicitly specified as the input. Each process specification has explicitly specified an output. The output is a variable that can either be an upper case variable or a lower case variable.

The assignment of variables is specified as follows.

- If invoking a process, variables are explicitly assigned to lower case input or output variables of the process specification in case these do not have the same name.
- Otherwise (when the variables at the invoking and specification have the same name), assignment is implied.

In the specification of a process, a specific macroblock may be referred to by the variable name having a value equal to the address of the specific macroblock.

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# 6 Source, coded, decoded and output data formats, scanning processes, and neighbouring relationships

## 6.1 Bitstream formats

This subclause specifies the relationship between the NAL unit stream and byte stream, either of which are referred to as the bitstream.

The bitstream can be in one of two formats: the NAL unit stream format or the byte stream format. The NAL unit stream format is conceptually the more "basic" type. It consists of a sequence of syntax structures called NAL units. This sequence is ordered in decoding order. There are constraints imposed on the decoding order (and contents) of the NAL units in the NAL unit stream.

The byte stream format can be constructed from the NAL unit stream format by ordering the NAL units in decoding order and prefixing each NAL unit with a start code prefix and zero or more zero-valued bytes to form a stream of bytes. The NAL unit stream format can be extracted from the byte stream format by searching for the location of the unique start code prefix pattern within this stream of bytes. Methods of framing the NAL units in a manner other than use of the byte stream format are outside the scope of this International Standard. The byte stream format is specified in Annex B.

## 6.2 Source, decoded, and output picture formats

This subclause specifies the relationship between source and decoded frames and fields that is given via the bitstream.

The video source that is represented by the bitstream is a sequence of either or both frames or fields (called collectively pictures) in decoding order.

The source and decoded pictures (frames or fields) are each comprised of one or more sample arrays:

- Luma (Y) only (monochrome), with or without an auxiliary array.
- Luma and two Chroma (YCbCr or YCgCo), with or without an auxiliary array.
- Green, Blue and Red (GBR, also known as RGB), with or without an auxiliary array.
- Arrays representing other unspecified monochrome or tri-stimulus colour samplings (for example, YZX, also known as XYZ), with or without an auxiliary array.

For convenience of notation and terminology in this specification, the variables and terms associated with these arrays are referred to as luma (or L or Y) and chroma, where the two chroma arrays are referred to as Cb and Cr; regardless of the actual colour representation method in use. The actual colour representation method in use can be indicated in syntax that is specified in Annex E. The (monochrome) auxiliary arrays, which may or may not be present as auxiliary pictures in a coded video sequence, are optional for decoding and can be used for such purposes as alpha blending.

The variables SubWidthC, and SubHeightC are specified in Table 6-1, depending on the chroma format sampling structure, which is specified through chroma_format_idc and separate_colour_plane_flag. An entry marked as "-" in Table 6-1 denotes an undefined value for SubWidthC or SubHeightC. Other values of chroma_format_idc, SubWidthC, and SubHeightC may be specified in the future by ITU-T | ISO/IEC.

**Table 6-1 – SubWidthC, and SubHeightC values derived from chroma_format_idc and separate_colour_plane_flag**

| chroma_format_idc | separate_colour_plane_flag | Chroma Format | SubWidthC | SubHeightC |
|---|---|---|---|---|
| 0 | 0 | monochrome | – | – |
| 1 | 0 | 4:2:0 | 2 | 2 |
| 2 | 0 | 4:2:2 | 2 | 1 |
| 3 | 0 | 4:4:4 | 1 | 1 |
| 3 | 1 | 4:4:4 | - | - |

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In monochrome sampling there is only one sample array, which is nominally considered the luma array.

In 4:2:0 sampling, each of the two chroma arrays has half the height and half the width of the luma array.

In 4:2:2 sampling, each of the two chroma arrays has the same height and half the width of the luma array.

In 4:4:4 sampling, depending on the value of separate_colour_plane_flag, the following applies.

– If separate_colour_plane_flag is equal to 0, each of the two chroma arrays has the same height and width as the luma array.

– Otherwise (separate_colour_plane_flag is equal to 1), the three colour planes are separately processed as monochrome sampled pictures.

The width and height of the luma sample arrays are each an integer multiple of 16. In coded video sequences using 4:2:0 chroma sampling, the width and height of chroma sample arrays are each an integer multiple of 8. In coded vide sequences using 4:2:2 sampling, the width of the chroma sample arrays is an integer multiple of 8 and the height is an integer multiple of 16. The height of a luma array that is coded as two separate fields or in macroblock-adaptive frame-field coding (see below) is an integer multiple of 32. In coded video sequences using 4:2:0 chroma sampling, the height of each chroma array that is coded as two separate fields or in macroblock-adaptive frame-field coding (see below) is an integer multiple of 16. The width or height of pictures output from the decoding process need not be an integer multiple of 16 and can be specified using a cropping rectangle.

The syntax for the luma and (when present) chroma arrays are ordered such when data for all three colour components is present, the data for the luma array is first, followed by any data for the Cb array, followed by any data for the Cr array, unless otherwise specified.

The width of fields coded referring to a specific sequence parameter set is the same as that of frames coded referring to the same sequence parameter set (see below). The height of fields coded referring to a specific sequence parameter set is half that of frames coded referring to the same sequence parameter set (see below).

The number of bits necessary for the representation of each of the samples in the luma and chroma arrays in a video sequence is in the range of 8 to 14, and the number of bits used in the luma array may differ from the number of bits used in the chroma arrays.

When the value of chroma_format_idc is equal to 1, the nominal vertical and horizontal relative locations of luma and chroma samples in frames are shown in Figure 6-1. Alternative chroma sample relative locations may be indicated in video usability information (see Annex E).

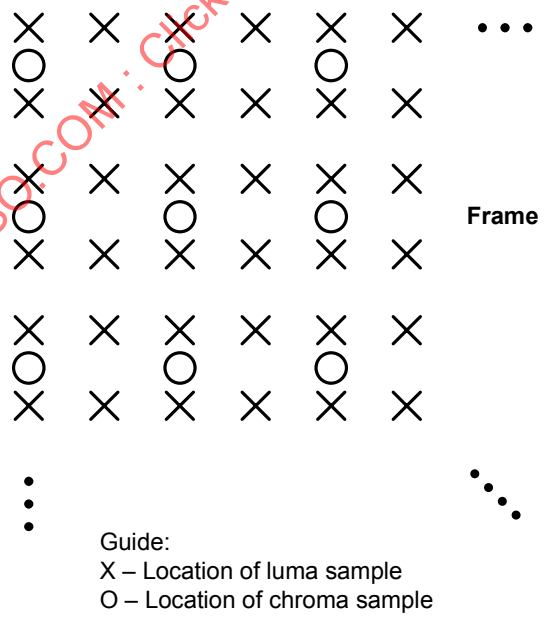


**Figure 6-1 – Nominal vertical and horizontal locations of 4:2:0 luma and chroma samples in a frame**

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A frame consists of two fields as described below. A coded picture may represent a coded frame or an individual coded field. A coded video sequence conforming to this International Standard may contain arbitrary combinations of coded frames and coded fields. The decoding process is also specified in a manner that allows smaller regions of a coded frame to be coded either as a frame or field region, by use of macroblock-adaptive frame-field coding.

Source and decoded fields are one of two types: top field or bottom field. When two fields are output at the same time, or are combined to be used as a reference frame (see below), the two fields (which shall be of opposite parity) are interleaved. The first (i.e., top), third, fifth, etc. rows of a decoded frame are the top field rows. The second, fourth, sixth, etc. rows of a decoded frame are the bottom field rows. A top field consists of only the top field rows of a decoded frame. When the top field or bottom field of a decoded frame is used as a reference field (see below) only the even rows (for a top field) or the odd rows (for a bottom field) of the decoded frame are used.

When the value of chroma_format_idc is equal to 1, the nominal vertical and horizontal relative locations of luma and chroma samples in top and bottom fields are shown in Figure 6-2. The nominal vertical sampling relative locations of the chroma samples in a top field are specified as shifted up by one-quarter luma sample height relative to the field-sampling grid. The vertical sampling locations of the chroma samples in a bottom field are specified as shifted down by one-quarter luma sample height relative to the field-sampling grid. Alternative chroma sample relative locations may be indicated in the video usability information (see Annex E).

NOTE – The shifting of the chroma samples is in order for these samples to align vertically to the usual location relative to the full-frame sampling grid as shown in Figure 6-1.

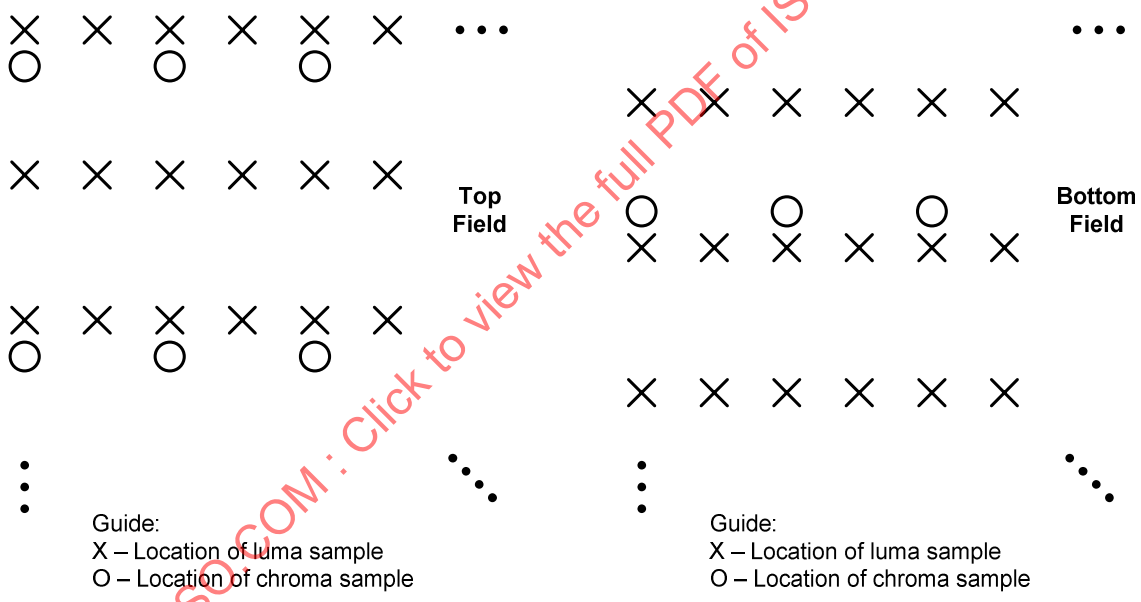


**Figure 6-2 – Nominal vertical and horizontal sampling locations of 4:2:0 samples in top and bottom fields**

When the value of chroma_format_idc is equal to 2, the chroma samples are co-sited with the corresponding luma samples and the nominal locations in a frame and in fields are as shown in Figure 6-3 and Figure 6-4, respectively.

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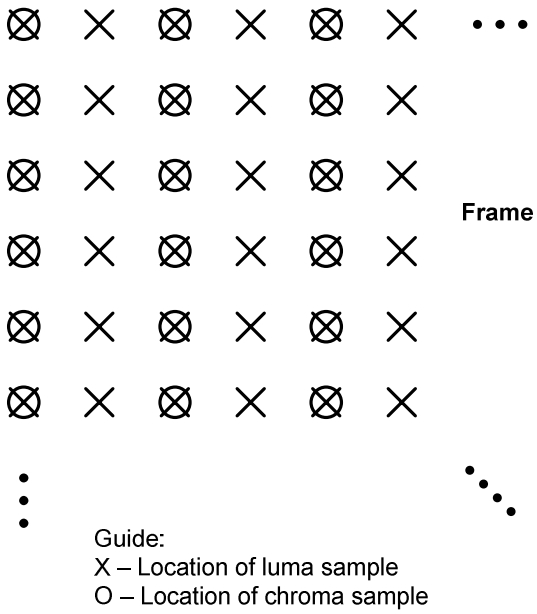


**Figure 6-3 – Nominal vertical and horizontal locations of 4:2:2 luma and chroma samples in a frame**

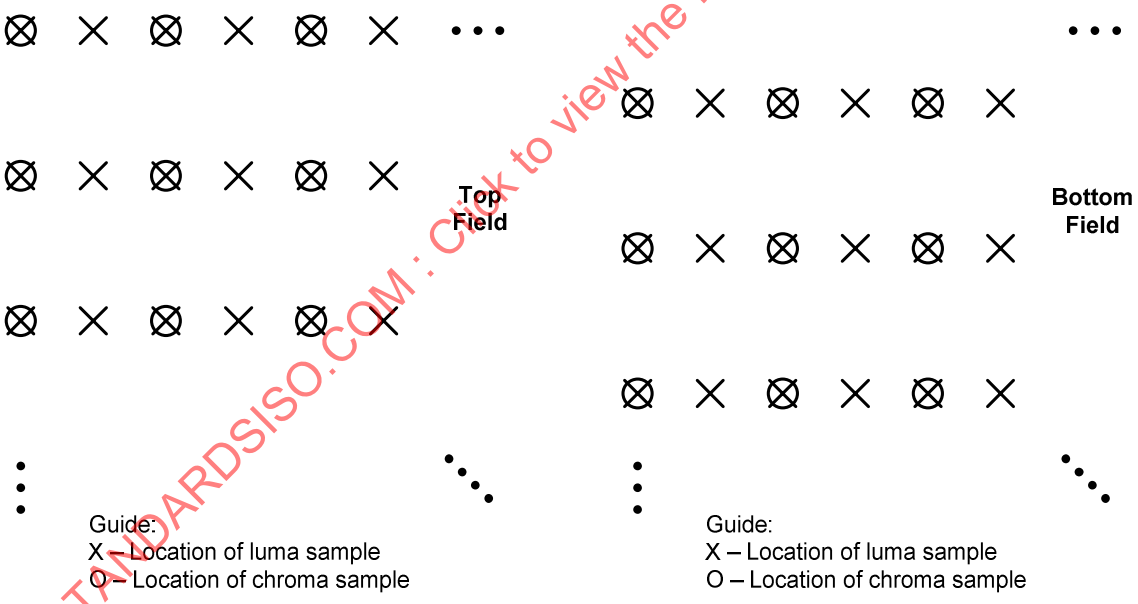


**Figure 6-4 – Nominal vertical and horizontal sampling locations of 4:2:2 samples top and bottom fields**

When the value of chroma_format_idc is equal to 3, all array samples are co-sited for all cases of frames and fields and the nominal locations in a frame and in fields are as shown in Figure 6-5 and 6-6, respectively.

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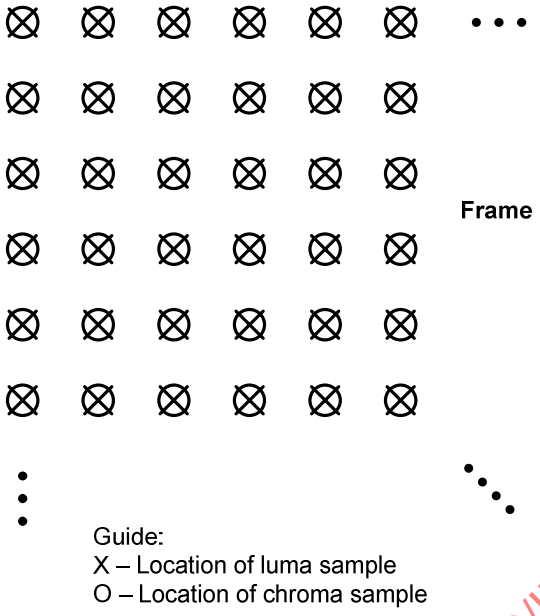


**Figure 6-5 – Nominal vertical and horizontal locations of 4:4:4 luma and chroma samples in a frame**

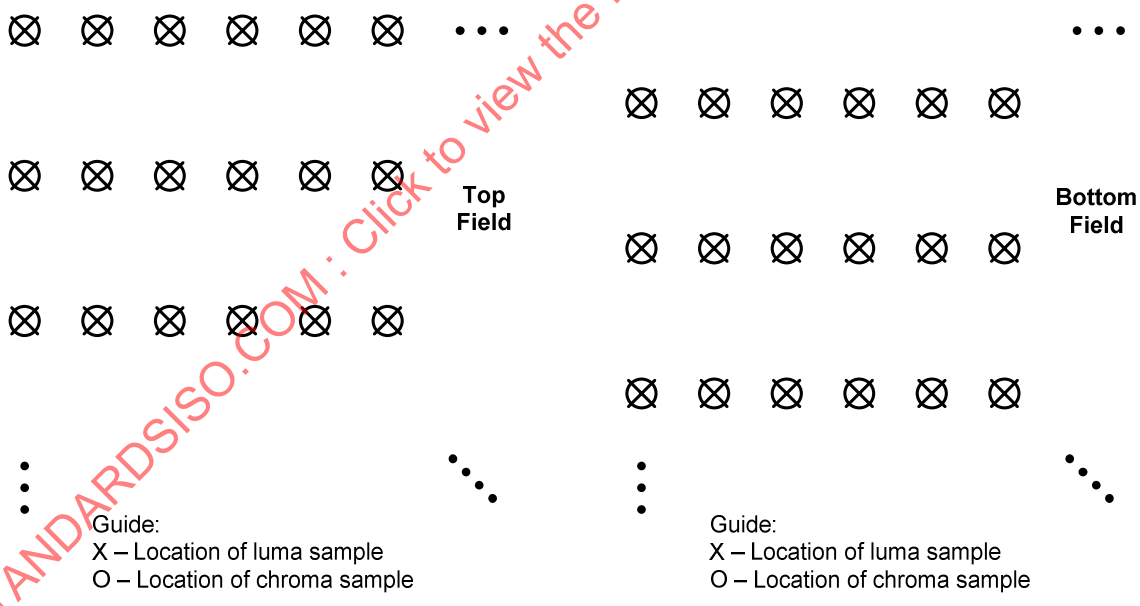


**Figure 6-6 – Nominal vertical and horizontal sampling locations of 4:4:4 samples top and bottom fields**

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The samples are processed in units of macroblocks. The luma array for each macroblock is 16 samples in both width and height. The variables MbWidthC and MbHeightC, which specify the width and height, respectively, of the chroma arrays for each macroblock, are derived as follows.

– If chroma_format_idc is equal to 0 (monochrome) or separate_colour_plane_flag is equal to 1, MbWidthC and MbHeightC are both equal to 0.

– Otherwise, MbWidthC and MbHeightC are derived as

$$MbWidthC = 16 / SubWidthC \quad (6\text{-}1)$$
$$MbHeightC = 16 / SubHeightC \quad (6\text{-}2)$$

## 6.3 Spatial subdivision of pictures and slices

This subclause specifies how a picture is partitioned into slices and macroblocks. Pictures are divided into slices. A slice is a sequence of macroblocks, or, when macroblock-adaptive frame/field decoding is in use, a sequence of macroblock pairs.

Each macroblock is comprised of one 16x16 luma array and, when the chroma sampling format is not equal to 4:0:0 and separate_colour_plane_flag is equal to 0, two corresponding chroma sample arrays. When separate_colour_plane_flag is equal to 1, each macroblock is comprised of one 16x16 luma or chroma sample array. When macroblock-adaptive frame/field decoding is not in use, each macroblock represents a spatial rectangular region of the picture. For example, a picture may be divided into two slices as shown in Figure 6-7.

When a picture is coded using three separate colour planes (separate_colour_plane_flag is equal to 1), a slice contains only macroblocks of one colour component being identified by the corresponding value of colour_plane_id, and each colour component array of a picture consists of slices having the same colour_plane_id value. Coded slices with different values of colour_plane_id within an access unit can be interleaved with each other under the constraint that for each value of colour_plane_id, the coded slice NAL units with that value colour_plane_id shall be in the order of increasing macroblock address for the first macroblock of each coded slice NAL unit.

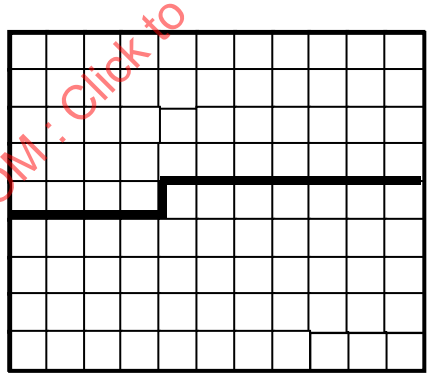

**Figure 6-7 – A picture with 11 by 9 macroblocks that is partitioned into two slices**

When macroblock-adaptive frame/field decoding is in use, the picture is partitioned into slices containing an integer number of macroblock pairs as shown in Figure 6-8. Each macroblock pair consists of two macroblocks.

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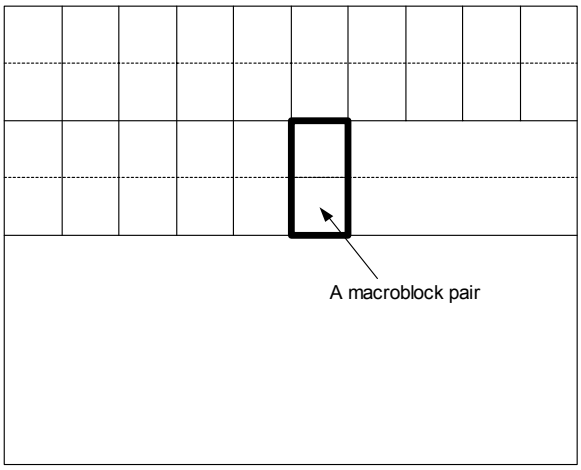


**Figure 6-8 – Partitioning of the decoded frame into macroblock pairs**

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## 6.4 Inverse scanning processes and derivation processes for neighbours

This subclause specifies inverse scanning processes; i.e., the mapping of indices to locations, and derivation processes for neighbours.

### 6.4.1 Inverse macroblock scanning process

Input to this process is a macroblock address mbAddr.

Output of this process is the location ( x, y ) of the upper-left luma sample for the macroblock with address mbAddr relative to the upper-left sample of the picture.

The inverse macroblock scanning process is specified as follows.

– If MbaffFrameFlag is equal to 0,

$$x = \text{InverseRasterScan}( \text{mbAddr}, 16, 16, \text{PicWidthInSamples}_L, 0 ) \quad (6\text{-}3)$$

$$y = \text{InverseRasterScan}( \text{mbAddr}, 16, 16, \text{PicWidthInSamples}_L, 1 ) \quad (6\text{-}4)$$

– Otherwise (MbaffFrameFlag is equal to 1), the following applies.

$$xO = \text{InverseRasterScan}( \text{mbAddr} / 2, 16, 32, \text{PicWidthInSamples}_L, 0 ) \quad (6\text{-}5)$$

$$yO = \text{InverseRasterScan}( \text{mbAddr} / 2, 16, 32, \text{PicWidthInSamples}_L, 1 ) \quad (6\text{-}6)$$

Depending on the current macroblock the following applies.

– If the current macroblock is a frame macroblock

$$x = xO \quad (6\text{-}7)$$

$$y = yO + ( \text{mbAddr} \% 2 ) * 16 \quad (6\text{-}8)$$

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– Otherwise (the current macroblock is a field macroblock),

$$x = xO \tag{6-9}$$

$$y = yO + ( mbAddr \% 2 ) \tag{6-10}$$

### 6.4.2 Inverse macroblock partition and sub-macroblock partition scanning process

Macroblocks or sub-macroblocks may be partitioned, and the partitions are scanned for inter prediction as shown in Figure 6-9. The outer rectangles refer to the samples in a macroblock or sub-macroblock, respectively. The rectangles refer to the partitions. The number in each rectangle specifies the index of the inverse macroblock partition scan or inverse sub-macroblock partition scan.

The functions MbPartWidth( ), MbPartHeight( ), SubMbPartWidth( ), and SubMbPartHeight( ) describing the width and height of macroblock partitions and sub-macroblock partitions are specified in Tables 7-13, 7-14, 7-17, and 7-18. MbPartWidth( ) and MbPartHeight( ) are set to appropriate values for each macroblock, depending on the macroblock type. SubMbPartWidth( ) and SubMbPartHeight( ) are set to appropriate values for each sub-macroblock of a macroblock with mb_type equal to P_8x8, P_8x8ref0, or B_8x8, depending on the sub-macroblock type.

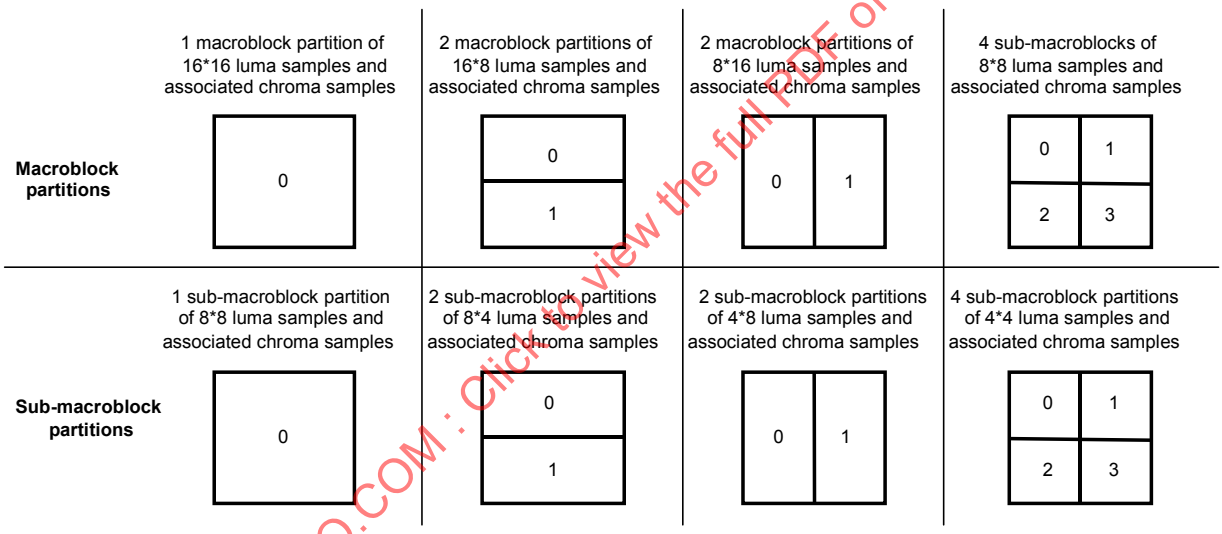


**Figure 6-9 – Macroblock partitions, sub-macroblock partitions, macroblock partition scans, and sub-macroblock partition scans**

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#### 6.4.2.1 Inverse macroblock partition scanning process

Input to this process is the index of a macroblock partition mbPartIdx.

Output of this process is the location ( x, y ) of the upper-left luma sample for the macroblock partition mbPartIdx relative to the upper-left sample of the macroblock.

The inverse macroblock partition scanning process is specified by

$$x = InverseRasterScan( mbPartIdx, MbPartWidth( mb_type ), MbPartHeight( mb_type ), 16, 0 ) \tag{6-11}$$

$$y = InverseRasterScan( mbPartIdx, MbPartWidth( mb_type ), MbPartHeight( mb_type ), 16, 1 ) \tag{6-12}$$


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#### 6.4.2.2 Inverse sub-macroblock partition scanning process

Inputs to this process are the index of a macroblock partition mbPartIdx and the index of a sub-macroblock partition subMbPartIdx.

Output of this process is the location ( x, y ) of the upper-left luma sample for the sub-macroblock partition subMbPartIdx relative to the upper-left sample of the sub-macroblock.

The inverse sub-macroblock partition scanning process is specified as follows.

– If mb_type is equal to P_8x8, P_8x8ref0, or B_8x8,

$$x = \text{InverseRasterScan}( \text{subMbPartIdx}, \text{SubMbPartWidth}( \text{sub_mb_type}[ \text{mbPartIdx} ] ), \text{SubMbPartHeight}( \text{sub_mb_type}[ \text{mbPartIdx} ] ), 8, 0 ) \quad (6\text{-}13)$$

$$y = \text{InverseRasterScan}( \text{subMbPartIdx}, \text{SubMbPartWidth}( \text{sub_mb_type}[ \text{mbPartIdx} ] ), \text{SubMbPartHeight}( \text{sub_mb_type}[ \text{mbPartIdx} ] ), 8, 1 ) \quad (6\text{-}14)$$

– Otherwise,

$$x = \text{InverseRasterScan}( \text{subMbPartIdx}, 4, 4, 8, 0 ) \quad (6\text{-}15)$$

$$y = \text{InverseRasterScan}( \text{subMbPartIdx}, 4, 4, 8, 1 ) \quad (6\text{-}16)$$

### 6.4.3 Inverse 4x4 luma block scanning process

Input to this process is the index of a 4x4 luma block luma4x4BlkIdx.

Output of this process is the location ( x, y ) of the upper-left luma sample for the 4x4 luma block with index luma4x4BlkIdx relative to the upper-left luma sample of the macroblock.

Figure 6-10 shows the scan for the 4x4 luma blocks.

| | | | |
|---|---|---|---|
| 0 | 1 | 4 | 5 |
| 2 | 3 | 6 | 7 |
| 8 | 9 | 12 | 13 |
| 10 | 11 | 14 | 15 |

**Figure 6-10 – Scan for 4x4 luma blocks**

The inverse 4x4 luma block scanning process is specified by

$$x = \text{InverseRasterScan}( \text{luma4x4BlkIdx} / 4, 8, 8, 16, 0 ) + \text{InverseRasterScan}( \text{luma4x4BlkIdx} \% 4, 4, 4, 8, 0 ) \quad (6\text{-}17)$$

$$y = \text{InverseRasterScan}( \text{luma4x4BlkIdx} / 4, 8, 8, 16, 1 ) + \text{InverseRasterScan}( \text{luma4x4BlkIdx} \% 4, 4, 4, 8, 1 ) \quad (6\text{-}18)$$

### 6.4.4 Inverse 4x4 Cb or Cr block scanning process for ChromaArrayType equal to 3

This process is only invoked when ChromaArrayType is equal to 3.

The inverse 4x4 chroma block scanning process is identical to inverse 4x4 luma block scanning process as specified in subclause 6.4.3 when substituting the term “luma” with the term “Cb” or the term “Cr”, and substituting the term “luma4x4BlkIdx” with the term “cb4x4BlkIdx” or the term “cr4x4BlkIdx” in all places in subclause 6.4.3.

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### 6.4.5 Inverse 8x8 luma block scanning process

Input to this process is the index of an 8x8 luma block luma8x8BlkIdx.

Output of this process is the location ( x, y ) of the upper-left luma sample for the 8x8 luma block with index luma8x8BlkIdx relative to the upper-left luma sample of the macroblock.

Figure 6-11 shows the scan for the 8x8 luma blocks.

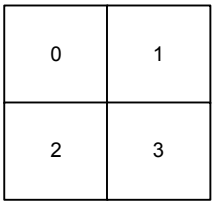


**Figure 6-11 – Scan for 8x8 luma blocks**

The inverse 8x8 luma block scanning process is specified by

$$x = \text{InverseRasterScan}( \text{luma8x8BlkIdx}, 8, 8, 16, 0 ) \quad (6\text{-}19)$$

$$y = \text{InverseRasterScan}( \text{luma8x8BlkIdx}, 8, 8, 16, 1 ) \quad (6\text{-}20)$$

### 6.4.6 Inverse 8x8 Cb or Cr block scanning process for ChromaArrayType equal to 3

This process is only invoked when ChromaArrayType is equal to 3.

The inverse 8x8 chroma block scanning process is identical to inverse 8x8 luma block scanning process as specified in subclause 6.4.5 when substituting the term “luma” with the term “Cb” or the term “Cr”, and substituting the term “luma8x8BlkIdx” with the term “cb8x8BlkIdx” or the term “cr8x8BlkIdx” in all places in subclause 6.4.5.

### 6.4.7 Derivation process of the availability for macroblock addresses

Input to this process is a macroblock address mbAddr.

Output of this process is the availability of the macroblock mbAddr.

NOTE – The meaning of availability is determined when this process is invoked.

The macroblock is marked as available, unless one of the following conditions is true in which case the macroblock is marked as not available:

– mbAddr < 0
– mbAddr > CurrMbAddr
– the macroblock with address mbAddr belongs to a different slice than the macroblock with address CurrMbAddr

### 6.4.8 Derivation process for neighbouring macroblock addresses and their availability

This process can only be invoked when MbaffFrameFlag is equal to 0.

The outputs of this process are

– mbAddrA: the address and availability status of the macroblock to the left of the current macroblock.
– mbAddrB: the address and availability status of the macroblock above the current macroblock.
– mbAddrC: the address and availability status of the macroblock above-right of the current macroblock.
– mbAddrD: the address and availability status of the macroblock above-left of the current macroblock.

Figure 6-12 shows the relative spatial locations of the macroblocks with mbAddrA, mbAddrB, mbAddrC, and mbAddrD relative to the current macroblock with CurrMbAddr.

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| | | |
|---|---|---|
| mbAddrD | mbAddrB | mbAddrC |
| mbAddrA | CurrMbAddr | |
| | | |

**Figure 6-12 – Neighbouring macroblocks for a given macroblock**

Input to the process in subclause 6.4.7 is mbAddrA = CurrMbAddr – 1 and the output is whether the macroblock mbAddrA is available. In addition, mbAddrA is marked as not available when CurrMbAddr % PicWidthInMbs is equal to 0.

Input to the process in subclause 6.4.7 is mbAddrB = CurrMbAddr – PicWidthInMbs and the output is whether the macroblock mbAddrB is available.

Input to the process in subclause 6.4.7 is mbAddrC = CurrMbAddr – PicWidthInMbs + 1 and the output is whether the macroblock mbAddrC is available. In addition, mbAddrC is marked as not available when ( CurrMbAddr + 1 ) % PicWidthInMbs is equal to 0.

Input to the process in subclause 6.4.7 is mbAddrD = CurrMbAddr – PicWidthInMbs - 1 and the output is whether the macroblock mbAddrD is available. In addition, mbAddrD is marked as not available when CurrMbAddr % PicWidthInMbs is equal to 0.

### 6.4.9 Derivation process for neighbouring macroblock addresses and their availability in MBAFF frames

This process can only be invoked when MbaffFrameFlag is equal to 1.

The outputs of this process are

- mbAddrA: the address and availability status of the top macroblock of the macroblock pair to the left of the current macroblock pair.
- mbAddrB: the address and availability status of the top macroblock of the macroblock pair above the current macroblock pair.
- mbAddrC: the address and availability status of the top macroblock of the macroblock pair above-right of the current macroblock pair.
- mbAddrD: the address and availability status of the top macroblock of the macroblock pair above-left of the current macroblock pair.

Figure 6-13 shows the relative spatial locations of the macroblocks with mbAddrA, mbAddrB, mbAddrC, and mbAddrD relative to the current macroblock with CurrMbAddr.

mbAddrA, mbAddrB, mbAddrC, and mbAddrD have identical values regardless whether the current macroblock is the top or the bottom macroblock of a macroblock pair.

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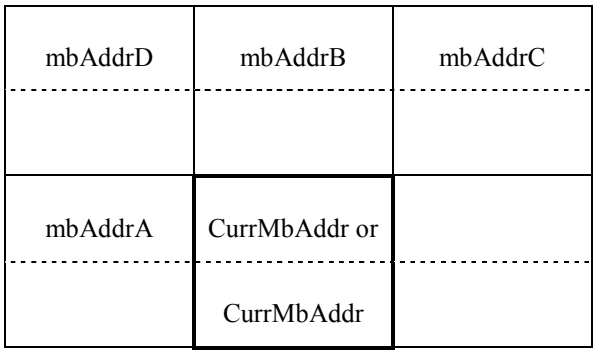


**Figure 6-13 – Neighbouring macroblocks for a given macroblock in MBAFF frames**

Input to the process in subclause 6.4.7 is mbAddrA =2 * ( CurrMbAddr / 2 – 1 ) and the output is whether the macroblock mbAddrA is available. In addition, mbAddrA is marked as not available when ( CurrMbAddr / 2 ) % PicWidthInMbs is equal to 0.

Input to the process in subclause 6.4.7 is mbAddrB =2 * ( CurrMbAddr / 2 – PicWidthInMbs ) and the output is whether the macroblock mbAddrB is available.

Input to the process in subclause 6.4.7 is mbAddrC = 2 * ( CurrMbAddr / 2 – PicWidthInMbs + 1 ) and the output is whether the macroblock mbAddrC is available. In addition, mbAddrC is marked as not available when ( CurrMbAddr / 2 + 1) % PicWidthInMbs is equal to 0.

Input to the process in subclause 6.4.7 is mbAddrD = 2 * ( CurrMbAddr / 2 – PicWidthInMbs - 1 ) and the output is whether the macroblock mbAddrD is available. In addition, mbAddrD is marked as not available when ( CurrMbAddr / 2 ) % PicWidthInMbs is equal to 0.

### 6.4.10 Derivation processes for neighbouring macroblocks, blocks, and partitions

Subclause 6.4.10.1 specifies the derivation process for neighbouring macroblocks.

Subclause 6.4.10.2 specifies the derivation process for neighbouring 8x8 luma blocks.

Subclause 6.4.10.3 specifies the derivation process for neighbouring 8x8 chroma blocks for ChromaArrayType equal to 3.

Subclause 6.4.10.4 specifies the derivation process for neighbouring 4x4 luma blocks.

Subclause 6.4.10.5 specifies the derivation process for neighbouring 4x4 chroma blocks.

Subclause 6.4.10.6 specifies the derivation process for neighbouring 4x4 chroma blocks for ChromaArrayType equal to 3.

Subclause 6.4.10.7 specifies the derivation process for neighbouring partitions.

Table 6-2 specifies the values for the difference of luma location ( xD, yD ) for the input and the replacement for N in mbAddrN, mbPartIdxN, subMbPartIdxN, luma8x8BlkIdxN, cb8x8BlkIdxN, cr8x8BlkIdxN, luma4x4BlkIdxN, cb4x4BlkIdxN, cr4x4BlkIdxN, and chroma4x4BlkIdxN for the output. These input and output assignments are used in subclauses 6.4.10.1 to 6.4.10.7. The variable predPartWidth is specified when Table 6-2 is referred to.

**Table 6-2 – Specification of input and output assignments for subclauses 6.4.10.1 to 6.4.10.7**

| N | xD | yD |
|---|---|---|
| A | -1 | 0 |
| B | 0 | -1 |
| C | predPartWidth | -1 |
| D | -1 | -1 |

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Figure 6-14 illustrates the relative location of the neighbouring macroblocks, blocks, or partitions A, B, C, and D to the current macroblock, partition, or block, when the current macroblock, partition, or block is in frame coding mode.

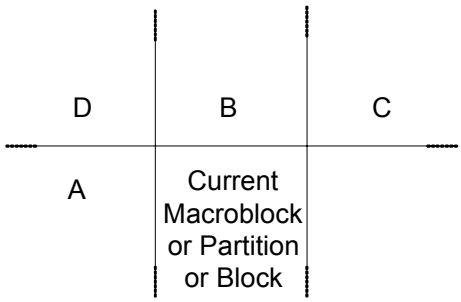


**Figure 6-14 – Determination of the neighbouring macroblock, blocks, and partitions (informative)**

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#### 6.4.10.1 Derivation process for neighbouring macroblocks

Outputs of this process are

– mbAddrA: the address of the macroblock to the left of the current macroblock and its availability status and

– mbAddrB: the address of the macroblock above the current macroblock and its availability status.

mbAddrN (with N being A or B) is derived as follows.

– The difference of luma location ( xD, yD ) is set according to Table 6-2.

– The derivation process for neighbouring locations as specified in subclause 6.4.11 is invoked for luma locations with ( xN, yN ) equal to ( xD, yD ), and the output is assigned to mbAddrN.

#### 6.4.10.2 Derivation process for neighbouring 8x8 luma block

Input to this process is an 8x8 luma block index luma8x8BlkIdx.

The luma8x8BlkIdx specifies the 8x8 luma blocks of a macroblock in a raster scan.

Outputs of this process are

– mbAddrA: either equal to CurrMbAddr or the address of the macroblock to the left of the current macroblock and its availability status,

– luma8x8BlkIdxA: the index of the 8x8 luma block to the left of the 8x8 block with index luma8x8BlkIdx and its availability status,

– mbAddrB: either equal to CurrMbAddr or the address of the macroblock above the current macroblock and its availability status,

– luma8x8BlkIdxB: the index of the 8x8 luma block above the 8x8 block with index luma8x8BlkIdx and its availability status.

mbAddrN and luma8x8BlkIdxN (with N being A or B) are derived as follows.

– The difference of luma location ( xD, yD ) is set according to Table 6-2.

– The luma location ( xN, yN ) is specified by

$$xN = ( luma8x8BlkIdx \% 2 ) * 8 + xD \quad (6\text{-}21)$$

$$yN = ( luma8x8BlkIdx / 2 ) * 8 + yD \quad (6\text{-}22)$$

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– The derivation process for neighbouring locations as specified in subclause 6.4.11 is invoked for luma locations with ( xN, yN ) as the input and the output is assigned to mbAddrN and ( xW, yW ).
– The variable luma8x8BlkIdxN is derived as follows.
  – If mbAddrN is not available, luma8x8BlkIdxN is marked as not available.
  – Otherwise (mbAddrN is available), the 8x8 luma block in the macroblock mbAddrN covering the luma location ( xW, yW ) is assigned to luma8x8BlkIdxN.

#### 6.4.10.3 Derivation process for neighbouring 8x8 chroma blocks for ChromaArrayType equal to 3

This process is only invoked when ChromaArrayType is equal to 3.

The derivation process for neighbouring 8x8 chroma block is identical to the derivation process for neighbouring 8x8 luma block as specified in subclause 6.4.10.2 when substituting the term “luma” with the term “Cb” or the term “Cr”, and substituting the term “luma8x8BlkIdx” with the term “cb8x8BlkIdx” or the term “cr8x8BlkIdx” in all places in subclause 6.4.10.2.

#### 6.4.10.4 Derivation process for neighbouring 4x4 luma blocks

Input to this process is a 4x4 luma block index luma4x4BlkIdx.

Outputs of this process are
– mbAddrA: either equal to CurrMbAddr or the address of the macroblock to the left of the current macroblock and its availability status,
– luma4x4BlkIdxA: the index of the 4x4 luma block to the left of the 4x4 block with index luma4x4BlkIdx and its availability status,
– mbAddrB: either equal to CurrMbAddr or the address of the macroblock above the current macroblock and its availability status,
– luma4x4BlkIdxB: the index of the 4x4 luma block above the 4x4 block with index luma4x4BlkIdx and its availability status.

mbAddrN and luma4x4BlkIdxN (with N being A or B) are derived as follows.
– The difference of luma location ( xD, yD ) is set according to Table 6-2.
– The inverse 4x4 luma block scanning process as specified in subclause 6.4.3 is invoked with luma4x4BlkIdx as the input and ( x, y ) as the output.
– The luma location ( xN, yN ) is specified by

$$xN = x + xD \tag{6-23}$$

$$yN = y + yD \tag{6-24}$$

– The derivation process for neighbouring locations as specified in subclause 6.4.11 is invoked for luma locations with ( xN, yN ) as the input and the output is assigned to mbAddrN and ( xW, yW ).
– The variable luma4x4BlkIdxN is derived as follows.
  – If mbAddrN is not available, luma4x4BlkIdxN is marked as not available.
  – Otherwise (mbAddrN is available), the 4x4 luma block in the macroblock mbAddrN covering the luma location ( xW, yW ) is assigned to luma4x4BlkIdxN.

#### 6.4.10.5 Derivation process for neighbouring 4x4 chroma blocks

Input to this process is a 4x4 chroma block index chroma4x4BlkIdx.

Outputs of this process are
– mbAddrA (either equal to CurrMbAddr or the address of the macroblock to the left of the current macroblock) and its availability status,

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– chroma4x4BlkIdxA (the index of the 4x4 chroma block to the left of the 4x4 chroma block with index chroma4x4BlkIdx) and its availability status,
– mbAddrB (either equal to CurrMbAddr or the address of the macroblock above the current macroblock) and its availability status,
– chroma4x4BlkIdxB (the index of the 4x4 chroma block above the 4x4 chroma block with index chroma4x4BlkIdx) and its availability status.

mbAddrN and chroma4x4BlkIdxN (with N being A or B) are derived as follows.

– The difference of chroma location ( xD, yD ) is set according to Table 6-2.
– The position ( x, y ) of the upper-left sample of the 4x4 chroma block with index chroma4x4BlkIdx is derived by

$$x = \text{InverseRasterScan}( \text{chroma4x4BlkIdx}, 4, 4, 8, 0 ) \quad (6\text{-}25)$$

$$y = \text{InverseRasterScan}( \text{chroma4x4BlkIdx}, 4, 4, 8, 1 ) \quad (6\text{-}26)$$

– The chroma location ( xN, yN ) is specified by

$$xN = x + xD \quad (6\text{-}27)$$

$$yN = y + yD \quad (6\text{-}28)$$

– The derivation process for neighbouring locations as specified in subclause 6.4.11 is invoked for chroma locations with ( xN, yN ) as the input and the output is assigned to mbAddrN and ( xW, yW ).
– The variable chroma4x4BlkIdxN is derived as follows.
  – If mbAddrN is not available, chroma4x4BlkIdxN is marked as not available.
  – Otherwise (mbAddrN is available), the 4x4 chroma block in the macroblock mbAddrN covering the chroma location ( xW, yW ) is assigned to chroma4x4BlkIdxN.

#### 6.4.10.6 Derivation process for neighbouring 4x4 chroma blocks for ChromaArrayType equal to 3

This process is only invoked when ChromaArrayType is equal to 3.

The derivation process for neighbouring 4x4 chroma block in 4:4:4 chroma format is identical to the derivation process for neighbouring 4x4 luma block as specified in subclause 6.4.10.4 when substituting the term “luma” with the term “Cb” or the term “Cr”, and substituting the term “luma4x4BlkIdx” with the term “cb4x4BlkIdx” or the term “cr4x4BlkIdx” in all places in subclause 6.4.10.4.

#### 6.4.10.7 Derivation process for neighbouring partitions

Inputs to this process are

– a macroblock partition index mbPartIdx
– a current sub-macroblock type currSubMbType
– a sub-macroblock partition index subMbPartIdx

Outputs of this process are

– mbAddrA\mbPartIdxA\subMbPartIdxA: specifying the macroblock or sub-macroblock partition to the left of the current macroblock and its availability status, or the sub-macroblock partition CurrMbAddr\mbPartIdx\subMbPartIdx and its availability status,

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– mbAddrB\mbPartIdxB\subMbPartIdxB: specifying the macroblock or sub-macroblock partition above the current macroblock and its availability status, or the sub-macroblock partition CurrMbAddr\mbPartIdx\subMbPartIdx and its availability status,

– mbAddrC\mbPartIdxC\subMbPartIdxC: specifying the macroblock or sub-macroblock partition to the right-above of the current macroblock and its availability status, or the sub-macroblock partition CurrMbAddr\mbPartIdx\subMbPartIdx and its availability status,

– mbAddrD\mbPartIdxD\subMbPartIdxD: specifying the macroblock or sub-macroblock partition to the left-above of the current macroblock and its availability status, or the sub-macroblock partition CurrMbAddr\mbPartIdx\subMbPartIdx and its availability status.

mbAddrN, mbPartIdxN, and subMbPartIdxN (with N being A, B, C, or D) are derived as follows.

– The inverse macroblock partition scanning process as described in subclause 6.4.2.1 is invoked with mbPartIdx as the input and ( x, y ) as the output.

– The location of the upper-left luma sample inside a macroblock partition ( xS, yS ) is derived as follows.

  — If mb_type is equal to P_8x8, P_8x8ref0 or B_8x8, the inverse sub-macroblock partition scanning process as described in subclause 6.4.2.2 is invoked with subMbPartIdx as the input and ( xS, yS ) as the output.

  — Otherwise, ( xS, yS ) are set to ( 0, 0 ).

– The variable predPartWidth in Table 6-2 is specified as follows.

  – If mb_type is equal to P_Skip, B_Skip, or B_Direct_16x16, predPartWidth = 16.

  – Otherwise, if mb_type is equal to B_8x8, the following applies.

    – If currSubMbType is equal to B_Direct_8x8, predPartWidth = 16.

      NOTE 1 – When currSubMbType is equal to B_Direct_8x8 and direct_spatial_mv_pred_flag is equal to 1, the predicted motion vector is the predicted motion vector for the complete macroblock.

    – Otherwise, predPartWidth = SubMbPartWidth( sub_mb_type[ mbPartIdx ] ).

  – Otherwise, if mb_type is equal to P_8x8 or P_8x8ref0, predPartWidth = SubMbPartWidth( sub_mb_type[ mbPartIdx ] ).

  – Otherwise, predPartWidth = MbPartWidth( mb_type ).

– The difference of luma location ( xD, yD ) is set according to Table 6-2.

– The neighbouring luma location ( xN, yN ) is specified by

$$xN = x + xS + xD \tag{6-29}$$

$$yN = y + yS + yD \tag{6-30}$$

– The derivation process for neighbouring locations as specified in subclause 6.4.11 is invoked for luma locations with ( xN, yN ) as the input and the output is assigned to mbAddrN and ( xW, yW ).

– Depending on mbAddrN, the following applies.

  – If mbAddrN is not available, the macroblock or sub-macroblock partition – mbAddrN\mbPartIdxN\subMbPartIdxN is marked as not available.

  – Otherwise (mbAddrN is available), the following applies.

    – The macroblock partition in the macroblock mbAddrN covering the luma location ( xW, yW ) is assigned to mbPartIdxN and the sub-macroblock partition inside the macroblock partition mbPartIdxN covering the sample ( xW, yW ) in the macroblock mbAddrN is assigned to subMbPartIdxN.

    – When the partition given by mbPartIdxN and subMbPartIdxN is not yet decoded, the macroblock partition mbPartIdxN and the sub-macroblock partition subMbPartIdxN are marked as not available.

  NOTE 2 – The latter condition is, for example, the case when mbPartIdx = 2, subMbPartIdx = 3, xD = 4, yD = -1, i.e., when neighbour C of the last 4x4 luma block of the third sub-macroblock is requested.

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### 6.4.11 Derivation process for neighbouring locations

Input to this process is a luma or chroma location ( xN, yN ) expressed relative to the upper left corner of the current macroblock.

Outputs of this process are

– mbAddrN: either equal to CurrMbAddr or to the address of neighbouring macroblock that contains (xN, yN) and its availability status,

– ( xW, yW ): the location (xN, yN) expressed relative to the upper-left corner of the macroblock mbAddrN (rather than relative to the upper-left corner of the current macroblock).

Let maxW and maxH be variables specifying maximum values of the location components xN, xW, and yN, yW, respectively. maxW and maxH are derived as follows.

– If this process is invoked for neighbouring luma locations,

$$maxW = maxH = 16 \tag{6-31}$$

– Otherwise (this process is invoked for neighbouring chroma locations),

$$maxW = MbWidthC \tag{6-32}$$

$$maxH = MbHeightC \tag{6-33}$$

Depending on the variable MbaffFrameFlag, the neighbouring locations are derived as follows.

– If MbaffFrameFlag is equal to 0, the specification for neighbouring locations in fields and non-MBAFF frames as described in subclause 6.4.11.1 is applied.

– Otherwise (MbaffFrameFlag is equal to 1), the specification for neighbouring locations in MBAFF frames as described in subclause 6.4.11.2 is applied.

#### 6.4.11.1 Specification for neighbouring locations in fields and non-MBAFF frames

The specifications in this subclause are applied when MbaffFrameFlag is equal to 0.

The derivation process for neighbouring macroblock addresses and their availability in subclause 6.4.8 is invoked with mbAddrA, mbAddrB, mbAddrC, and mbAddrD as well as their availability status as the output.

Table 6-3 specifies mbAddrN depending on ( xN, yN ).

**Table 6-3 – Specification of mbAddrN**

| xN | yN | mbAddrN |
|---|---|---|
| < 0 | < 0 | mbAddrD |
| < 0 | 0 .. maxH - 1 | mbAddrA |
| 0 .. maxW - 1 | < 0 | mbAddrB |
| 0 .. maxW - 1 | 0 .. maxH - 1 | CurrMbAddr |
| > maxW - 1 | < 0 | mbAddrC |
| > maxW - 1 | 0 .. maxH - 1 | not available |
| | > maxH - 1 | not available |

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The neighbouring location ( xW, yW ) relative to the upper-left corner of the macroblock mbAddrN is derived as

$$xW = ( xN + maxW ) \% maxW \quad (6\text{-}34)$$

$$yW = ( yN + maxH ) \% maxH \quad (6\text{-}35)$$

#### 6.4.11.2 Specification for neighbouring locations in MBAFF frames

The specifications in this subclause are applied when MbaffFrameFlag is equal to 1.

The derivation process for neighbouring macroblock addresses and their availability in subclause 6.4.9 is invoked with mbAddrA, mbAddrB, mbAddrC, and mbAddrD as well as their availability status as the output.

Table 6-4 specifies the macroblock addresses mbAddrN and yM in two ordered steps:

1. Specification of a macroblock address mbAddrX depending on ( xN, yN ) and the following variables.
   - The variable currMbFrameFlag is derived as follows.
     - If the macroblock with address CurrMbAddr is a frame macroblock, currMbFrameFlag is set equal to 1,
     - Otherwise (the macroblock with address CurrMbAddr is a field macroblock), currMbFrameFlag is set equal to 0.
   - The variable mbIsTopMbFlag is derived as follows.
     - If the macroblock with address CurrMbAddr is a top macroblock (CurrMbAddr % 2 is equal to 0), mbIsTopMbFlag is set equal to 1;
     - Otherwise (the macroblock with address CurrMbAddr is a bottom macroblock, CurrMbAddr % 2 is equal to 1), mbIsTopMbFlag is set equal to 0.
2. Depending on the availability of mbAddrX, the following applies.
   - If mbAddrX is not available, mbAddrN is marked as not available.
   - Otherwise (mbAddrX is available), mbAddrN is marked as available and Table 6-4 specifies mbAddrN and yM depending on ( xN, yN ), currMbFrameFlag, mbIsTopMbFlag, and the variable mbAddrXFrameFlag, which is derived as follows.
     - If the macroblock mbAddrX is a frame macroblock, mbAddrXFrameFlag is set equal to 1,
     - Otherwise (the macroblock mbAddrX is a field macroblock), mbAddrXFrameFlag is set equal to 0.

Unspecified values (na) of the above flags in Table 6-4 indicate that the value of the corresponding flag is not relevant for the current table rows.

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**Table 6-4 – Specification of mbAddrN and yM**

| xN | yN | currMbFrameFlag | mbIsTopMbFlag | mbAddrX | mbAddrXFrameFlag | additional condition | mbAddrN | yM |
|---|---|---|---|---|---|---|---|---|
| < 0 | < 0 | 1 | 1 | mbAddrD | | | mbAddrD + 1 | yN |
| | | | 0 | mbAddrA | 1 | | mbAddrA | yN |
| | | | | | 0 | | mbAddrA + 1 | ( yN + maxH ) >> 1 |
| | | 0 | 1 | mbAddrD | 1 | | mbAddrD + 1 | 2*yN |
| | | | | | 0 | | mbAddrD | yN |
| | | | 0 | mbAddrD | | | mbAddrD + 1 | yN |
| < 0 | 0 .. maxH - 1 | 1 | 1 | mbAddrA | 1 | | mbAddrA | yN |
| | | | | | 0 | yN % 2 = = 0 | mbAddrA | yN >> 1 |
| | | | | | | yN % 2 != 0 | mbAddrA + 1 | yN >> 1 |
| | | | 0 | mbAddrA | 1 | | mbAddrA + 1 | yN |
| | | | | | 0 | yN % 2 = = 0 | mbAddrA | ( yN + maxH ) >> 1 |
| | | | | | | yN % 2 != 0 | mbAddrA + 1 | ( yN + maxH ) >> 1 |
| | | 0 | 1 | mbAddrA | 1 | yN < ( maxH / 2 ) | mbAddrA | yN <<1 |
| | | | | | | yN >= ( maxH / 2 ) | mbAddrA + 1 | ( yN <<1 ) - maxH |
| | | | | | 0 | | mbAddrA | yN |
| | | | 0 | mbAddrA | 1 | yN < ( maxH / 2 ) | mbAddrA | ( yN <<1 ) + 1 |
| | | | | | | yN >= ( maxH / 2 ) | mbAddrA + 1 | ( yN <<1 ) + 1 – maxH |
| | | | | | 0 | | mbAddrA + 1 | yN |
| 0 .. maxW – 1 | < 0 | 1 | 1 | mbAddrB | | | mbAddrB + 1 | yN |
| | | | 0 | CurrMbAddr | | | CurrMbAddr - 1 | yN |
| | | 0 | 1 | mbAddrB | 1 | | mbAddrB + 1 | 2 * yN |
| | | | | | 0 | | mbAddrB | yN |
| | | | 0 | mbAddrB | | | mbAddrB + 1 | yN |
| 0 .. maxW – 1 | 0 .. maxH - 1 | | | CurrMbAddr | | | CurrMbAddr | yN |
| > maxW – 1 | < 0 | 1 | 1 | mbAddrC | | | mbAddrC + 1 | yN |
| | | | 0 | not available | | | not available | na |
| | | 0 | 1 | mbAddrC | 1 | | mbAddrC + 1 | 2 * yN |
| | | | | | 0 | | mbAddrC | yN |
| | | | 0 | mbAddrC | | | mbAddrC + 1 | yN |
| > maxW – 1 | 0 .. maxH - 1 | | | not available | | | not available | na |
| | > maxH - 1 | | | not available | | | not available | na |

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The neighbouring luma location ( xW, yW ) relative to the upper-left corner of the macroblock mbAddrN is derived as

$$xW = ( xN + maxW ) \% maxW \quad (6\text{-}36)$$

$$yW = ( yM + maxH ) \% maxH \quad (6\text{-}37)$$

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# 7 Syntax and semantics

## 7.1 Method of specifying syntax in tabular form

The syntax tables specify a superset of the syntax of all allowed bitstreams. Additional constraints on the syntax may be specified, either directly or indirectly, in other clauses.

NOTE – An actual decoder should implement means for identifying entry points into the bitstream and means to identify and handle non-conforming bitstreams. The methods for identifying and handling errors and other such situations are not specified here.

The following table lists examples of pseudo code used to describe the syntax. When **syntax_element** appears, it specifies that a syntax element is parsed from the bitstream and the bitstream pointer is advanced to the next position beyond the syntax element in the bitstream parsing process.

| | C | Descriptor |
|---|---|---|
| /* A statement can be a syntax element with an associated syntax category and descriptor or can be an expression used to specify conditions for the existence, type, and quantity of syntax elements, as in the following two examples */ | | |
| **syntax_element** | 3 | ue(v) |
| conditioning statement | | |
| | | |
| /* A group of statements enclosed in curly brackets is a compound statement and is treated functionally as a single statement. */ | | |
| { | | |
| statement | | |
| statement | | |
| … | | |
| } | | |
| | | |
| /* A "while" structure specifies a test of whether a condition is true, and if true, specifies evaluation of a statement (or compound statement) repeatedly until the condition is no longer true */ | | |
| while( condition ) | | |
| statement | | |
| | | |
| /* A "do … while" structure specifies evaluation of a statement once, followed by a test of whether a condition is true, and if true, specifies repeated evaluation of the statement until the condition is no longer true */ | | |
| do | | |
| statement | | |
| while( condition ) | | |
| | | |
| /* An "if … else" structure specifies a test of whether a condition is true, and if the condition is true, specifies evaluation of a primary statement, otherwise, specifies evaluation of an alternative statement. The "else" part of the structure and the associated alternative statement is omitted if no alternative statement evaluation is needed */ | | |
| if( condition ) | | |
| primary statement | | |
| else | | |
| alternative statement | | |
| | | |

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| | | |
|---|---|---|
| /* A “for” structure specifies evaluation of an initial statement, followed by a test of a condition, and if the condition is true, specifies repeated evaluation of a primary statement followed by a subsequent statement until the condition is no longer true. */ | | |
| for( initial statement; condition; subsequent statement ) | | |
| primary statement | | |

## 7.2 Specification of syntax functions, categories, and descriptors

The functions presented here are used in the syntactical description. These functions assume the existence of a bitstream pointer with an indication of the position of the next bit to be read by the decoding process from the bitstream.

byte_aligned( ) is specified as follows.

- If the current position in the bitstream is on a byte boundary, i.e., the next bit in the bitstream is the first bit in a byte, the return value of byte_aligned( ) is equal to TRUE.
- Otherwise, the return value of byte_aligned( ) is equal to FALSE.

more_data_in_byte_stream( ), which is used only in the byte stream NAL unit syntax structure specified in Annex B, is specified as follows.

- If more data follow in the byte stream, the return value of more_data_in_byte_stream( ) is equal to TRUE.
- Otherwise, the return value of more_data_in_byte_stream( ) is equal to FALSE.

more_rbsp_data( ) is specified as follows.

- If there is more data in an RBSP before rbsp_trailing_bits( ), the return value of more_rbsp_data( ) is equal to TRUE.
- Otherwise, the return value of more_rbsp_data( ) is equal to FALSE.

The method for enabling determination of whether there is more data in the RBSP is specified by the application (or in Annex B for applications that use the byte stream format).

more_rbsp_trailing_data( ) is specified as follows.

- If there is more data in an RBSP, the return value of more_rbsp_trailing_data( ) is equal to TRUE.
- Otherwise, the return value of more_rbsp_trailing_data( ) is equal to FALSE.

next_bits( n ) provides the next bits in the bitstream for comparison purposes, without advancing the bitstream pointer. Provides a look at the next n bits in the bitstream with n being its argument. When used within the byte stream as specified in Annex B, next_bits( n ) returns a value of 0 if fewer than n bits remain within the byte stream.

read_bits( n ) reads the next n bits from the bitstream and advances the bitstream pointer by n bit positions. When n is equal to 0, read_bits( n ) is specified to return a value equal to 0 and to not advance the bitstream pointer.

Categories (labelled in the table as **C**) specify the partitioning of slice data into at most three slice data partitions. Slice data partition A contains all syntax elements of category 2. Slice data partition B contains all syntax elements of category 3. Slice data partition C contains all syntax elements of category 4. The meaning of other category values is not specified. For some syntax elements, two category values, separated by a vertical bar, are used. In these cases, the category value to be applied is further specified in the text. For syntax structures used within other syntax structures, the categories of all syntax elements found within the included syntax structure are listed, separated by a vertical bar. A syntax element or syntax structure with category marked as "All" is present within all syntax structures that include that syntax element or syntax structure. For syntax structures used within other syntax structures, a numeric category value provided in a syntax table at the location of the inclusion of a syntax structure containing a syntax element with category marked as "All" is considered to apply to the syntax elements with category "All".

The following descriptors specify the parsing process of each syntax element. For some syntax elements, two descriptors, separated by a vertical bar, are used. In these cases, the left descriptors apply when entropy_coding_mode_flag is equal to 0 and the right descriptor applies when entropy_coding_mode_flag is equal to 1.

- ae(v): context-adaptive arithmetic entropy-coded syntax element. The parsing process for this descriptor is specified in subclause 9.3.

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– b(8): byte having any pattern of bit string (8 bits). The parsing process for this descriptor is specified by the return value of the function read_bits( 8 ).

– ce(v): context-adaptive variable-length entropy-coded syntax element with the left bit first. The parsing process for this descriptor is specified in subclause 9.2.

– f(n): fixed-pattern bit string using n bits written (from left to right) with the left bit first. The parsing process for this descriptor is specified by the return value of the function read_bits( n ).

– i(n): signed integer using n bits. When n is "v" in the syntax table, the number of bits varies in a manner dependent on the value of other syntax elements. The parsing process for this descriptor is specified by the return value of the function read_bits( n ) interpreted as a two's complement integer representation with most significant bit written first.

– me(v): mapped Exp-Golomb-coded syntax element with the left bit first. The parsing process for this descriptor is specified in subclause 9.1.

– se(v): signed integer Exp-Golomb-coded syntax element with the left bit first. The parsing process for this descriptor is specified in subclause 9.1.

– te(v): truncated Exp-Golomb-coded syntax element with left bit first. The parsing process for this descriptor is specified in subclause 9.1.

– u(n): unsigned integer using n bits. When n is "v" in the syntax table, the number of bits varies in a manner dependent on the value of other syntax elements. The parsing process for this descriptor is specified by the return value of the function read_bits( n ) interpreted as a binary representation of an unsigned integer with most significant bit written first.

– ue(v): unsigned integer Exp-Golomb-coded syntax element with the left bit first. The parsing process for this descriptor is specified in subclause 9.1.

## 7.3 Syntax in tabular form

### 7.3.1 NAL unit syntax

| nal_unit( NumBytesInNALunit ) { | C | Descriptor |
|---|---|---|
| **forbidden_zero_bit** | All | f(1) |
| **nal_ref_idc** | All | u(2) |
| **nal_unit_type** | All | u(5) |
| NumBytesInRBSP = 0 | | |
| nalUnitHeaderBytes = 1 | | |
| if( nal_unit_type == 14 \|\| nal_unit_type == 20 ) { | | |
| nal_unit_header_svc_extension( ) /* specified in Annex G */ | | |
| nalUnitHeaderBytes += 3 | | |
| } | | |
| for( i = nalUnitHeaderBytes; i < NumBytesInNALunit; i++ ) { | | |
| if( i + 2 < NumBytesInNALunit && next_bits( 24 ) == 0x000003 ) { | | |
| **rbsp_byte[** NumBytesInRBSP++ **]** | All | b(8) |
| **rbsp_byte[** NumBytesInRBSP++ **]** | All | b(8) |
| i += 2 | | |
| **emulation_prevention_three_byte** /* equal to 0x03 */ | All | f(8) |
| } else | | |
| **rbsp_byte[** NumBytesInRBSP++ **]** | All | b(8) |
| } | | |
| } | | |

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### 7.3.2 Raw byte sequence payloads and RBSP trailing bits syntax

#### 7.3.2.1 Sequence parameter set RBSP syntax

| seq_parameter_set_rbsp( ) { | C | Descriptor |
|---|---|---|
| seq_parameter_set_data( ) | 0 | |
| rbsp_trailing_bits( ) | 0 | |
| } | | |

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#### 7.3.2.1.1 Sequence parameter set data syntax

| seq_parameter_set_data( ) { | C | Descriptor |
|---|---|---|
| **profile_idc** | 0 | u(8) |
| **constraint_set0_flag** | 0 | u(1) |
| **constraint_set1_flag** | 0 | u(1) |
| **constraint_set2_flag** | 0 | u(1) |
| **constraint_set3_flag** | 0 | u(1) |
| **reserved_zero_4bits** /* equal to 0 */ | 0 | u(4) |
| **level_idc** | 0 | u(8) |
| **seq_parameter_set_id** | 0 | ue(v) |
| if( profile_idc == 100 \|\| profile_idc == 110 \|\| profile_idc == 122 \|\| profile_idc == 244 \|\| profile_idc == 44 \|\| profile_idc == 83 \|\| profile_idc == 86 ) { | | |
| **chroma_format_idc** | 0 | ue(v) |
| if( chroma_format_idc == 3 ) | | |
| **separate_colour_plane_flag** | 0 | u(1) |
| **bit_depth_luma_minus8** | 0 | ue(v) |
| **bit_depth_chroma_minus8** | 0 | ue(v) |
| **qpprime_y_zero_transform_bypass_flag** | 0 | u(1) |
| **seq_scaling_matrix_present_flag** | 0 | u(1) |
| if( seq_scaling_matrix_present_flag ) | | |
| for( i = 0; i < ( ( chroma_format_idc != 3 ) ? 8 : 12 ); i++ ) { | | |
| **seq_scaling_list_present_flag[** i **]** | 0 | u(1) |
| if( seq_scaling_list_present_flag[ i ] ) | | |
| if( i < 6 ) | | |
| scaling_list( ScalingList4x4[ i ], 16, UseDefaultScalingMatrix4x4Flag[ i ]) | 0 | |
| else | | |
| scaling_list( ScalingList8x8[ i – 6 ], 64, UseDefaultScalingMatrix8x8Flag[ i – 6 ] ) | 0 | |
| } | | |
| } | | |
| **log2_max_frame_num_minus4** | 0 | ue(v) |
| **pic_order_cnt_type** | 0 | ue(v) |
| if( pic_order_cnt_type == 0 ) | | |
| **log2_max_pic_order_cnt_lsb_minus4** | 0 | ue(v) |
| else if( pic_order_cnt_type == 1 ) { | | |
| **delta_pic_order_always_zero_flag** | 0 | u(1) |
| **offset_for_non_ref_pic** | 0 | se(v) |
| **offset_for_top_to_bottom_field** | 0 | se(v) |
| **num_ref_frames_in_pic_order_cnt_cycle** | 0 | ue(v) |
| for( i = 0; i < num_ref_frames_in_pic_order_cnt_cycle; i++ ) | | |
| **offset_for_ref_frame[** i **]** | 0 | se(v) |
| } | | |
| **num_ref_frames** | 0 | ue(v) |
| **gaps_in_frame_num_value_allowed_flag** | 0 | u(1) |

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| | | |
|---|---|---|
| **pic_width_in_mbs_minus1** | 0 | ue(v) |
| **pic_height_in_map_units_minus1** | 0 | ue(v) |
| **frame_mbs_only_flag** | 0 | u(1) |
| if( !frame_mbs_only_flag ) | | |
| **mb_adaptive_frame_field_flag** | 0 | u(1) |
| **direct_8x8_inference_flag** | 0 | u(1) |
| **frame_cropping_flag** | 0 | u(1) |
| if( frame_cropping_flag ) { | | |
| **frame_crop_left_offset** | 0 | ue(v) |
| **frame_crop_right_offset** | 0 | ue(v) |
| **frame_crop_top_offset** | 0 | ue(v) |
| **frame_crop_bottom_offset** | 0 | ue(v) |
| } | | |
| **vui_parameters_present_flag** | 0 | u(1) |
| if( vui_parameters_present_flag ) | | |
| vui_parameters( ) | 0 | |
| } | | |

#### 7.3.2.1.1.1 Scaling list syntax

| scaling_list( scalingList, sizeOfScalingList, useDefaultScalingMatrixFlag ) { | C | Descriptor |
|---|---|---|
| lastScale = 8 | | |
| nextScale = 8 | | |
| for( j = 0; j < sizeOfScalingList; j++ ) { | | |
| if( nextScale != 0 ) { | | |
| **delta_scale** | 0 \| 1 | se(v) |
| nextScale = ( lastScale + delta_scale + 256 ) % 256 | | |
| useDefaultScalingMatrixFlag = ( j == 0 && nextScale == 0 ) | | |
| } | | |
| scalingList[ j ] = ( nextScale == 0 ) ? lastScale : nextScale | | |
| lastScale = scalingList[ j ] | | |
| } | | |
| } | | |

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#### 7.3.2.1.2 Sequence parameter set extension RBSP syntax

| seq_parameter_set_extension_rbsp( ) { | C | Descriptor |
|---|---|---|
| **seq_parameter_set_id** | 10 | ue(v) |
| **aux_format_idc** | 10 | ue(v) |
| if( aux_format_idc != 0 ) { | | |
| **bit_depth_aux_minus8** | 10 | ue(v) |
| **alpha_incr_flag** | 10 | u(1) |
| **alpha_opaque_value** | 10 | u(v) |
| **alpha_transparent_value** | 10 | u(v) |
| } | | |
| **additional_extension_flag** | 10 | u(1) |
| rbsp_trailing_bits() | 10 | |
| } | | |

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#### 7.3.2.2 Picture parameter set RBSP syntax

| pic_parameter_set_rbsp( ) { | C | Descriptor |
|---|---|---|
| **pic_parameter_set_id** | 1 | ue(v) |
| **seq_parameter_set_id** | 1 | ue(v) |
| **entropy_coding_mode_flag** | 1 | u(1) |
| **pic_order_present_flag** | 1 | u(1) |
| **num_slice_groups_minus1** | 1 | ue(v) |
| if( num_slice_groups_minus1 > 0 ) { | | |
| **slice_group_map_type** | 1 | ue(v) |
| if( slice_group_map_type == 0 ) | | |
| for( iGroup = 0; iGroup <= num_slice_groups_minus1; iGroup++ ) | | |
| **run_length_minus1[** iGroup **]** | 1 | ue(v) |
| else if( slice_group_map_type == 2 ) | | |
| for( iGroup = 0; iGroup < num_slice_groups_minus1; iGroup++ ) { | | |
| **top_left[** iGroup **]** | 1 | ue(v) |
| **bottom_right[** iGroup **]** | 1 | ue(v) |
| } | | |
| else if( slice_group_map_type == 3 \|\| slice_group_map_type == 4 \|\| slice_group_map_type == 5 ) { | | |
| **slice_group_change_direction_flag** | 1 | u(1) |
| **slice_group_change_rate_minus1** | 1 | ue(v) |
| } else if( slice_group_map_type == 6 ) { | | |
| **pic_size_in_map_units_minus1** | 1 | ue(v) |
| for( i = 0; i <= pic_size_in_map_units_minus1; i++ ) | | |
| **slice_group_id[** i **]** | 1 | u(v) |
| } | | |
| } | | |
| **num_ref_idx_l0_active_minus1** | 1 | ue(v) |
| **num_ref_idx_l1_active_minus1** | 1 | ue(v) |
| **weighted_pred_flag** | 1 | u(1) |
| **weighted_bipred_idc** | 1 | u(2) |
| **pic_init_qp_minus26** /* relative to 26 */ | 1 | se(v) |
| **pic_init_qs_minus26** /* relative to 26 */ | 1 | se(v) |
| **chroma_qp_index_offset** | 1 | se(v) |
| **deblocking_filter_control_present_flag** | 1 | u(1) |
| **constrained_intra_pred_flag** | 1 | u(1) |
| **redundant_pic_cnt_present_flag** | 1 | u(1) |
| if( more_rbsp_data( ) ) { | | |
| **transform_8x8_mode_flag** | 1 | u(1) |
| **pic_scaling_matrix_present_flag** | 1 | u(1) |
| if( pic_scaling_matrix_present_flag ) | | |
| for( i = 0; i < 6 + ( (chroma_format_idc != 3 ) ? 2 : 6 ) * transform_8x8_mode_flag; i++ ) { | | |
| **pic_scaling_list_present_flag[** i **]** | 1 | u(1) |

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| | | |
|---|---|---|
| if( pic_scaling_list_present_flag[ i ] ) | | |
| if( i < 6 ) | | |
| scaling_list( ScalingList4x4[ i ], 16, UseDefaultScalingMatrix4x4Flag[ i ] ) | 1 | |
| else | | |
| scaling_list( ScalingList8x8[ i – 6 ], 64, UseDefaultScalingMatrix8x8Flag[ i – 6 ] ) | 1 | |
| } | | |
| **second_chroma_qp_index_offset** | 1 | se(v) |
| } | | |
| rbsp_trailing_bits( ) | 1 | |
| } | | |

#### 7.3.2.3 Supplemental enhancement information RBSP syntax

| sei_rbsp( ) { | C | Descriptor |
|---|---|---|
| do | | |
| sei_message( ) | 5 | |
| while( more_rbsp_data( ) ) | | |
| rbsp_trailing_bits( ) | 5 | |
| } | | |

##### 7.3.2.3.1 Supplemental enhancement information message syntax

| sei_message( ) { | C | Descriptor |
|---|---|---|
| payloadType = 0 | | |
| while( next_bits( 8 ) == 0xFF ) { | | |
| **ff_byte** /* equal to 0xFF */ | 5 | f(8) |
| payloadType += 255 | | |
| } | | |
| **last_payload_type_byte** | 5 | u(8) |
| payloadType += last_payload_type_byte | | |
| payloadSize = 0 | | |
| while( next_bits( 8 ) == 0xFF ) { | | |
| **ff_byte** /* equal to 0xFF */ | 5 | f(8) |
| payloadSize += 255 | | |
| } | | |
| **last_payload_size_byte** | 5 | u(8) |
| payloadSize += last_payload_size_byte | | |
| sei_payload( payloadType, payloadSize ) | 5 | |
| } | | |

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#### 7.3.2.4 Access unit delimiter RBSP syntax

| access_unit_delimiter_rbsp( ) { | C | Descriptor |
|---|---|---|
| **primary_pic_type** | 6 | u(3) |
| rbsp_trailing_bits( ) | 6 | |
| } | | |

#### 7.3.2.5 End of sequence RBSP syntax

| end_of_seq_rbsp( ) { | C | Descriptor |
|---|---|---|
| } | | |

#### 7.3.2.6 End of stream RBSP syntax

| end_of_stream_rbsp( ) { | C | Descriptor |
|---|---|---|
| } | | |

#### 7.3.2.7 Filler data RBSP syntax

| filler_data_rbsp( ) { | C | Descriptor |
|---|---|---|
| while( next_bits( 8 ) == 0xFF ) | | |
| **ff_byte** /* equal to 0xFF */ | 9 | f(8) |
| rbsp_trailing_bits( ) | 9 | |
| } | | |

#### 7.3.2.8 Slice layer without partitioning RBSP syntax

| slice_layer_without_partitioning_rbsp( ) { | C | Descriptor |
|---|---|---|
| slice_header( ) | 2 | |
| slice_data( ) /* all categories of slice_data( ) syntax */ | 2 \| 3 \| 4 | |
| rbsp_slice_trailing_bits( ) | 2 | |
| } | | |

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#### 7.3.2.9 Slice data partition RBSP syntax

##### 7.3.2.9.1 Slice data partition A RBSP syntax

| slice_data_partition_a_layer_rbsp( ) { | C | Descriptor |
|---|---|---|
| slice_header( ) | 2 | |
| **slice_id** | All | ue(v) |
| slice_data( ) /* only category 2 parts of slice_data( ) syntax */ | 2 | |
| rbsp_slice_trailing_bits( ) | 2 | |
| } | | |

##### 7.3.2.9.2 Slice data partition B RBSP syntax

| slice_data_partition_b_layer_rbsp( ) { | C | Descriptor |
|---|---|---|
| **slice_id** | All | ue(v) |
| if( separate_colour_plane_flag == 1 ) | | |
| **colour_plane_id** | All | u(2) |
| if( redundant_pic_cnt_present_flag ) | | |
| **redundant_pic_cnt** | All | ue(v) |
| slice_data( ) /* only category 3 parts of slice_data( ) syntax */ | 3 | |
| rbsp_slice_trailing_bits( ) | 3 | |
| } | | |

##### 7.3.2.9.3 Slice data partition C RBSP syntax

| slice_data_partition_c_layer_rbsp( ) { | C | Descriptor |
|---|---|---|
| **slice_id** | All | ue(v) |
| if( separate_colour_plane_flag == 1 ) | | |
| **colour_plane_id** | All | u(2) |
| if( redundant_pic_cnt_present_flag ) | | |
| **redundant_pic_cnt** | All | ue(v) |
| slice_data( ) /* only category 4 parts of slice_data( ) syntax */ | 4 | |
| rbsp_slice_trailing_bits( ) | 4 | |
| } | | |

#### 7.3.2.10 RBSP slice trailing bits syntax

| rbsp_slice_trailing_bits( ) { | C | Descriptor |
|---|---|---|
| rbsp_trailing_bits( ) | All | |
| if( entropy_coding_mode_flag ) | | |
| while( more_rbsp_trailing_data( ) ) | | |
| **cabac_zero_word** /* equal to 0x0000 */ | All | f(16) |
| } | | |

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#### 7.3.2.11 RBSP trailing bits syntax

| rbsp_trailing_bits( ) { | C | Descriptor |
|---|---|---|
| **rbsp_stop_one_bit** /* equal to 1 */ | All | f(1) |
| while( !byte_aligned( ) ) | | |
| **rbsp_alignment_zero_bit** /* equal to 0 */ | All | f(1) |
| } | | |

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### 7.3.3 Slice header syntax

| slice_header( ) { | C | Descriptor |
|---|---|---|
| **first_mb_in_slice** | 2 | ue(v) |
| **slice_type** | 2 | ue(v) |
| **pic_parameter_set_id** | 2 | ue(v) |
| if( separate_colour_plane_flag == 1 ) | | |
| **colour_plane_id** | 2 | u(2) |
| **frame_num** | 2 | u(v) |
| if( !frame_mbs_only_flag ) { | | |
| **field_pic_flag** | 2 | u(1) |
| if( field_pic_flag ) | | |
| **bottom_field_flag** | 2 | u(1) |
| } | | |
| if( nal_unit_type == 5 ) | | |
| **idr_pic_id** | 2 | ue(v) |
| if( pic_order_cnt_type == 0 ) { | | |
| **pic_order_cnt_lsb** | 2 | u(v) |
| if( pic_order_present_flag && !field_pic_flag ) | | |
| **delta_pic_order_cnt_bottom** | 2 | se(v) |
| } | | |
| if( pic_order_cnt_type == 1 && !delta_pic_order_always_zero_flag ) { | | |
| **delta_pic_order_cnt[** 0 **]** | 2 | se(v) |
| if( pic_order_present_flag && !field_pic_flag ) | | |
| **delta_pic_order_cnt[** 1 **]** | 2 | se(v) |
| } | | |
| if( redundant_pic_cnt_present_flag ) | | |
| **redundant_pic_cnt** | 2 | ue(v) |
| if( slice_type == B ) | | |
| **direct_spatial_mv_pred_flag** | 2 | u(1) |
| if( slice_type == P \|\| slice_type == SP \|\| slice_type == B ) { | | |
| **num_ref_idx_active_override_flag** | 2 | u(1) |
| if( num_ref_idx_active_override_flag ) { | | |
| **num_ref_idx_l0_active_minus1** | 2 | ue(v) |
| if( slice_type == B ) | | |
| **num_ref_idx_l1_active_minus1** | 2 | ue(v) |
| } | | |
| } | | |
| ref_pic_list_reordering( ) | 2 | |
| if( ( weighted_pred_flag && ( slice_type == P \|\| slice_type == SP ) ) \|\| ( weighted_bipred_idc == 1 && slice_type == B ) ) | | |
| pred_weight_table( ) | 2 | |
| if( nal_ref_idc != 0 ) | | |
| dec_ref_pic_marking( ) | 2 | |
| if( entropy_coding_mode_flag && slice_type != I && slice_type != SI ) | | |
| **cabac_init_idc** | 2 | ue(v) |

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| | | |
|---|---|---|
| **slice_qp_delta** | 2 | se(v) |
| if( slice_type == SP \|\| slice_type == SI ) { | | |
| if( slice_type == SP ) | | |
| **sp_for_switch_flag** | 2 | u(1) |
| **slice_qs_delta** | 2 | se(v) |
| } | | |
| if( deblocking_filter_control_present_flag ) { | | |
| **disable_deblocking_filter_idc** | 2 | ue(v) |
| if( disable_deblocking_filter_idc != 1 ) { | | |
| **slice_alpha_c0_offset_div2** | 2 | se(v) |
| **slice_beta_offset_div2** | 2 | se(v) |
| } | | |
| } | | |
| if( num_slice_groups_minus1 > 0 && slice_group_map_type >= 3 && slice_group_map_type <= 5) | | |
| **slice_group_change_cycle** | 2 | u(v) |
| } | | |

#### 7.3.3.1 Reference picture list reordering syntax

| ref_pic_list_reordering( ) { | C | Descriptor |
|---|---|---|
| if( slice_type % 5 != 2 && slice_type % 5 != 4 ) { | | |
| **ref_pic_list_reordering_flag_l0** | 2 | u(1) |
| if( ref_pic_list_reordering_flag_l0 ) | | |
| do { | | |
| **reordering_of_pic_nums_idc** | 2 | ue(v) |
| if( reordering_of_pic_nums_idc == 0 \|\| reordering_of_pic_nums_idc == 1 ) | | |
| **abs_diff_pic_num_minus1** | **2** | **ue(v)** |
| else if( reordering_of_pic_nums_idc == 2 ) | | |
| **long_term_pic_num** | 2 | ue(v) |
| } while( reordering_of_pic_nums_idc != 3 ) | | |
| } | | |
| if( slice_type % 5 == 1 ) { | | |
| **ref_pic_list_reordering_flag_l1** | 2 | u(1) |
| if( ref_pic_list_reordering_flag_l1 ) | | |
| do { | | |
| **reordering_of_pic_nums_idc** | 2 | ue(v) |
| if( reordering_of_pic_nums_idc == 0 \|\| reordering_of_pic_nums_idc == 1 ) | | |
| **abs_diff_pic_num_minus1** | **2** | **ue(v)** |
| else if( reordering_of_pic_nums_idc == 2 ) | | |
| **long_term_pic_num** | 2 | ue(v) |
| } while( reordering_of_pic_nums_idc != 3 ) | | |
| } | | |
| } | | |

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#### 7.3.3.2 Prediction weight table syntax

| pred_weight_table( ) { | C | Descriptor |
|---|---|---|
| **luma_log2_weight_denom** | 2 | ue(v) |
| if( ChromaArrayType != 0 ) | | |
| **chroma_log2_weight_denom** | 2 | ue(v) |
| for( i = 0; i <= num_ref_idx_l0_active_minus1; i++ ) { | | |
| **luma_weight_l0_flag** | 2 | u(1) |
| if( luma_weight_l0_flag ) { | | |
| **luma_weight_l0[** i **]** | 2 | se(v) |
| **luma_offset_l0[** i **]** | 2 | se(v) |
| } | | |
| if ( ChromaArrayType != 0 ) { | | |
| **chroma_weight_l0_flag** | 2 | u(1) |
| if( chroma_weight_l0_flag ) | | |
| for( j =0; j < 2; j++ ) { | | |
| **chroma_weight_l0[** i **][** j **]** | 2 | se(v) |
| **chroma_offset_l0[** i **][** j **]** | 2 | se(v) |
| } | | |
| } | | |
| } | | |
| if( slice_type % 5 == 1 ) | | |
| for( i = 0; i <= num_ref_idx_l1_active_minus1; i++ ) { | | |
| **luma_weight_l1_flag** | 2 | u(1) |
| if( luma_weight_l1_flag ) { | | |
| **luma_weight_l1[** i **]** | 2 | se(v) |
| **luma_offset_l1[** i **]** | 2 | se(v) |
| } | | |
| if( ChromaArrayType != 0 ) { | | |
| **chroma_weight_l1_flag** | 2 | u(1) |
| if( chroma_weight_l1_flag ) | | |
| for( j = 0; j < 2; j++ ) { | | |
| **chroma_weight_l1[** i **][** j **]** | 2 | se(v) |
| **chroma_offset_l1[** i **][** j **]** | 2 | se(v) |
| } | | |
| } | | |
| } | | |
| } | | |

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#### 7.3.3.3 Decoded reference picture marking syntax

| dec_ref_pic_marking( ) { | C | Descriptor |
|---|---|---|
| if( IdrPicFlag ) { | | |
| **no_output_of_prior_pics_flag** | 2 \| 5 | u(1) |
| **long_term_reference_flag** | 2 \| 5 | u(1) |
| } else { | | |
| **adaptive_ref_pic_marking_mode_flag** | 2 \| 5 | u(1) |
| if( adaptive_ref_pic_marking_mode_flag ) | | |
| do { | | |
| **memory_management_control_operation** | 2 \| 5 | ue(v) |
| if( memory_management_control_operation == 1 \|\| memory_management_control_operation == 3 ) | | |
| **difference_of_pic_nums_minus1** | 2 \| 5 | ue(v) |
| if(memory_management_control_operation == 2 ) | | |
| **long_term_pic_num** | 2 \| 5 | ue(v) |
| if( memory_management_control_operation == 3 \|\| memory_management_control_operation == 6 ) | | |
| **long_term_frame_idx** | 2 \| 5 | ue(v) |
| if( memory_management_control_operation == 4 ) | | |
| **max_long_term_frame_idx_plus1** | 2 \| 5 | ue(v) |
| } while( memory_management_control_operation != 0 ) | | |
| } | | |
| } | | |

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### 7.3.4 Slice data syntax

| slice_data( ) { | C | Descriptor |
|---|---|---|
| if( entropy_coding_mode_flag ) | | |
| while( !byte_aligned( ) ) | | |
| **cabac_alignment_one_bit** | 2 | f(1) |
| CurrMbAddr = first_mb_in_slice * ( 1 + MbaffFrameFlag ) | | |
| moreDataFlag = 1 | | |
| prevMbSkipped = 0 | | |
| do { | | |
| if( slice_type != I && slice_type != SI ) | | |
| if( !entropy_coding_mode_flag ) { | | |
| **mb_skip_run** | 2 | ue(v) |
| prevMbSkipped = ( mb_skip_run > 0 ) | | |
| for( i=0; i<mb_skip_run; i++ ) | | |
| CurrMbAddr = NextMbAddress( CurrMbAddr ) | | |
| moreDataFlag = more_rbsp_data( ) | | |
| } else { | | |
| **mb_skip_flag** | 2 | ae(v) |
| moreDataFlag = !mb_skip_flag | | |
| } | | |
| if( moreDataFlag ) { | | |
| if( MbaffFrameFlag && ( CurrMbAddr % 2 == 0 \|\| ( CurrMbAddr % 2 == 1 && prevMbSkipped ) ) ) | | |
| **mb_field_decoding_flag** | 2 | u(1) \| ae(v) |
| macroblock_layer( ) | 2 \| 3 \| 4 | |
| } | | |
| if( !entropy_coding_mode_flag ) | | |
| moreDataFlag = more_rbsp_data( ) | | |
| else { | | |
| if( slice_type != I && slice_type != SI ) | | |
| prevMbSkipped = mb_skip_flag | | |
| if( MbaffFrameFlag && CurrMbAddr % 2 == 0 ) | | |
| moreDataFlag = 1 | | |
| else { | | |
| **end_of_slice_flag** | 2 | ae(v) |
| moreDataFlag = !end_of_slice_flag | | |
| } | | |
| } | | |
| CurrMbAddr = NextMbAddress( CurrMbAddr ) | | |
| } while( moreDataFlag ) | | |
| } | | |

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### 7.3.5 Macroblock layer syntax

| macroblock_layer( ) { | C | Descriptor |
|---|---|---|
| **mb_type** | 2 | ue(v) \| ae(v) |
| if( mb_type == I_PCM ) { | | |
| while( !byte_aligned( ) ) | | |
| **pcm_alignment_zero_bit** | 3 | f(1) |
| for( i = 0; i < 256; i++ ) | | |
| **pcm_sample_luma[** i **]** | 3 | u(v) |
| for( i = 0; i < 2 * MbWidthC * MbHeightC; i++ ) | | |
| **pcm_sample_chroma[** i **]** | 3 | u(v) |
| } else { | | |
| noSubMbPartSizeLessThan8x8Flag = 1 | | |
| if( mb_type != I_NxN && MbPartPredMode( mb_type, 0 ) != Intra_16x16 && NumMbPart( mb_type ) == 4 ) { | | |
| sub_mb_pred( mb_type ) | 2 | |
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| if( sub_mb_type[ mbPartIdx ] != B_Direct_8x8 ) { | | |
| if( NumSubMbPart( sub_mb_type[ mbPartIdx ] ) > 1 ) | | |
| noSubMbPartSizeLessThan8x8Flag = 0 | | |
| } else if( !direct_8x8_inference_flag ) | | |
| noSubMbPartSizeLessThan8x8Flag = 0 | | |
| } else { | | |
| if( transform_8x8_mode_flag && mb_type == I_NxN ) | | |
| **transform_size_8x8_flag** | 2 | u(1) \| ae(v) |
| mb_pred( mb_type ) | 2 | |
| } | | |
| if( MbPartPredMode( mb_type, 0 ) != Intra_16x16 ) { | | |
| **coded_block_pattern** | 2 | me(v) \| ae(v) |
| if( CodedBlockPatternLuma > 0 && transform_8x8_mode_flag && mb_type != I_NxN && noSubMbPartSizeLessThan8x8Flag && ( mb_type != B_Direct_16x16 \|\| direct_8x8_inference_flag ) ) | | |
| **transform_size_8x8_flag** | 2 | u(1) \| ae(v) |
| } | | |
| if( CodedBlockPatternLuma > 0 \|\| CodedBlockPatternChroma > 0 \|\| MbPartPredMode( mb_type, 0 ) == Intra_16x16 ) { | | |
| **mb_qp_delta** | 2 | se(v) \| ae(v) |
| residual( 0, 0, 15 ) | 3 \| 4 | |
| } | | |
| } | | |
| } | | |

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### 7.3.5.1 Macroblock prediction syntax

| mb_pred( mb_type ) { | C | Descriptor |
|---|---|---|
| if( MbPartPredMode( mb_type, 0 ) == Intra_4x4 \|\| MbPartPredMode( mb_type, 0 ) == Intra_8x8 \|\| MbPartPredMode( mb_type, 0 ) == Intra_16x16 ) { | | |
| if( MbPartPredMode( mb_type, 0 ) == Intra_4x4 ) | | |
| for( luma4x4BlkIdx=0; luma4x4BlkIdx<16; luma4x4BlkIdx++ ) { | | |
| **prev_intra4x4_pred_mode_flag[** luma4x4BlkIdx **]** | 2 | u(1) \| ae(v) |
| if( !prev_intra4x4_pred_mode_flag[ luma4x4BlkIdx ] ) | | |
| **rem_intra4x4_pred_mode[** luma4x4BlkIdx **]** | 2 | u(3) \| ae(v) |
| } | | |
| if( MbPartPredMode( mb_type, 0 ) == Intra_8x8 ) | | |
| for( luma8x8BlkIdx=0; luma8x8BlkIdx<4; luma8x8BlkIdx++ ) { | | |
| **prev_intra8x8_pred_mode_flag[** luma8x8BlkIdx **]** | 2 | u(1) \| ae(v) |
| if( !prev_intra8x8_pred_mode_flag[ luma8x8BlkIdx ] ) | | |
| **rem_intra8x8_pred_mode[** luma8x8BlkIdx **]** | 2 | u(3) \| ae(v) |
| } | | |
| if( ChromaArrayType == 1 \|\| ChromaArrayType == 2 ) | | |
| **intra_chroma_pred_mode** | 2 | ue(v) \| ae(v) |
| } else if( MbPartPredMode( mb_type, 0 ) != Direct ) { | | |
| for( mbPartIdx = 0; mbPartIdx < NumMbPart( mb_type ); mbPartIdx++) | | |
| if( ( num_ref_idx_l0_active_minus1 > 0 \|\| mb_field_decoding_flag ) && MbPartPredMode( mb_type, mbPartIdx ) != Pred_L1 ) | | |
| **ref_idx_l0[** mbPartIdx **]** | 2 | te(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < NumMbPart( mb_type ); mbPartIdx++) | | |
| if( ( num_ref_idx_l1_active_minus1 > 0 \|\| mb_field_decoding_flag ) && MbPartPredMode( mb_type, mbPartIdx ) != Pred_L0 ) | | |
| **ref_idx_l1[** mbPartIdx **]** | 2 | te(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < NumMbPart( mb_type ); mbPartIdx++) | | |
| if( MbPartPredMode ( mb_type, mbPartIdx ) != Pred_L1 ) | | |
| for( compIdx = 0; compIdx < 2; compIdx++ ) | | |
| **mvd_l0[** mbPartIdx **][** 0 **][** compIdx **]** | 2 | se(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < NumMbPart( mb_type ); mbPartIdx++) | | |
| if( MbPartPredMode( mb_type, mbPartIdx ) != Pred_L0 ) | | |
| for( compIdx = 0; compIdx < 2; compIdx++ ) | | |
| **mvd_l1[** mbPartIdx **][** 0 **][** compIdx **]** | 2 | se(v) \| ae(v) |
| } | | |
| } | | |

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### 7.3.5.2 Sub-macroblock prediction syntax

| sub_mb_pred( mb_type ) { | C | Descriptor |
|---|---|---|
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| **sub_mb_type[** mbPartIdx **]** | 2 | ue(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| if( ( num_ref_idx_l0_active_minus1 > 0 \|\| mb_field_decoding_flag ) && mb_type != P_8x8ref0 && sub_mb_type[ mbPartIdx ] != B_Direct_8x8 && SubMbPredMode( sub_mb_type[ mbPartIdx ] ) != Pred_L1 ) | | |
| **ref_idx_l0[** mbPartIdx **]** | 2 | te(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| if( (num_ref_idx_l1_active_minus1 > 0 \|\| mb_field_decoding_flag ) && sub_mb_type[ mbPartIdx ] != B_Direct_8x8 && SubMbPredMode( sub_mb_type[ mbPartIdx ] ) != Pred_L0 ) | | |
| **ref_idx_l1[** mbPartIdx **]** | 2 | te(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| if( sub_mb_type[ mbPartIdx ] != B_Direct_8x8 && SubMbPredMode( sub_mb_type[ mbPartIdx ] ) != Pred_L1 ) | | |
| for( subMbPartIdx = 0; subMbPartIdx < NumSubMbPart( sub_mb_type[ mbPartIdx ] ); subMbPartIdx++) | | |
| for( compIdx = 0; compIdx < 2; compIdx++ ) | | |
| **mvd_l0[** mbPartIdx **][** subMbPartIdx **][** compIdx **]** | 2 | se(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++) | | |
| if( sub_mb_type[ mbPartIdx ] != B_Direct_8x8 && SubMbPredMode( sub_mb_type[ mbPartIdx ] ) != Pred_L0 ) | | |
| for( subMbPartIdx = 0; subMbPartIdx < NumSubMbPart( sub_mb_type[ mbPartIdx ] ); subMbPartIdx++) | | |
| for( compIdx = 0; compIdx < 2; compIdx++ ) | | |
| **mvd_l1[** mbPartIdx **][** subMbPartIdx **][** compIdx **]** | 2 | se(v) \| ae(v) |
| } | | |

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### 7.3.5.3 Residual data syntax

| residual( bmFlag, startIdx, endIdx ) { | C | Descriptor |
|---|---|---|
| if( !entropy_coding_mode_flag ) | | |
| residual_block = residual_block_cavlc | | |
| else | | |
| residual_block = residual_block_cabac | | |
| residual_luma( i16x16DClevel, i16x16AClevel, level, level8x8, bmFlag, startIdx, endIdx ) | | |
| Intra16x16DCLevel = i16x16DClevel | | |
| Intra16x16ACLevel = i16x16AClevel | | |
| LumaLevel = level | | |
| LumaLevel8x8 = level8x8 | | |
| if( ChromaArrayType == 1 \|\| ChromaArrayType == 2 ) { | | |
| NumC8x8 = 4 / ( SubWidthC * SubHeightC ) | | |
| for( iCbCr = 0; iCbCr < 2; iCbCr++ ) | | |
| if( ( CodedBlockPatternChroma & 3 ) && startIdx == 0 ) /* chroma DC residual present */ | | |
| residual_block( ChromaDCLevel[ iCbCr ], 0, 4 * NumC8x8 - 1, 4 * NumC8x8 ) | 3 \| 4 | |
| else | | |
| for( i = 0; i < 4 * NumC8x8; i++ ) | | |
| ChromaDCLevel[ iCbCr ][ i ] = 0 | | |
| for( iCbCr = 0; iCbCr < 2; iCbCr++ ) | | |
| for( i8x8 = 0; i8x8 < NumC8x8; i8x8++ ) | | |
| for( i4x4 = 0; i4x4 < 4; i4x4++ ) | | |
| if( ( CodedBlockPatternChroma & 2 ) && endIdx > 0 ) /* chroma AC residual present */ | | |
| residual_block( ChromaACLevel[ iCbCr ][ i8x8*4+i4x4 ], max( 0, startIdx – 1 ), endIdx – 1, 15) | 3 \| 4 | |
| else | | |
| for( i = 0; i < 15; i++ ) | | |
| ChromaACLevel[ iCbCr ][ i8x8*4+i4x4 ][ i ] = 0 | | |
| } else if( ChromaArrayType == 3 ) { | | |
| residual_luma( i16x16DClevel, i16x16AClevel, level, level8x8, bmFlag, startIdx, endIdx ) | | |
| CbIntra16x16DCLevel = i16x16DClevel | | |
| CbIntra16x16ACLevel = i16x16AClevel | | |
| CbLevel = level | | |
| CbLevel8x8 = level8x8 | | |
| residual_luma( i16x16DClevel, i16x16AClevel, level, level8x8, bmFlag, startIdx, endIdx ) | | |
| CrIntra16x16DCLevel = i16x16DClevel | | |
| CrIntra16x16ACLevel = i16x16AClevel | | |
| CrLevel = level | | |
| CrLevel8x8 = level8x8 | | |
| } | | |

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#### 7.3.5.3.1 Residual luma syntax

| residual_luma( i16x16DClevel, i16x16AClevel, level, level8x8, bmFlag, startIdx, endIdx ) { | C | Descriptor |
|---|---|---|
| if( !entropy_coding_mode_flag ) | | |
| residual_block = residual_block_cavlc | | |
| else | | |
| residual_block = residual_block_cabac | | |
| if( !bmFlag && startIdx == 0 && MbPartPredMode( mb_type, 0 ) == Intra_16x16 ) | | |
| residual_block( i16x16DClevel, 0, 15, 16 ) | 3 | |
| for( i8x8 = 0; i8x8 < 4; i8x8++ ) | | |
| if( !transform_size_8x8_flag \|\| !entropy_coding_mode_flag ) | | |
| for( i4x4 = 0; i4x4 < 4; i4x4++ ) { | | |
| if( CodedBlockPatternLuma & ( 1 << i8x8 ) ) | | |
| if( !bmFlag && endIdx > 0 && MbPartPredMode( mb_type, 0 ) == Intra_16x16 ) | | |
| residual_block( i16x16AClevel[i8x8*4+ i4x4], max( 0, startIdx – 1 ), endIdx – 1, 15) | 3 | |
| else | | |
| residual_block( level[ i8x8 * 4 + i4x4 ], startIdx, endIdx, 16) | 3 \| 4 | |
| else if( !bmFlag && MbPartPredMode( mb_type, 0 ) == Intra_16x16 ) | | |
| for( i = 0; i < 15; i++ ) | | |
| i16x16AClevel[ i8x8 * 4 + i4x4 ][ i ] = 0 | | |
| else | | |
| for( i = 0; i < 16; i++ ) | | |
| level[ i8x8 * 4 + i4x4 ][ i ] = 0 | | |
| if( !entropy_coding_mode_flag && transform_size_8x8_flag ) | | |
| for( i = 0; i < 16; i++ ) | | |
| level8x8[ i8x8 ][ 4 * i + i4x4 ] = level[ i8x8 * 4 + i4x4 ][ i ] | | |
| } | | |
| else if( CodedBlockPatternLuma & ( 1 << i8x8 ) ) | | |
| residual_block( level8x8[ i8x8 ], 4 * startIdx, 4 * endIdx + 3, 64 ) | 3 \| 4 | |
| else | | |
| for( i = 0; i < 64; i++ ) | | |
| level8x8[ i8x8 ][ i ] = 0 | | |
| } | | |

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#### 7.3.5.3.2 Residual block CAVLC syntax

| residual_block_cavlc( coeffLevel, startIdx, endIdx, maxNumCoeff ) { | C | Descriptor |
|---|---|---|
| for( i = 0; i < maxNumCoeff; i++ ) | | |
| coeffLevel[ i ] = 0 | | |
| **coeff_token** | 3 \| 4 | ce(v) |
| if( TotalCoeff( coeff_token ) > 0 ) { | | |
| if( TotalCoeff( coeff_token ) > 10 && TrailingOnes( coeff_token ) < 3 ) | | |
| suffixLength = 1 | | |
| else | | |
| suffixLength = 0 | | |
| for( i = 0; i < TotalCoeff( coeff_token ); i++ ) | | |
| if( i < TrailingOnes( coeff_token ) ) { | | |
| **trailing_ones_sign_flag** | 3 \| 4 | u(1) |
| level[ i ] = 1 – 2 * trailing_ones_sign_flag | | |
| } else { | | |
| **level_prefix** | 3 \| 4 | ce(v) |
| levelCode = ( Min( 15, level_prefix ) << suffixLength ) | | |
| if( suffixLength > 0 \|\| level_prefix >= 14 ) { | | |
| **level_suffix** | 3 \| 4 | u(v) |
| levelCode += level_suffix | | |
| } | | |
| if( level_prefix >= 15 && suffixLength == 0 ) | | |
| levelCode += 15 | | |
| if( level_prefix >= 16 ) | | |
| levelCode += ( 1 << ( level_prefix – 3 ) ) – 4096 | | |
| if( i == TrailingOnes( coeff_token ) && TrailingOnes( coeff_token ) < 3 ) | | |
| levelCode += 2 | | |
| if( levelCode % 2 == 0 ) | | |
| level[ i ] = ( levelCode + 2 ) >> 1 | | |
| else | | |
| level[ i ] = ( –levelCode – 1 ) >> 1 | | |
| if( suffixLength == 0 ) | | |
| suffixLength = 1 | | |
| if( Abs( level[ i ] ) > ( 3 << ( suffixLength – 1 ) ) && suffixLength < 6 ) | | |
| suffixLength++ | | |
| } | | |
| if( TotalCoeff( coeff_token ) < endIdx – startIdx + 1 ) { | | |
| **total_zeros** | 3 \| 4 | ce(v) |
| zerosLeft = total_zeros | | |
| } else | | |
| zerosLeft = 0 | | |
| for( i = 0; i < TotalCoeff( coeff_token ) – 1; i++ ) { | | |
| if( zerosLeft > 0 ) { | | |
| **run_before** | 3 \| 4 | ce(v) |

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| | | |
|---|---|---|
| run[ i ] = run_before | | |
| } else | | |
| run[ i ] = 0 | | |
| zerosLeft = zerosLeft – run[ i ] | | |
| } | | |
| run[ TotalCoeff( coeff_token ) – 1 ] = zerosLeft | | |
| coeffNum = -1 | | |
| for( i = TotalCoeff( coeff_token ) – 1; i >= 0; i-- ) { | | |
| coeffNum += run[ i ] + 1 | | |
| coeffLevel[ startIdx + coeffNum ] = level[ i ] | | |
| } | | |
| } | | |
| } | | |

#### 7.3.5.3.3 Residual block CABAC syntax

| residual_block_cabac( coeffLevel, startIdx, endIdx, maxNumCoeff ) { | C | Descriptor |
|---|---|---|
| if( maxNumCoeff == 64 \|\| ( ChromaArrayType == 3 ) ) | | |
| **coded_block_flag** | 3 \| 4 | ae(v) |
| for( i = 0; i < maxNumCoeff; i++ ) | | |
| coeffLevel[ i ] = 0 | | |
| if( coded_block_flag ) { | | |
| numCoeff = endIdx + 1 | | |
| i = startIdx | | |
| do { | | |
| **significant_coeff_flag[** i **]** | 3 \| 4 | ae(v) |
| if( significant_coeff_flag[ i ] ) { | | |
| **last_significant_coeff_flag[** i **]** | 3 \| 4 | ae(v) |
| if( last_significant_coeff_flag[ i ] ) | | |
| numCoeff = i + 1 | | |
| } | | |
| i++ | | |
| } while( i < numCoeff – 1 ) | | |
| **coeff_abs_level_minus1[** numCoeff – 1 **]** | 3 \| 4 | ae(v) |
| **coeff_sign_flag[** numCoeff – 1 **]** | 3 \| 4 | ae(v) |
| coeffLevel[ numCoeff – 1 ] = ( coeff_abs_level_minus1[ numCoeff – 1 ] + 1 ) * ( 1 – 2 * coeff_sign_flag[ numCoeff – 1 ] ) | | |
| for( i = numCoeff – 2; i >= 0; i-- ) | | |
| if( significant_coeff_flag[ i ] ) { | | |
| **coeff_abs_level_minus1[** i **]** | 3 \| 4 | ae(v) |
| **coeff_sign_flag[** i **]** | 3 \| 4 | ae(v) |
| coeffLevel[ i ] = ( coeff_abs_level_minus1[ i ] + 1 ) * ( 1 – 2 * coeff_sign_flag[ i ] ) | | |
| } | | |
| } | | |
| } | | |

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## 7.4 Semantics

Semantics associated with the syntax structures and with the syntax elements within these structures are specified in this subclause. When the semantics of a syntax element are specified using a table or a set of tables, any values that are not specified in the table(s) shall not be present in the bitstream unless otherwise specified in this International Standard.

### 7.4.1 NAL unit semantics

NOTE 1 – The VCL is specified to efficiently represent the content of the video data. The NAL is specified to format that data and provide header information in a manner appropriate for conveyance on a variety of communication channels or storage media. All data are contained in NAL units, each of which contains an integer number of bytes. A NAL unit specifies a generic format for use in both packet-oriented and bitstream systems. The format of NAL units for both packet-oriented transport and byte stream is identical except that each NAL unit can be preceded by a start code prefix and extra padding bytes in the byte stream format.

NumBytesInNALunit specifies the size of the NAL unit in bytes. This value is required for decoding of the NAL unit. Some form of demarcation of NAL unit boundaries is necessary to enable inference of NumBytesInNALunit. One such demarcation method is specified in Annex B for the byte stream format. Other methods of demarcation may be specified outside of this International Standard.

**forbidden_zero_bit** shall be equal to 0.

**nal_ref_idc** not equal to 0 specifies that the content of the NAL unit contains a sequence parameter set, a sequence parameter set extension, a subset sequence parameter set, a picture parameter set, a slice of a reference picture, a slice data partition of a reference picture, or a prefix NAL unit preceding a slice of a reference picture.

For coded video sequences conforming to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9, nal_ref_idc equal to 0 for a NAL unit containing a slice or slice data partition indicates that the slice or slice data partition is part of a non-reference picture.

nal_ref_idc shall not be equal to 0 for sequence parameter set or sequence parameter set extension or subset sequence parameter set or picture parameter set NAL units. When nal_ref_idc is equal to 0 for one NAL unit with nal_unit_type in the range of 1 to 4, inclusive, of a particular picture, it shall be equal to 0 for all NAL units with nal_unit_type in the range of 1 to 4, inclusive, of the picture.

nal_ref_idc shall not be equal to 0 for NAL units with nal_unit_type equal to 5.

nal_ref_idc shall be equal to 0 for all NAL units having nal_unit_type equal to 6, 9, 10, 11, or 12.

**nal_unit_type** specifies the type of RBSP data structure contained in the NAL unit as specified in Table 7-1.

The column marked "C" in Table 7-1 lists the categories of the syntax elements that may be present in the NAL unit. In addition, syntax elements with syntax category "All" may be present, as determined by the syntax and semantics of the RBSP data structure. The presence or absence of any syntax elements of a particular listed category is determined from the syntax and semantics of the associated RBSP data structure. nal_unit_type shall not be equal to 3 or 4 unless at least one syntax element is present in the RBSP data structure having a syntax element category value equal to the value of nal_unit_type and not categorized as "All".

For coded video sequences conforming to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9, VCL and non-VCL NAL units are specified in Table 7-1 in the column labelled "Annex A NAL unit type class". For coded video sequences conforming to one or more of the profiles specified in Annex G that are decoded using the decoding process specified in Annex G, VCL and non-VCL NAL units are specified in Table 7-1 in the column labelled "Annex G NAL unit type class". The entry "suffix dependent" for nal_unit_type equal to 14, specifies the following.

– If the NAL unit directly following in decoding order a NAL unit with nal_unit_type equal to 14 is a NAL unit with nal_unit_type equal to 1 or 5, the NAL unit with nal_unit_type equal to 14 is a VCL NAL unit.

– Otherwise, if the NAL unit directly following in decoding order a NAL unit with nal_unit_type equal to 14 is a NAL unit with nal_unit_type equal to 12, the NAL unit with nal_unit_type equal to 14 is a non-VCL NAL unit.

– Otherwise (the NAL unit directly following in decoding order a NAL unit with nal_unit_type equal to 14 is a NAL unit with nal_unit_type not equal to 1, 5, or 12), the NAL unit with nal_unit_type equal to 14 is a non-VCL NAL unit and decoders shall ignore (remove from the bitstream and discard) the NAL unit with nal_unit_type equal to14 and the NAL unit directly following in decoding order the NAL unit with nal_unit_type equal to 14.

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**Table 7-1 – NAL unit type codes, syntax element categories, and NAL unit type classes**

| nal_unit_type | Content of NAL unit and RBSP syntax structure | C | Annex A NAL unit type class | Annex G NAL unit type class |
|---|---|---|---|---|
| 0 | Unspecified | | non-VCL | non-VCL |
| 1 | Coded slice of a non-IDR picture<br>slice_layer_without_partitioning_rbsp( ) | 2, 3, 4 | VCL | VCL |
| 2 | Coded slice data partition A<br>slice_data_partition_a_layer_rbsp( ) | 2 | VCL | not applicable |
| 3 | Coded slice data partition B<br>slice_data_partition_b_layer_rbsp( ) | 3 | VCL | not applicable |
| 4 | Coded slice data partition C<br>slice_data_partition_c_layer_rbsp( ) | 4 | VCL | not applicable |
| 5 | Coded slice of an IDR picture<br>slice_layer_without_partitioning_rbsp( ) | 2, 3 | VCL | VCL |
| 6 | Supplemental enhancement information (SEI)<br>sei_rbsp( ) | 5 | non-VCL | non-VCL |
| 7 | Sequence parameter set<br>seq_parameter_set_rbsp( ) | 0 | non-VCL | non-VCL |
| 8 | Picture parameter set<br>pic_parameter_set_rbsp( ) | 1 | non-VCL | non-VCL |
| 9 | Access unit delimiter<br>access_unit_delimiter_rbsp( ) | 6 | non-VCL | non-VCL |
| 10 | End of sequence<br>end_of_seq_rbsp( ) | 7 | non-VCL | non-VCL |
| 11 | End of stream<br>end_of_stream_rbsp( ) | 8 | non-VCL | non-VCL |
| 12 | Filler data<br>filler_data_rbsp( ) | 9 | non-VCL | non-VCL |
| 13 | Sequence parameter set extension<br>seq_parameter_set_extension_rbsp( ) | 10 | non-VCL | non-VCL |
| 14 | Prefix NAL unit in scalable extension<br>prefix_nal_unit_rbsp( ) /* specified in Annex G */ | 2 | non-VCL | suffix dependent |
| 15 | Subset sequence parameter set<br>subset_seq_parameter_set_rbsp( ) /* specified in Annex G */ | 0 | non-VCL | non-VCL |
| 16..18 | Reserved | | non-VCL | non-VCL |
| 19 | Coded slice of an auxiliary coded picture without partitioning<br>slice_layer_without_partitioning_rbsp( ) | 2, 3, 4 | non-VCL | non-VCL |
| 20 | Coded slice in scalable extension<br>slice_layer_in_scalable_extension_rbsp( )<br>/* specified in Annex G */ | 2, 3, 4 | non-VCL | VCL |
| 21..23 | Reserved | | non-VCL | non-VCL |
| 24..31 | Unspecified | | non-VCL | non-VCL |

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NAL units having nal_unit_type equal to 13 or 19 may be discarded by decoders without affecting the decoding process for NAL units having nal_unit_type not equal to 13 or 19 and without affecting conformance to this International Standard.

NAL units having nal_unit_type equal to 14, 15, or 20 may be discarded by decoders without affecting the decoding process for NAL units having nal_unit_type not equal to 14, 15, or 20 and without affecting conformance to profiles specified in Annex A.

NAL units that use nal_unit_type equal to 0 or in the range of 24..31, inclusive, shall not affect the decoding process specified in this International Standard.

NOTE 2 – NAL unit types 0 and 24..31 may be used as determined by the application. No decoding process for these values of nal_unit_type is specified in this International Standard.

Decoders shall ignore (remove from the bitstream and discard) the contents of all NAL units that use reserved values of nal_unit_type.

NOTE 3 – This requirement allows future definition of compatible extensions to this International Standard.

In the text, coded slice NAL unit collectively refers to a coded slice of a non-IDR picture NAL unit or to a coded slice of an IDR picture NAL unit. The following flag is specified

$$IdrPicFlag = ( nal_unit_type == 5 \ ? \ 1 \ : \ 0 ) \quad (7\text{-}1)$$

When the value of nal_unit_type is equal to 5 for a NAL unit containing a slice of a particular picture, the picture shall not contain NAL units with nal_unit_type in the range of 1 to 4, inclusive. For coded video sequences conforming to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9, such a picture is referred to as an IDR picture.

NOTE 4 – Slice data partitioning cannot be used for IDR pictures.

**rbsp_byte[** i **]** is the i-th byte of an RBSP. An RBSP is specified as an ordered sequence of bytes as follows.

The RBSP contains an SODB as follows.

– If the SODB is empty (i.e., zero bits in length), the RBSP is also empty.

– Otherwise, the RBSP contains the SODB as follows.

1) The first byte of the RBSP contains the (most significant, left-most) eight bits of the SODB; the next byte of the RBSP shall contain the next eight bits of the SODB, etc., until fewer than eight bits of the SODB remain.

2) rbsp_trailing_bits( ) are present after the SODB as follows:

   i) The first (most significant, left-most) bits of the final RBSP byte contains the remaining bits of the SODB, (if any)

   ii) The next bit consists of a single rbsp_stop_one_bit equal to 1, and

   iii) When the rbsp_stop_one_bit is not the last bit of a byte-aligned byte, one or more rbsp_alignment_zero_bit is present to result in byte alignment.

3) One or more cabac_zero_word 16-bit syntax elements equal to 0x0000 may be present in some RBSPs after the rbsp_trailing_bits( ) at the end of the RBSP.

Syntax structures having these RBSP properties are denoted in the syntax tables using an "_rbsp" suffix. These structures shall be carried within NAL units as the content of the rbsp_byte[ i ] data bytes. The association of the RBSP syntax structures to the NAL units shall be as specified in Table 7-1.

NOTE 5 – When the boundaries of the RBSP are known, the decoder can extract the SODB from the RBSP by concatenating the bits of the bytes of the RBSP and discarding the rbsp_stop_one_bit, which is the last (least significant, right-most) bit equal to 1, and discarding any following (less significant, farther to the right) bits that follow it, which are equal to 0. The data necessary for the decoding process is contained in the SODB part of the RBSP.

**emulation_prevention_three_byte** is a byte equal to 0x03. When an emulation_prevention_three_byte is present in the NAL unit, it shall be discarded by the decoding process.

The last byte of the NAL unit shall not be equal to 0x00.

Within the NAL unit, the following three-byte sequences shall not occur at any byte-aligned position:

– 0x000000

– 0x000001

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– 0x000002

Within the NAL unit, any four-byte sequence that starts with 0x000003 other than the following sequences shall not occur at any byte-aligned position:

– 0x00000300
– 0x00000301
– 0x00000302
– 0x00000303

NOTE 6 – When nal_unit_type is equal to 0, particular care must be exercised in the design of encoders to avoid the presence of the above-listed three-byte and four-byte patterns at the beginning of the NAL unit syntax structure, as the syntax element emulation_prevention_three_byte cannot be the third byte of a NAL unit.

#### 7.4.1.1 Encapsulation of an SODB within an RBSP (informative)

This subclause does not form an integral part of this International Standard.

The form of encapsulation of an SODB within an RBSP and the use of the emulation_prevention_three_byte for encapsulation of an RBSP within a NAL unit is specified for the following purposes:

– to prevent the emulation of start codes within NAL units while allowing any arbitrary SODB to be represented within a NAL unit,
– to enable identification of the end of the SODB within the NAL unit by searching the RBSP for the rbsp_stop_one_bit starting at the end of the RBSP, and
– to enable a NAL unit to have a size larger than that of the SODB under some circumstances (using one or more cabac_zero_word).

The encoder can produce a NAL unit from an RBSP by the following procedure:

The RBSP data is searched for byte-aligned bits of the following binary patterns:

'00000000 00000000 000000xx' (where xx represents any 2 bit pattern: 00, 01, 10, or 11),

and a byte equal to 0x03 is inserted to replace these bit patterns with the patterns

'00000000 00000000 00000011 000000xx',

and finally, when the last byte of the RBSP data is equal to 0x00 (which can only occur when the RBSP ends in a cabac_zero_word), a final byte equal to 0x03 is appended to the end of the data.

The resulting sequence of bytes is then prefixed with the first byte of the NAL unit containing the indication of the type of RBSP data structure it contains. This results in the construction of the entire NAL unit.

This process can allow any SODB to be represented in a NAL unit while ensuring that

– no byte-aligned start code prefix is emulated within the NAL unit, and
– no sequence of 8 zero-valued bits followed by a start code prefix, regardless of byte-alignment, is emulated within the NAL unit.

#### 7.4.1.2 Order of NAL units and association to coded pictures, access units, and video sequences

This subclause specifies constraints on the order of NAL units in the bitstream.

Any order of NAL units in the bitstream obeying these constraints is referred to in the text as the decoding order of NAL units. Within a NAL unit, the syntax in subclauses 7.3, D.1, and E.1 specifies the decoding order of syntax elements. Decoders conforming to this International Standard shall be capable of receiving NAL units and their syntax elements in decoding order.

##### 7.4.1.2.1 Order of sequence and picture parameter set RBSPs and their activation

This subclause specifies the activation process of picture and sequence parameter sets for coded video sequences that conform to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9.

NOTE 1 – The sequence and picture parameter set mechanism decouples the transmission of infrequently changing information from the transmission of coded macroblock data. Sequence and picture parameter sets may, in some applications, be conveyed "out-of-band" using a reliable transport mechanism.

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A picture parameter set RBSP includes parameters that can be referred to by the coded slice NAL units or coded slice data partition A NAL units of one or more coded pictures. Each picture parameter set RBSP is initially considered not active at the start of the operation of the decoding process. At most one picture parameter set RBSP is considered active at any given moment during the operation of the decoding process, and the activation of any particular picture parameter set RBSP results in the deactivation of the previously-active picture parameter set RBSP (if any).

When a picture parameter set RBSP (with a particular value of pic_parameter_set_id) is not active and it is referred to by a coded slice NAL unit or coded slice data partition A NAL unit (using that value of pic_parameter_set_id), it is activated. This picture parameter set RBSP is called the active picture parameter set RBSP until it is deactivated by the activation of another picture parameter set RBSP. A picture parameter set RBSP, with that particular value of pic_parameter_set_id, shall be available to the decoding process prior to its activation.

Any picture parameter set NAL unit containing the value of pic_parameter_set_id for the active picture parameter set RBSP shall have the same content as that of the active picture parameter set RBSP unless it follows the last VCL NAL unit of a coded picture and precedes the first VCL NAL unit of another coded picture.

A sequence parameter set RBSP includes parameters that can be referred to by one or more picture parameter set RBSPs or one or more SEI NAL units containing a buffering period SEI message. Each sequence parameter set RBSP is initially considered not active at the start of the operation of the decoding process. At most one sequence parameter set RBSP is considered active at any given moment during the operation of the decoding process, and the activation of any particular sequence parameter set RBSP results in the deactivation of the previously-active sequence parameter set RBSP (if any).

When a sequence parameter set RBSP (with a particular value of seq_parameter_set_id) is not already active and it is referred to by activation of a picture parameter set RBSP (using that value of seq_parameter_set_id) or is referred to by an SEI NAL unit containing a buffering period SEI message (using that value of seq_parameter_set_id), it is activated. This sequence parameter set RBSP is called the active sequence parameter set RBSP until it is deactivated by the activation of another sequence parameter set RBSP. A sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation. An activated sequence parameter set RBSP shall remain active for the entire coded video sequence.

NOTE 2 – Because an IDR access unit begins a new coded video sequence and an activated sequence parameter set RBSP must remain active for the entire coded video sequence, a sequence parameter set RBSP can only be activated by a buffering period SEI message when the buffering period SEI message is part of an IDR access unit.

Any sequence parameter set NAL unit containing the value of seq_parameter_set_id for the active sequence parameter set RBSP shall have the same content as that of the active sequence parameter set RBSP unless it follows the last access unit of a coded video sequence and precedes the first VCL NAL unit and the first SEI NAL unit containing a buffering period SEI message (when present) of another coded video sequence.

NOTE 3 – If picture parameter set RBSP or sequence parameter set RBSP are conveyed within the bitstream, these constraints impose an order constraint on the NAL units that contain the picture parameter set RBSP or sequence parameter set RBSP, respectively. Otherwise (picture parameter set RBSP or sequence parameter set RBSP are conveyed by other means not specified in this International Standard), they must be available to the decoding process in a timely fashion such that these constraints are obeyed.

When present, a sequence parameter set extension RBSP includes parameters having a similar function to those of a sequence parameter set RBSP. For purposes of establishing constraints on the syntax elements of the sequence parameter set extension RBSP and for purposes of determining activation of a sequence parameter set extension RBSP, the sequence parameter set extension RBSP shall be considered part of the preceding sequence parameter set RBSP with the same value of seq_parameter_set_id. When a sequence parameter set RBSP is present that is not followed by a sequence parameter set extension RBSP with the same value of seq_parameter_set_id prior to the activation of the sequence parameter set RBSP, the sequence parameter set extension RBSP and its syntax elements shall be considered not present for the active sequence parameter set RBSP.

All constraints that are expressed on the relationship between the values of the syntax elements (and the values of variables derived from those syntax elements) in sequence parameter sets and picture parameter sets and other syntax elements are expressions of constraints that apply only to the active sequence parameter set and the active picture parameter set. If any sequence parameter set RBSP is present that is not activated in the bitstream, its syntax elements shall have values that would conform to the specified constraints if it were activated by reference in an otherwise-conforming bitstream. If any picture parameter set RBSP is present that is not ever activated in the bitstream, its syntax elements shall have values that would conform to the specified constraints if it were activated by reference in an otherwise-conforming bitstream.

During operation of the decoding process (see clause 8), the values of parameters of the active picture parameter set and the active sequence parameter set shall be considered in effect. For interpretation of SEI messages, the values of the

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parameters of the picture parameter set and sequence parameter set that are active for the operation of the decoding process for the VCL NAL units of the primary coded picture in the same access unit shall be considered in effect unless otherwise specified in the SEI message semantics.

#### 7.4.1.2.2 Order of access units and association to coded video sequences

A bitstream conforming to this International Standard consists of one or more coded video sequences.

A coded video sequence consists of one or more access units. For coded video sequences that conform to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9, the order of NAL units and coded pictures and their association to access units is described in subclause 7.4.1.2.3.

The first access unit of each coded video sequence is an IDR access unit. All subsequent access units in the coded video sequence are non-IDR access units.

The values of picture order count for the coded pictures in consecutive access units in decoding order containing non-reference pictures shall be non-decreasing.

When present, an access unit following an access unit that contains an end of sequence NAL unit shall be an IDR access unit.

When an SEI NAL unit contains data that pertain to more than one access unit (for example, when the SEI NAL unit has a coded video sequence as its scope), it shall be contained in the first access unit to which it applies.

When an end of stream NAL unit is present in an access unit, this access unit shall be the last access unit in the bitstream and the end of stream NAL unit shall be the last NAL unit in that access unit.

#### 7.4.1.2.3 Order of NAL units and coded pictures and association to access units

This subclause specifies the order of NAL units and coded pictures and association to access unit for coded video sequences that conform to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9.

An access unit consists of one primary coded picture, zero or more corresponding redundant coded pictures, and zero or more non-VCL NAL units. The association of VCL NAL units to primary or redundant coded pictures is described in subclause 7.4.1.2.5.

The first access unit in the bitstream starts with the first NAL unit of the bitstream.

The first of any of the following NAL units after the last VCL NAL unit of a primary coded picture specifies the start of a new access unit.

– access unit delimiter NAL unit (when present)
– sequence parameter set NAL unit (when present)
– picture parameter set NAL unit (when present)
– SEI NAL unit (when present)
– NAL units with nal_unit_type in the range of 14 to 18, inclusive
– first VCL NAL unit of a primary coded picture (always present)

The constraints for the detection of the first VCL NAL unit of a primary coded picture are specified in subclause 7.4.1.2.4.

The following constraints shall be obeyed by the order of the coded pictures and non-VCL NAL units within an access unit.

– When an access unit delimiter NAL unit is present, it shall be the first NAL unit. There shall be at most one access unit delimiter NAL unit in any access unit.
– When any SEI NAL units are present, they shall precede the primary coded picture.
– When an SEI NAL unit containing a buffering period SEI message is present, the buffering period SEI message shall be the first SEI message payload of the first SEI NAL unit in the access unit
– The primary coded picture shall precede the corresponding redundant coded pictures.

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– When redundant coded pictures are present, they shall be ordered in ascending order of the value of redundant_pic_cnt.

– When a sequence parameter set extension NAL unit is present, it shall be the next NAL unit after a sequence parameter set NAL unit having the same value of seq_parameter_set_id as in the sequence parameter set extension NAL unit.

– When one or more coded slice of an auxiliary coded picture without partitioning NAL units is present, they shall follow the primary coded picture and all redundant coded pictures (if any).

– When an end of sequence NAL unit is present, it shall follow the primary coded picture and all redundant coded pictures (if any) and all coded slice of an auxiliary coded picture without partitioning NAL units (if any).

– When an end of stream NAL unit is present, it shall be the last NAL unit.

– NAL units having nal_unit_type equal to 0, 12, or in the range of 20 to 31, inclusive, shall not precede the first VCL NAL unit of the primary coded picture.

NOTE 1 – Sequence parameter set NAL units or picture parameter set NAL units may be present in an access unit, but cannot follow the last VCL NAL unit of the primary coded picture within the access unit, as this condition would specify the start of a new access unit.

NOTE 2 – When a NAL unit having nal_unit_type equal to 7 or 8 is present in an access unit, it may or may not be referred to in the coded pictures of the access unit in which it is present, and may be referred to in coded pictures of subsequent access units.

The structure of access units not containing any NAL units with nal_unit_type equal to 0, 7, 8, or in the range of 12 to 18, inclusive, or in the range of 20 to 31, inclusive, is shown in Figure 7-1.

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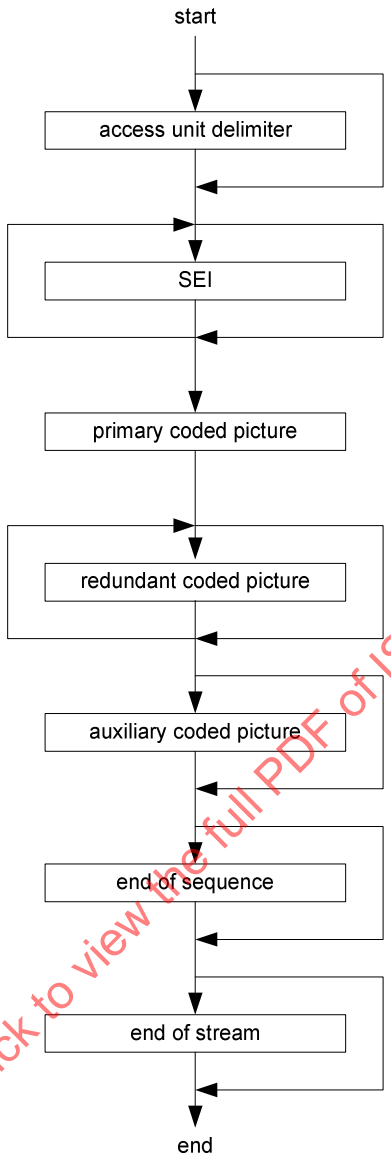


**Figure 7-1 – Structure of an access unit not containing any NAL units with nal_unit_type equal to 0, 7, 8, or in the range of 12 to 18, inclusive, or in the range of 20 to 31, inclusive**

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#### 7.4.1.2.4 Detection of the first VCL NAL unit of a primary coded picture

This subclause specifies constraints on VCL NAL unit syntax that are sufficient to enable the detection of the first VCL NAL unit of each primary coded picture for coded video sequences that conform to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9.

Any coded slice NAL unit or coded slice data partition A NAL unit of the primary coded picture of the current access unit shall be different from any coded slice NAL unit or coded slice data partition A NAL unit of the primary coded picture of the previous access unit in one or more of the following ways.

– frame_num differs in value. The value of frame_num used to test this condition is the value of frame_num that appears in the syntax of the slice header, regardless of whether that value is inferred to have been equal to 0 for subsequent use in the decoding process due to the presence of memory_management_control_operation equal to 5.

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NOTE 1 – A consequence of the above statement is that a primary coded picture having frame_num equal to 1 cannot contain a memory_management_control_operation equal to 5 unless some other condition listed below is fulfilled for the next primary coded picture that follows after it (if any).

– pic_parameter_set_id differs in value.

– field_pic_flag differs in value.

– bottom_field_flag is present in both and differs in value.

– nal_ref_idc differs in value with one of the nal_ref_idc values being equal to 0.

– pic_order_cnt_type is equal to 0 for both and either pic_order_cnt_lsb differs in value, or delta_pic_order_cnt_bottom differs in value.

– pic_order_cnt_type is equal to 1 for both and either delta_pic_order_cnt[ 0 ] differs in value, or delta_pic_order_cnt[ 1 ] differs in value.

– nal_unit_type differs in value with one of the nal_unit_type values being equal to 5.

– nal_unit_type is equal to 5 for both and idr_pic_id differs in value.

NOTE 2 – Some of the VCL NAL units in redundant coded pictures or some non-VCL NAL units (e.g. an access unit delimiter NAL unit) may also be used for the detection of the boundary between access units, and may therefore aid in the detection of the start of a new primary coded picture.

#### 7.4.1.2.5 Order of VCL NAL units and association to coded pictures

This subclause specifies the order of VCL NAL units and association to coded pictures for coded video sequences that conform to one or more of the profiles specified in Annex A that are decoded using the decoding process specified in clauses 2-9.

Each VCL NAL unit is part of a coded picture.

The order of the VCL NAL units within a coded IDR picture is constrained as follows.

– If arbitrary slice order is allowed as specified in Annex A, coded slice of an IDR picture NAL units may have any order relative to each other.

– Otherwise (arbitrary slice order is not allowed), the following applies.

  – If separate_colour_plane_flag is equal to 0, coded slice of an IDR picture NAL units of a slice group shall not be interleaved with coded slice of an IDR picture NAL units of another slice group and the order of coded slice of an IDR picture NAL units within a slice group shall be in the order of increasing macroblock address for the first macroblock of each coded slice of an IDR picture NAL unit of the particular slice group.

  – Otherwise (separate_colour_plane_flag is equal to 1), coded slice of an IDR picture NAL units of a slice group for a particular value of colour_plane_id shall not be interleaved with coded slice of an IDR picture NAL units of another slice group with the same value of colour_plane_id and the order of coded slices of IDR picture NAL units within a slice group for a particular value of colour_plane_id shall be in the order of increasing macroblock address for the first macroblock of each coded slice of an IDR picture NAL unit of the particular slice group having the particular value of colour_plane_id.

    NOTE 1 – When separate_colour_plane_flag is equal to 1, the relative ordering of coded slices having different values of colour_plane_id is not constrained.

The order of the VCL NAL units within a coded non-IDR picture is constrained as follows.

– If arbitrary slice order is allowed as specified in Annex A, coded slice of a non-IDR picture NAL units or coded slice data partition A NAL units may have any order relative to each other. A coded slice data partition A NAL unit with a particular value of slice_id shall precede any present coded slice data partition B NAL unit with the same value of slice_id. A coded slice data partition A NAL unit with a particular value of slice_id shall precede any present coded slice data partition C NAL unit with the same value of slice_id. When a coded slice data partition B NAL unit with a particular value of slice_id is present, it shall precede any present coded slice data partition C NAL unit with the same value of slice_id.

– Otherwise (arbitrary slice order is not allowed), the following applies.

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– If separate_colour_plane_flag is equal to 0, coded slice of a non-IDR picture NAL units or coded slice data partition NAL units of a slice group shall not be interleaved with coded slice of a non-IDR picture NAL units or coded slice data partition NAL units of another slice group and the order of coded slice of a non-IDR picture NAL units or coded slice data partition A NAL units within a slice group shall be in the order of increasing macroblock address for the first macroblock of each coded slice of a non-IDR picture NAL unit or coded slice data partition A NAL unit of the particular slice group. A coded slice data partition A NAL unit with a particular value of slice_id shall immediately precede any present coded slice data partition B NAL unit with the same value of slice_id. A coded slice data partition A NAL unit with a particular value of slice_id shall immediately precede any present coded slice data partition C NAL unit with the same value of slice_id, when a coded slice data partition B NAL unit with the same value of slice_id is not present. When a coded slice data partition B NAL unit with a particular value of slice_id is present, it shall immediately precede any present coded slice data partition C NAL unit with the same value of slice_id.

– Otherwise (separate_colour_plane_flag is equal to 1), coded slice of a non-IDR picture NAL units or coded slice data partition NAL units of a slice group for a particular value of colour_plane_id shall not be interleaved with coded slice of a non-IDR picture NAL units or coded slice data partition NAL units of another slice group with the same value of colour_plane_id and the order of coded slice of a non-IDR picture NAL units or coded slice data partition A NAL units within a slice group for particular value of colour_plane_id shall be in the order of increasing macroblock address for the first macroblock of each coded slice of a non-IDR picture NAL unit or coded slice data partition A NAL unit of the particular slice group having the particular value of colour_plane_id. A coded slice data partition A NAL unit associated with a particular value of slice_id and colour_plane_id shall immediately precede any present coded slice data partition B NAL unit with the same value of slice_id and colour_plane_id. A coded slice data partition A NAL unit associated with a particular value of slice_id and colour_plane_id shall immediately precede any present coded slice data partition C NAL unit with the same value of slice_id and colour_plane_id, when a coded slice data partition B NAL unit with the same value of slice_id and colour_plane_id is not present. When a coded slice data partition B NAL unit with a particular value of slice_id and colour_plane_id is present, it shall immediately precede any present coded slice data partition C NAL unit with the same value of slice_id and colour_plane_id.

NOTE 2 – When separate_colour_plane_flag is equal to 1, the relative ordering of coded slices having different values of colour_plane_id is not constrained.

NAL units having nal_unit_type equal to 12 may be present in the access unit but shall not precede the first VCL NAL unit of the primary coded picture within the access unit.

NAL units having nal_unit_type equal to 0 or in the range of 24 to 31, inclusive, which are unspecified, may be present in the access unit but shall not precede the first VCL NAL unit of the primary coded picture within the access unit.

NAL units having nal_unit_type in the range of 20 to 23, inclusive, shall not precede the first VCL NAL unit of the primary coded picture within the access unit.

### 7.4.2 Raw byte sequence payloads and RBSP trailing bits semantics

#### 7.4.2.1 Sequence parameter set RBSP semantics

##### 7.4.2.1.1 Sequence parameter set data semantics

**profile_idc** and **level_idc** indicate the profile and level to which the coded video sequence conforms.

**constraint_set0_flag** equal to 1 indicates that the coded video sequence obeys all constraints specified in subclause A.2.1. constraint_set0_flag equal to 0 indicates that the coded video sequence may or may not obey all constraints specified in subclause A.2.1.

**constraint_set1_flag** equal to 1 indicates that the coded video sequence obeys all constraints specified in subclause A.2.2. constraint_set1_flag equal to 0 indicates that the coded video sequence may or may not obey all constraints specified in subclause A.2.2.

**constraint_set2_flag** equal to 1 indicates that the coded video sequence obeys all constraints specified in subclause A.2.3. constraint_set2_flag equal to 0 indicates that the coded video sequence may or may not obey all constraints specified in subclause A.2.3.

NOTE 1 – When one or more than one of constraint_set0_flag, constraint_set1_flag, or constraint_set2_flag are equal to 1, the coded video sequence must obey the constraints of all of the indicated subclauses of subclause A.2. When profile_idc is equal to 44, 100, 110, 122, or 244, the values of constraint_set0_flag, constraint_set1_flag, and constraint_set2_flag must all be equal to 0.

**constraint_set3_flag** indicates the following.

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– If profile_idc is equal to 66, 77, or 88 and level_idc is equal to 11, constraint_set3_flag equal to 1 indicates that the coded video sequence obeys all constraints specified in Annex A for level 1b and constraint_set3_flag equal to 0 indicates that the coded video sequence may or may not obey all constraints specified in Annex A for level 1b.
– Otherwise, if profile_idc is equal to 100 or 110, constraint_set3_flag equal to 1 indicates that the coded video sequence obeys all constraints specified in Annex A for the High 10 Intra profile, and constraint_set3_flag equal to 0 indicates that the coded video sequence may or may not obey these corresponding constraints.
– Otherwise, if profile_idc is equal to 122, constraint_set3_flag equal to 1 indicates that the coded video sequence obeys all constraints specified in Annex A for the High 4:2:2 Intra profile, and constraint_set3_flag equal to 0 indicates that the coded video sequence may or may not obey these corresponding constraints.
– Otherwise, if profile_idc is equal to 44, constraint_set3_flag shall be equal to 1. When profile_idc is equal to 44, the value of 0 for constraint_set3_flag is forbidden.
– Otherwise, if profile_idc is equal to 244, constraint_set3_flag equal to 1 indicates that the coded video sequence obeys all constraints specified in Annex A for the High 4:4:4 Intra profile, and constraint_set3_flag equal to 0 indicates that the coded video sequence may or may not obey these corresponding constraints.
– Otherwise (profile_idc is equal to 66, 77, or 88 and level_idc is not equal to 11), the value of 1 for constraint_set3_flag is reserved for future use by ITU-T | ISO/IEC. constraint_set3_flag shall be equal to 0 for coded video sequences with profile_idc equal to 66, 77, or 88 and level_idc not equal to 11 in bitstreams conforming to this International Standard. Decoders conforming to this International Standard shall ignore the value of constraint_set3_flag when profile_idc is equal to 66, 77, or 88 and level_idc is not equal to 11.

**reserved_zero_4bits** shall be equal to 0. Other values of reserved_zero_4bits may be specified in the future by ITU-T | ISO/IEC. Decoders shall ignore the value of reserved_zero_4bits.

**seq_parameter_set_id** identifies the sequence parameter set that is referred to by the picture parameter set. The value of seq_parameter_set_id shall be in the range of 0 to 31, inclusive.

NOTE 2 – When feasible, encoders should use distinct values of seq_parameter_set_id when the values of other sequence parameter set syntax elements differ rather than changing the values of the syntax elements associated with a specific value of seq_parameter_set_id.

**chroma_format_idc** specifies the chroma sampling relative to the luma sampling as specified in subclause 6.2. The value of chroma_format_idc shall be in the range of 0 to 3, inclusive. When chroma_format_idc is not present, it shall be inferred to be equal to 1 (4:2:0 chroma format).

**separate_colour_plane_flag** equal to 1 specifies that the three colour components of the 4:4:4 chroma format are coded separately. separate_colour_plane_flag equal to 0 specifies that the colour components are not coded separately. When separate_colour_plane_flag is not present, it shall be inferred to be equal to 0. When separate_colour_plane_flag is equal to 1, the primary coded picture consists of three separate components, each of which consists of coded samples of one colour plane (Y, Cb or Cr) that each use the monochrome coding syntax. In this case, each colour plane is associated with a specific colour_plane_id value.

NOTE 3 – There is no dependency in decoding processes between the colour planes having different colour_plane_id values. For example, the decoding process of a monochrome picture with one value of colour_plane_id does not use any data from monochrome pictures having different values of colour_plane_id for inter prediction.

Depending on the value of separate_colour_plane_flag, the value of the variable ChromaArrayType is assigned as follows.

– If separate_colour_plane_flag is equal to 0, ChromaArrayType is set equal to chroma_format_idc.
– Otherwise (separate_colour_plane_flag is equal to 1), ChromaArrayType is set equal to 0.

**bit_depth_luma_minus8** specifies the bit depth of the samples of the luma array and the value of the luma quantisation parameter range offset $QpBdOffset_Y$, as specified by

$$BitDepth_Y = 8 + bit_depth_luma_minus8 \quad (7\text{-}2)$$

$$QpBdOffset_Y = 6 * bit_depth_luma_minus8 \quad (7\text{-}3)$$

When bit_depth_luma_minus8 is not present, it shall be inferred to be equal to 0. bit_depth_luma_minus8 shall be in the range of 0 to 6, inclusive.

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**bit_depth_chroma_minus8** specifies the bit depth of the samples of the chroma arrays and the value of the chroma quantisation parameter range offset $QpBdOffset_C$, as specified by

$$BitDepth_C = 8 + bit_depth_chroma_minus8 \quad (7\text{-}4)$$

$$QpBdOffset_C = 6 * ( bit_depth_chroma_minus8 + residual_colour_transform_flag ) \quad (7\text{-}5)$$

When bit_depth_chroma_minus8 is not present, it shall be inferred to be equal to 0. bit_depth_chroma_minus8 shall be in the range of 0 to 6, inclusive.

NOTE 4 – The value of bit_depth_chroma_minus8 is not used in the decoding process when ChromaArrayType is equal to 0. In particular, when separate_colour_plane_flag is equal to 1, each colour plane is decoded as a distinct monochrome picture using the luma component decoding process (except for the selection of scaling matrices) and the luma bit depth is used for all three colour components.

The variable RawMbBits is derived as

$$RawMbBits = 256 * BitDepth_Y + 2 * MbWidthC * MbHeightC * BitDepth_C \quad (7\text{-}6)$$

**qpprime_y_zero_transform_bypass_flag** equal to 1 specifies that, when $QP'_Y$ is equal to 0, a transform bypass operation for the transform coefficient decoding process and picture construction process prior to deblocking filter process as specified in subclause 8.5 shall be applied. qpprime_y_zero_transform_bypass_flag equal to 0 specifies that the transform coefficient decoding process and picture construction process prior to deblocking filter process shall not use the transform bypass operation. When qpprime_y_zero_transform_bypass_flag is not present, it shall be inferred to be equal to 0.

**seq_scaling_matrix_present_flag** equal to 1 specifies that the flags seq_scaling_list_present_flag[ i ] for i = 0..7 or i = 0..11 are present. seq_scaling_matrix_present_flag equal to 0 specifies that these flags are not present and the sequence-level scaling list specified by Flat_4x4_16 shall be inferred for i = 0..5 and the sequence-level scaling list specified by Flat_8x8_16 shall be inferred for i = 6..11. When seq_scaling_matrix_present_flag is not present, it shall be inferred to be equal to 0.

The scaling lists Flat_4x4_16 and Flat_8x8_16 are specified as follows:

$$Flat_4x4_16[ i ] = 16, \quad \text{with } i = 0..15, \quad (7\text{-}7)$$

$$Flat_8x8_16[ i ] = 16, \quad \text{with } i = 0..63. \quad (7\text{-}8)$$

**seq_scaling_list_present_flag[** i **]** equal to 1 specifies that the syntax structure for scaling list i is present in the sequence parameter set. seq_scaling_list_present_flag[ i ] equal to 0 specifies that the syntax structure for scaling list i is not present in the sequence parameter set and the scaling list fall-back rule set A specified in Table 7-2 shall be used to infer the sequence-level scaling list for index i.

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**Table 7-2 – Assignment of mnemonic names to scaling list indices and specification of fall-back rule**

| Value of scaling list index | Mnemonic name | Block size | MB prediction type | Component | Scaling list fall-back rule set A | Scaling list fall-back rule set B | Default scaling list |
|---|---|---|---|---|---|---|---|
| 0 | Sl_4x4_Intra_Y | 4x4 | Intra | Y | default scaling list | sequence-level scaling list | Default_4x4_Intra |
| 1 | Sl_4x4_Intra_Cb | 4x4 | Intra | Cb | scaling list for i = 0 | scaling list for i = 0 | Default_4x4_Intra |
| 2 | Sl_4x4_Intra_Cr | 4x4 | Intra | Cr | scaling list for i = 1 | scaling list for i = 1 | Default_4x4_Intra |
| 3 | Sl_4x4_Inter_Y | 4x4 | Inter | Y | default scaling list | sequence-level scaling list | Default_4x4_Inter |
| 4 | Sl_4x4_Inter_Cb | 4x4 | Inter | Cb | scaling list for i = 3 | scaling list for i = 3 | Default_4x4_Inter |
| 5 | Sl_4x4_Inter_Cr | 4x4 | Inter | Cr | scaling list for i = 4 | scaling list for i = 4 | Default_4x4_Inter |
| 6 | Sl_8x8_Intra_Y | 8x8 | Intra | Y | default scaling list | sequence-level scaling list | Default_8x8_Intra |
| 7 | Sl_8x8_Inter_Y | 8x8 | Inter | Y | default scaling list | sequence-level scaling list | Default_8x8_Inter |
| 8 | Sl_8x8_Intra_Cb | 8x8 | Intra | Cb | scaling list for i = 6 | scaling list for i = 6 | Default_8x8_Intra |
| 9 | Sl_8x8_Inter_Cb | 8x8 | Inter | Cb | scaling list for i = 7 | scaling list for i = 7 | Default_8x8_Inter |
| 10 | Sl_8x8_Intra_Cr | 8x8 | Intra | Cr | scaling list for i = 8 | scaling list for i = 8 | Default_8x8_Intra |
| 11 | Sl_8x8_Inter_Cr | 8x8 | Inter | Cr | scaling list for i = 9 | scaling list for i = 9 | Default_8x8_Inter |

Table 7-3 specifies the default scaling lists Default_4x4_Intra and Default_4x4_Inter. Table 7-4 specifies the default scaling lists Default_8x8_Intra and Default_8x8_Inter.

**Table 7-3 – Specification of default scaling lists Default_4x4_Intra and Default_4x4_Inter**

| idx | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Default_4x4_Intra[ idx ]** | 6 | 13 | 13 | 20 | 20 | 20 | 28 | 28 | 28 | 28 | 32 | 32 | 32 | 37 | 37 | 42 |
| **Default_4x4_Inter[ idx ]** | 10 | 14 | 14 | 20 | 20 | 20 | 24 | 24 | 24 | 24 | 27 | 27 | 27 | 30 | 30 | 34 |

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**Table 7-4 – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter**

| idx | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Default_8x8_Intra[ idx ] | 6 | 10 | 10 | 13 | 11 | 13 | 16 | 16 | 16 | 16 | 18 | 18 | 18 | 18 | 18 | 23 |
| Default_8x8_Inter[ idx ] | 9 | 13 | 13 | 15 | 13 | 15 | 17 | 17 | 17 | 17 | 19 | 19 | 19 | 19 | 19 | 21 |

**Table 7-4 (continued) – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter**

| idx | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Default_8x8_Intra[ idx ] | 23 | 23 | 23 | 23 | 23 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 27 | 27 | 27 | 27 |
| Default_8x8_Inter[ idx ] | 21 | 21 | 21 | 21 | 21 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 24 | 24 | 24 | 24 |

**Table 7-4 (continued) – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter**

| idx | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Default_8x8_Intra[ idx ] | 27 | 27 | 27 | 27 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 31 | 31 | 31 | 31 | 31 |
| Default_8x8_Inter[ idx ] | 24 | 24 | 24 | 24 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 27 | 27 | 27 | 27 | 27 |

**Table 7-4 (concluded) – Specification of default scaling lists Default_8x8_Intra and Default_8x8_Inter**

| idx | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Default_8x8_Intra[ idx ] | 31 | 33 | 33 | 33 | 33 | 33 | 36 | 36 | 36 | 36 | 38 | 38 | 38 | 40 | 40 | 42 |
| Default_8x8_Inter[ idx ] | 27 | 28 | 28 | 28 | 28 | 28 | 30 | 30 | 30 | 30 | 32 | 32 | 32 | 33 | 33 | 35 |

**log2_max_frame_num_minus4** specifies the value of the variable MaxFrameNum that is used in frame_num related derivations as follows:

$$\text{MaxFrameNum} = 2^{( \text{log2_max_frame_num_minus4} + 4 )} \quad (7\text{-}9)$$

The value of log2_max_frame_num_minus4 shall be in the range of 0 to 12, inclusive.

**pic_order_cnt_type** specifies the method to decode picture order count (as specified in subclause 8.2.1). The value of pic_order_cnt_type shall be in the range of 0 to 2, inclusive.

pic_order_cnt_type shall not be equal to 2 in a coded video sequence that contains any of the following

- an access unit containing a non-reference frame followed immediately by an access unit containing a non-reference picture;
- two access units each containing a field with the two fields together forming a complementary non-reference field pair followed immediately by an access unit containing a non-reference picture;
- an access unit containing a non-reference field followed immediately by an access unit containing another non-reference picture that does not form a complementary non-reference field pair with the first of the two access units.

**log2_max_pic_order_cnt_lsb_minus4** specifies the value of the variable MaxPicOrderCntLsb that is used in the decoding process for picture order count as specified in subclause 8.2.1 as follows:

$$\text{MaxPicOrderCntLsb} = 2^{( \text{log2_max_pic_order_cnt_lsb_minus4} + 4 )} \quad (7\text{-}10)$$

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The value of log2_max_pic_order_cnt_lsb_minus4 shall be in the range of 0 to 12, inclusive.

**delta_pic_order_always_zero_flag** equal to 1 specifies that delta_pic_order_cnt[ 0 ] and delta_pic_order_cnt[ 1 ] are not present in the slice headers of the sequence and shall be inferred to be equal to 0. delta_pic_order_always_zero_flag equal to 0 specifies that delta_pic_order_cnt[ 0 ] is present in the slice headers of the sequence and delta_pic_order_cnt[ 1 ] may be present in the slice headers of the sequence.

**offset_for_non_ref_pic** is used to calculate the picture order count of a non-reference picture as specified in 8.2.1. The value of offset_for_non_ref_pic shall be in the range of $-2^{31}$ to $2^{31} - 1$, inclusive.

**offset_for_top_to_bottom_field** is used to calculate the picture order count of a bottom field as specified in subclause 8.2.1. The value of offset_for_top_to_bottom_field shall be in the range of $-2^{31}$ to $2^{31} - 1$, inclusive.

**num_ref_frames_in_pic_order_cnt_cycle** is used in the decoding process for picture order count as specified in subclause 8.2.1. The value of num_ref_frames_in_pic_order_cnt_cycle shall be in the range of 0 to 255, inclusive.

**offset_for_ref_frame[** i **]** is an element of a list of num_ref_frames_in_pic_order_cnt_cycle values used in the decoding process for picture order count as specified in subclause 8.2.1. The value of offset_for_ref_frame[ i ] shall be in the range of $-2^{31}$ to $2^{31} - 1$, inclusive.

**num_ref_frames** specifies the maximum number of short-term and long-term reference frames, complementary reference field pairs, and non-paired reference fields that may be used by the decoding process for inter prediction of any picture in the sequence. num_ref_frames also determines the size of the sliding window operation as specified in subclause 8.2.5.3. The value of num_ref_frames shall be in the range of 0 to MaxDpbSize (as specified in subclause A.3.1 or A.3.2), inclusive.

**gaps_in_frame_num_value_allowed_flag** specifies the allowed values of frame_num as specified in subclause 7.4.3 and the decoding process in case of an inferred gap between values of frame_num as specified in subclause 8.2.5.2.

**pic_width_in_mbs_minus1** plus 1 specifies the width of each decoded picture in units of macroblocks.

The variable for the picture width in units of macroblocks is derived as follows

$$PicWidthInMbs = pic_width_in_mbs_minus1 + 1 \quad (7\text{-}11)$$

The variable for picture width for the luma component is derived as follows

$$PicWidthInSamples_L = PicWidthInMbs * 16 \quad (7\text{-}12)$$

The variable for picture width for the chroma components is derived as follows

$$PicWidthInSamples_C = PicWidthInMbs * MbWidthC \quad (7\text{-}13)$$

**pic_height_in_map_units_minus1** plus 1 specifies the height in slice group map units of a decoded frame or field.

The variables PicHeightInMapUnits and PicSizeInMapUnits are derived as follows

$$PicHeightInMapUnits = pic_height_in_map_units_minus1 + 1 \quad (7\text{-}14)$$

$$PicSizeInMapUnits = PicWidthInMbs * PicHeightInMapUnits \quad (7\text{-}15)$$

**frame_mbs_only_flag** equal to 0 specifies that coded pictures of the coded video sequence may either be coded fields or coded frames. frame_mbs_only_flag equal to 1 specifies that every coded picture of the coded video sequence is a coded frame containing only frame macroblocks.

The allowed range of values for pic_width_in_mbs_minus1, pic_height_in_map_units_minus1, and frame_mbs_only_flag is specified by constraints in Annex A.

Depending on frame_mbs_only_flag, semantics are assigned to pic_height_in_map_units_minus1 as follows.

– If frame_mbs_only_flag is equal to 0, pic_height_in_map_units_minus1 plus 1 is the height of a field in units of macroblocks.

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– Otherwise (frame_mbs_only_flag is equal to 1), pic_height_in_map_units_minus1 plus 1 is the height of a frame in units of macroblocks.

The variable FrameHeightInMbs is derived as follows

$$FrameHeightInMbs = ( 2 - frame_mbs_only_flag ) * PicHeightInMapUnits \quad (7\text{-}16)$$

**mb_adaptive_frame_field_flag** equal to 0 specifies no switching between frame and field macroblocks within a picture. mb_adaptive_frame_field_flag equal to 1 specifies the possible use of switching between frame and field macroblocks within frames. When mb_adaptive_frame_field_flag is not present, it shall be inferred to be equal to 0.

**direct_8x8_inference_flag** specifies the method used in the derivation process for luma motion vectors for B_Skip, B_Direct_16x16 and B_Direct_8x8 as specified in subclause 8.4.1.2. When frame_mbs_only_flag is equal to 0, direct_8x8_inference_flag shall be equal to 1.

**frame_cropping_flag** equal to 1 specifies that the frame cropping offset parameters follow next in the sequence parameter set. frame_cropping_flag equal to 0 specifies that the frame cropping offset parameters are not present.

**frame_crop_left_offset, frame_crop_right_offset, frame_crop_top_offset, frame_crop_bottom_offset** specify the samples of the pictures in the coded video sequence that are output from the decoding process, in terms of a rectangular region specified in frame coordinates for output.

The variables CropUnitX and CropUnitY are derived as follows:

— If ChromaArrayType is equal to 0, CropUnitX and CropUnitY are derived as

$$CropUnitX = 1 \quad (7\text{-}17)$$
$$CropUnitY = 2 - frame_mbs_only_flag \quad (7\text{-}18)$$

— Otherwise (ChromaArrayType is equal to 1, 2, or 3), CropUnitX and CropUnitY are derived as

$$CropUnitX = SubWidthC \quad (7\text{-}19)$$
$$CropUnitY = SubHeightC * ( 2 - frame_mbs_only_flag ) \quad (7\text{-}20)$$

The frame cropping rectangle contains luma samples with horizontal frame coordinates from CropUnitX * frame_crop_left_offset to $PicWidthInSamples_L$ – ( CropUnitX * frame_crop_right_offset + 1 ) and vertical frame coordinates from CropUnitY * frame_crop_top_offset to ( 16 * FrameHeightInMbs ) – ( CropUnitY * frame_crop_bottom_offset + 1 ), inclusive. The value of frame_crop_left_offset shall be in the range of 0 to ( $PicWidthInSamples_L$ / CropUnitX ) – ( frame_crop_right_offset + 1 ), inclusive; and the value of frame_crop_top_offset shall be in the range of 0 to ( 16 * FrameHeightInMbs / CropUnitY ) – ( frame_crop_bottom_offset + 1 ), inclusive.

When frame_cropping_flag is equal to 0, the values of frame_crop_left_offset, frame_crop_right_offset, frame_crop_top_offset, and frame_crop_bottom_offset shall be inferred to be equal to 0.

When ChromaArrayType is not equal to 0, the corresponding specified samples of the two chroma arrays are the samples having frame coordinates ( x / SubWidthC, y / SubHeightC ), where ( x, y ) are the frame coordinates of the specified luma samples.

For decoded fields, the specified samples of the decoded field are the samples that fall within the rectangle specified in frame coordinates.

**vui_parameters_present_flag** equal to 1 specifies that the vui_parameters( ) syntax structure as specified in Annex E is present. vui_parameters_present_flag equal to 0 specifies that the vui_parameters( ) syntax structure as specified in Annex E is not present.

#### 7.4.2.1.1.1 Scaling list semantics

**delta_scale** is used to derive the j-th element of the scaling list for j in the range of 0 to sizeOfScalingList - 1, inclusive. The value of delta_scale shall be in the range of -128 to +127, inclusive.

When useDefaultScalingMatrixFlag is derived to be equal to 1, the scaling list shall be inferred to be equal to the default scaling list as specified in Table 7-2.

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#### 7.4.2.1.2 Sequence parameter set extension RBSP semantics

**seq_parameter_set_id** identifies the sequence parameter set associated with the sequence parameter set extension. The value of seq_parameter_set_id shall be in the range of 0 to 31, inclusive.

**aux_format_idc** equal to 0 indicates that there are no auxiliary coded pictures in the coded video sequence. aux_format_idc equal to 1 indicates that exactly one auxiliary coded picture is present in each access unit of the coded video sequence, and that for alpha blending purposes the decoded samples of the associated primary coded picture in each access unit should be multiplied by the interpretation sample values of the auxiliary coded picture in the access unit in the display process after output from the decoding process. aux_format_idc equal to 2 indicates that exactly one auxiliary coded picture exists in each access unit of the coded video sequence, and that for alpha blending purposes the decoded samples of the associated primary coded picture in each access unit should not be multiplied by the interpretation sample values of the auxiliary coded picture in the access unit in the display process after output from the decoding process. aux_format_idc equal to 3 indicates that exactly one auxiliary coded picture exists in each access unit of the coded video sequence, and that the usage of the auxiliary coded pictures is unspecified. The value of aux_format_idc shall be in the range of 0 to 3, inclusive. Values greater than 3 for aux_format_idc are reserved to indicate the presence of exactly one auxiliary coded picture in each access unit of the coded video sequence for purposes to be specified in the future by ITU-T | ISO/IEC. When aux_format_idc is not present, it shall be inferred to be equal to 0.

NOTE 1 – Decoders conforming to this International Standard are not required to decode auxiliary coded pictures.

**bit_depth_aux_minus8** specifies the bit depth of the samples of the sample array of the auxiliary coded picture. bit_depth_aux_minus8 shall be in the range of 0 to 4, inclusive.

**alpha_incr_flag** equal to 0 indicates that the interpretation sample value for each decoded auxiliary coded picture sample value is equal to the decoded auxiliary coded picture sample value for purposes of alpha blending. alpha_incr_flag equal to 1 indicates that, for purposes of alpha blending, after decoding the auxiliary coded picture samples, any auxiliary coded picture sample value that is greater than Min(alpha_opaque_value, alpha_transparent_value) should be increased by one to obtain the interpretation sample value for the auxiliary coded picture sample, and any auxiliary coded picture sample value that is less than or equal to Min(alpha_opaque_value, alpha_transparent_value) should be used without alteration as the interpretation sample value for the decoded auxiliary coded picture sample value.

**alpha_opaque_value** specifies the interpretation sample value of an auxiliary coded picture sample for which the associated luma and chroma samples of the same access unit are considered opaque for purposes of alpha blending. The number of bits used for the representation of the alpha_opaque_value syntax element is bit_depth_aux_minus8 + 9 bits.

**alpha_transparent_value** specifies the interpretation sample value of an auxiliary coded picture sample for which the associated luma and chroma samples of the same access unit are considered transparent for purposes of alpha blending. The number of bits used for the representation of the alpha_transparent_value syntax element is bit_depth_aux_minus8 + 9 bits.

When alpha_incr_flag is equal to 1, alpha_transparent_value shall not be equal to alpha_opaque_value and Log2( Abs( alpha_opaque_value – alpha_transparent_value ) ) shall have an integer value. A value of alpha_transparent_value that is equal to alpha_opaque_value indicates that the auxiliary coded picture is not intended for alpha blending purposes.

NOTE 2 – For alpha blending purposes, alpha_opaque_value may be greater than alpha_transparent_value, or it may be less than alpha_transparent_value. Interpretation sample values should be clipped to the range of alpha_opaque_value to alpha_transparent_value, inclusive.

The decoding of the sequence parameter set extension and the decoding of auxiliary coded pictures is not required for conformance with this International Standard.

The syntax of each coded slice of an auxiliary coded picture shall obey the same constraints as a coded slice of a redundant picture, with the following differences of constraints.

- The following applies in regard to whether the primary coded picture is an IDR picture.
  - If the primary coded picture is an IDR picture, the auxiliary coded slice syntax shall correspond to that of a slice having nal_unit_type equal to 5 (a slice of an IDR picture);
  - Otherwise (the primary coded picture is not an IDR picture), the auxiliary coded slice syntax shall correspond to that of a slice having nal_unit_type equal to 1 (a slice of a non-IDR picture).
- The slices of an auxiliary coded picture (when present) shall contain all macroblocks corresponding to those of the primary coded picture.

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– redundant_pic_cnt shall be equal to 0 in all auxiliary coded slices.

The (optional) decoding process for the decoding of auxiliary coded pictures is the same as if the auxiliary coded pictures were primary coded pictures in a separate coded video stream that differs from the primary coded pictures in the current coded video stream in the following ways.

– The IDR or non-IDR status of each auxiliary coded picture shall be inferred to be the same as the IDR or non-IDR status of the primary picture in the same access unit, rather than being inferred from the value of nal_ref_idc.

– The value of chroma_format_idc and the value of ChromaArrayType shall be inferred to be equal to 0 for the decoding of the auxiliary coded pictures.

– The value of bit_depth_luma_minus8 shall be inferred to be equal to bit_depth_aux_minus8 for the decoding of the auxiliary coded pictures.

NOTE 3 – Alpha blending composition is normally performed with a background picture B, a foreground picture F, and a decoded auxiliary coded picture A, all of the same size. Assume for purposes of example illustration that the chroma resolution of B and F have been upsampled to the same resolution as the luma. Denote corresponding samples of B, F and A by b, f and a, respectively. Denote luma and chroma samples by subscripts Y, Cb and Cr.

Define the variables alphaRange, alphaFwt and alphaBwt as follows:

alphaRange = Abs( alpha_opaque_value - alpha_transparent_value )

alphaFwt = Abs( a - alpha_transparent_value )

alphaBwt = Abs( a - alpha_opaque_value )

Then, in alpha blending composition, samples d of the displayed picture D may be calculated as

$d_Y = ( alphaFwt*f_Y + alphaBwt*b_Y + alphaRange/2 ) / alphaRange$

$d_{CB} = ( alphaFwt*f_{CB} + alphaBwt*b_{CB} + alphaRange/2 ) / alphaRange$

$d_{CR} = ( alphaFwt*f_{CR} + alphaBwt*b_{CR} + alphaRange/2 ) / alphaRange$

The samples of pictures D, F and B could also represent red, green, and blue component values (see subclause E.2.1). Here we have assumed Y, Cb and Cr component values. Each component, e.g. Y, is assumed for purposes of example illustration above to have the same bit depth in each of the pictures D, F and B. However, different components, e.g. Y and Cb, need not have the same bit depth in this example.

When aux_format_idc is equal to 1, F would be the decoded picture obtained from the decoded luma and chroma, and A would be the decoded picture obtained from the decoded auxiliary coded picture. In this case, the indicated example alpha blending composition involves multiplying the samples of F by factors obtained from the samples of A.

A picture format that is useful for editing or direct viewing, and that is commonly used, is called pre-multiplied-black video. If the foreground picture was F, then the pre-multiplied-black video S is given by

$s_Y = ( alphaFwt*f_Y ) / alphaRange$

$s_{CB} = ( alphaFwt*f_{CB} ) / alphaRange$

$s_{CR} = ( alphaFwt*f_{CR} ) / alphaRange$

Pre-multiplied-black video has the characteristic that the picture S will appear correct if displayed against a black background. For a non-black background B, the composition of the displayed picture D may be calculated as

$d_Y = s_Y + ( alphaBwt*b_Y + alphaRange/2 ) / alphaRange$

$d_{CB} = s_{CB} + ( alphaBwt*b_{CB} + alphaRange/2 ) / alphaRange$

$d_{CR} = s_{CR} + ( alphaBwt*b_{CR} + alphaRange/2 ) / alphaRange$

When aux_format_idc is equal to 2, S would be the decoded picture obtained from the decoded luma and chroma, and A would again be the decoded picture obtained from the decoded auxiliary coded picture. In this case, alpha blending composition does not involve multiplication of the samples of S by factors obtained from the samples of A.

**additional_extension_flag** equal to 0 indicates that no additional data follows within the sequence parameter set extension syntax structure prior to the RBSP trailing bits. The value of additional_extension_flag shall be equal to 0. The value of 1 for additional_extension_flag is reserved for future use by ITU-T | ISO/IEC. Decoders that conform to this International Standard shall ignore all data that follows the value of 1 for additional_extension_flag in a sequence parameter set extension NAL unit.

#### 7.4.2.2 Picture parameter set RBSP semantics

**pic_parameter_set_id** identifies the picture parameter set that is referred to in the slice header. The value of pic_parameter_set_id shall be in the range of 0 to 255, inclusive.

**seq_parameter_set_id** refers to the active sequence parameter set. The value of seq_parameter_set_id shall be in the range of 0 to 31, inclusive.

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**entropy_coding_mode_flag** selects the entropy decoding method to be applied for the syntax elements for which two descriptors appear in the syntax tables as follows.

– If entropy_coding_mode_flag is equal to 0, the method specified by the left descriptor in the syntax table is applied (Exp-Golomb coded, see subclause 9.1 or CAVLC, see subclause 9.2).

– Otherwise (entropy_coding_mode_flag is equal to 1), the method specified by the right descriptor in the syntax table is applied (CABAC, see subclause 9.3).

**pic_order_present_flag** equal to 1 specifies that the picture order count related syntax elements are present in the slice headers as specified in subclause 7.3.3. pic_order_present_flag equal to 0 specifies that the picture order count related syntax elements are not present in the slice headers.

**num_slice_groups_minus1** plus 1 specifies the number of slice groups for a picture. When num_slice_groups_minus1 is equal to 0, all slices of the picture belong to the same slice group. The allowed range of num_slice_groups_minus1 is specified in Annex A.

**slice_group_map_type** specifies how the mapping of slice group map units to slice groups is coded. The value of slice_group_map_type shall be in the range of 0 to 6, inclusive.

slice_group_map_type equal to 0 specifies interleaved slice groups.

slice_group_map_type equal to 1 specifies a dispersed slice group mapping.

slice_group_map_type equal to 2 specifies one or more "foreground" slice groups and a "leftover" slice group.

slice_group_map_type values equal to 3, 4, and 5 specify changing slice groups. When num_slice_groups_minus1 is not equal to 1, slice_group_map_type shall not be equal to 3, 4, or 5.

slice_group_map_type equal to 6 specifies an explicit assignment of a slice group to each slice group map unit.

Slice group map units are specified as follows.

– If frame_mbs_only_flag is equal to 0 and mb_adaptive_frame_field_flag is equal to 1 and the coded picture is a frame, the slice group map units are macroblock pair units.

– Otherwise, if frame_mbs_only_flag is equal to 1 or a coded picture is a field, the slice group map units are units of macroblocks.

– Otherwise (frame_mbs_only_flag is equal to 0 and mb_adaptive_frame_field_flag is equal to 0 and the coded picture is a frame), the slice group map units are units of two macroblocks that are vertically contiguous as in a frame macroblock pair of an MBAFF frame.

**run_length_minus1[** i **]** is used to specify the number of consecutive slice group map units to be assigned to the i-th slice group in raster scan order of slice group map units. The value of run_length_minus1[ i ] shall be in the range of 0 to PicSizeInMapUnits - 1, inclusive.

**top_left[** i **]** and **bottom_right[** i **]** specify the top-left and bottom-right corners of a rectangle, respectively. top_left[ i ] and bottom_right[ i ] are slice group map unit positions in a raster scan of the picture for the slice group map units. For each rectangle i, all of the following constraints shall be obeyed by the values of the syntax elements top_left[ i ] and bottom_right[ i ]

– top_left[ i ] shall be less than or equal to bottom_right[ i ] and bottom_right[ i ] shall be less than PicSizeInMapUnits.

– ( top_left[ i ] % PicWidthInMbs ) shall be less than or equal to the value of ( bottom_right[ i ] % PicWidthInMbs ).

**slice_group_change_direction_flag** is used with slice_group_map_type to specify the refined map type when slice_group_map_type is 3, 4, or 5.

**slice_group_change_rate_minus1** is used to specify the variable SliceGroupChangeRate. SliceGroupChangeRate specifies the multiple in number of slice group map units by which the size of a slice group can change from one picture to the next. The value of slice_group_change_rate_minus1 shall be in the range of 0 to PicSizeInMapUnits – 1, inclusive. The SliceGroupChangeRate variable is specified as follows:

$$SliceGroupChangeRate = slice_group_change_rate_minus1 + 1 \quad (7\text{-}21)$$

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**pic_size_in_map_units_minus1** is used to specify the number of slice group map units in the picture. pic_size_in_map_units_minus1 shall be equal to PicSizeInMapUnits - 1.

**slice_group_id[** i **]** identifies a slice group of the i-th slice group map unit in raster scan order. The size of the slice_group_id[ i ] syntax element is Ceil( Log2( num_slice_groups_minus1 + 1 ) ) bits. The value of slice_group_id[ i ] shall be in the range of 0 to num_slice_groups_minus1, inclusive.

**num_ref_idx_l0_active_minus1** specifies the maximum reference index for reference picture list 0 that shall be used to decode each slice of the picture in which list 0 prediction is used when num_ref_idx_active_override_flag is equal to 0 for the slice. When MbaffFrameFlag is equal to 1, num_ref_idx_l0_active_minus1 is the maximum index value for the decoding of frame macroblocks and 2 * num_ref_idx_l0_active_minus1 + 1 is the maximum index value for the decoding of field macroblocks. The value of num_ref_idx_l0_active_minus1 shall be in the range of 0 to 31, inclusive.

**num_ref_idx_l1_active_minus1** has the same semantics as num_ref_idx_l0_active_minus1 with l0 and list 0 replaced by l1 and list 1, respectively.

**weighted_pred_flag** equal to 0 specifies that weighted prediction shall not be applied to P and SP slices. weighted_pred_flag equal to 1 specifies that weighted prediction shall be applied to P and SP slices.

**weighted_bipred_idc** equal to 0 specifies that the default weighted prediction shall be applied to B slices. weighted_bipred_idc equal to 1 specifies that explicit weighted prediction shall be applied to B slices. weighted_bipred_idc equal to 2 specifies that implicit weighted prediction shall be applied to B slices. The value of weighted_bipred_idc shall be in the range of 0 to 2, inclusive.

**pic_init_qp_minus26** specifies the initial value minus 26 of $SliceQP_Y$ for each slice. The initial value is modified at the slice layer when a non-zero value of slice_qp_delta is decoded, and is modified further when a non-zero value of mb_qp_delta is decoded at the macroblock layer. The value of pic_init_qp_minus26 shall be in the range of $-(26 + QpBdOffset_Y)$ to +25, inclusive.

**pic_init_qs_minus26** specifies the initial value minus 26 of $SliceQS_Y$ for all macroblocks in SP or SI slices. The initial value is modified at the slice layer when a non-zero value of slice_qs_delta is decoded. The value of pic_init_qs_minus26 shall be in the range of -26 to +25, inclusive.

**chroma_qp_index_offset** specifies the offset that shall be added to $QP_Y$ and $QS_Y$ for addressing the table of $QP_C$ values for the Cb chroma component. The value of chroma_qp_index_offset shall be in the range of -12 to +12, inclusive.

**deblocking_filter_control_present_flag** equal to 1 specifies that a set of syntax elements controlling the characteristics of the deblocking filter is present in the slice header. deblocking_filter_control_present_flag equal to 0 specifies that the set of syntax elements controlling the characteristics of the deblocking filter is not present in the slice headers and their inferred values are in effect.

**constrained_intra_pred_flag** equal to 0 specifies that intra prediction allows usage of residual data and decoded samples of neighbouring macroblocks coded using Inter macroblock prediction modes for the prediction of macroblocks coded using Intra macroblock prediction modes. constrained_intra_pred_flag equal to 1 specifies constrained intra prediction, in which case prediction of macroblocks coded using Intra macroblock prediction modes only uses residual data and decoded samples from I or SI macroblock types.

**redundant_pic_cnt_present_flag** equal to 0 specifies that the redundant_pic_cnt syntax element is not present in slice headers, data partitions B, and data partitions C that refer (either directly or by association with a corresponding data partition A) to the picture parameter set. redundant_pic_cnt_present_flag equal to 1 specifies that the redundant_pic_cnt syntax element is present in all slice headers, data partitions B, and data partitions C that refer (either directly or by association with a corresponding data partition A) to the picture parameter set.

**transform_8x8_mode_flag** equal to 1 specifies that the 8x8 transform decoding process may be in use (see subclause 8.5). transform_8x8_mode_flag equal to 0 specifies that the 8x8 transform decoding process is not in use. When transform_8x8_mode_flag is not present, it shall be inferred to be 0.

**pic_scaling_matrix_present_flag** equal to 1 specifies that parameters are present to modify the scaling lists specified in the sequence parameter set. pic_scaling_matrix_present_flag equal to 0 specifies that the scaling lists used for the picture shall be inferred to be equal to those specified by the sequence parameter set. When pic_scaling_matrix_present_flag is not present, it shall be inferred to be equal to 0.

**pic_scaling_list_present_flag[** i **]** equal to 1 specifies that the scaling list syntax structure is present to specify the scaling list for index i. pic_scaling_list_present_flag[ i ] equal to 0 specifies that the syntax structure for scaling list i is

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not present in the picture parameter set and that depending on the value of seq_scaling_matrix_present_flag, the following applies.

– If seq_scaling_matrix_present_flag is equal to 0, the scaling list fall-back rule set A as specified in Table 7-2 shall be used to derive the picture-level scaling list for index i.

– Otherwise (seq_scaling_matrix_present_flag is equal to 1), the scaling list fall-back rule set B as specified in Table 7-2 shall be used to derive the picture-level scaling list for index i.

**second_chroma_qp_index_offset** specifies the offset that shall be added to $QP_Y$ and $QS_Y$ for addressing the table of $QP_C$ values for the Cr chroma component. The value of second_chroma_qp_index_offset shall be in the range of -12 to +12, inclusive.

When second_chroma_qp_index_offset is not present, it shall be inferred to be equal to chroma_qp_index_offset.

NOTE – When ChromaArrayType is equal to 0, the values of bit_depth_chroma_minus8, chroma_qp_index_offset and second_chroma_qp_index_offset are not used in the decoding process. In particular, when separate_colour_plane_flag is equal to 1, each colour plane is decoded as a distinct monochrome picture using the luma component decoding process (except for the selection of scaling matrices), including the application of the luma quantisation parameter derivation process without application of an offset for the decoding of the pictures having colour_plane_id not equal to 0.

#### 7.4.2.3 Supplemental enhancement information RBSP semantics

Supplemental Enhancement Information (SEI) contains information that is not necessary to decode the samples of coded pictures from VCL NAL units.

##### 7.4.2.3.1 Supplemental enhancement information message semantics

An SEI NAL unit contains one or more SEI messages. Each SEI message consists of the variables specifying the type payloadType and size payloadSize of the SEI payload. SEI payloads are specified in Annex D. The derived SEI payload size payloadSize is specified in bytes and shall be equal to the number of bytes in the SEI payload.

**ff_byte** is a byte equal to 0xFF identifying a need for a longer representation of the syntax structure that it is used within.

**last_payload_type_byte** is the last byte of the payload type of an SEI message.

**last_payload_size_byte** is the last byte of the size of an SEI message.

#### 7.4.2.4 Access unit delimiter RBSP semantics

The access unit delimiter may be used to indicate the type of slices present in a primary coded picture and to simplify the detection of the boundary between access units. There is no normative decoding process associated with the access unit delimiter.

**primary_pic_type** indicates that the slice_type values for all slices of the primary coded picture are members of the set listed in Table 7-5 for the given value of primary_pic_type.

**Table 7-5 – Meaning of primary_pic_type**

| primary_pic_type | slice_type values that may be present in the primary coded picture |
|---|---|
| 0 | 2, 7 |
| 1 | 0, 2, 5, 7 |
| 2 | 0, 1, 2, 5, 6, 7 |
| 3 | 4, 9 |
| 4 | 3, 4, 8, 9 |
| 5 | 2, 4, 7, 9 |
| 6 | 0, 2, 3, 4, 5, 7, 8, 9 |
| 7 | 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 |

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#### 7.4.2.5 End of sequence RBSP semantics

The end of sequence RBSP specifies that the next subsequent access unit in the bitstream in decoding order (if any) shall be an IDR access unit. The syntax content of the SODB and RBSP for the end of sequence RBSP are empty. No normative decoding process is specified for an end of sequence RBSP.

#### 7.4.2.6 End of stream RBSP semantics

The end of stream RBSP indicates that no additional NAL units shall be present in the bitstream that are subsequent to the end of stream RBSP in decoding order. The syntax content of the SODB and RBSP for the end of stream RBSP are empty. No normative decoding process is specified for an end of stream RBSP.

#### 7.4.2.7 Filler data RBSP semantics

The filler data RBSP contains bytes whose value shall be equal to 0xFF. No normative decoding process is specified for a filler data RBSP.

**ff_byte** is a byte equal to 0xFF.

#### 7.4.2.8 Slice layer without partitioning RBSP semantics

The slice layer without partitioning RBSP consists of a slice header and slice data.

#### 7.4.2.9 Slice data partition RBSP semantics

##### 7.4.2.9.1 Slice data partition A RBSP semantics

When slice data partitioning is in use, the coded data for a single slice is divided into three separate partitions. Partition A contains all syntax elements of category 2.

Category 2 syntax elements include all syntax elements in the slice header and slice data syntax structures other than the syntax elements in the residual( ) syntax structure.

**slice_id** identifies the slice associated with the data partition. The value of slice_id is constrained as follows.

- If separate_colour_plane_flag is equal to 0, the following applies.
  - If arbitrary slice order is not allowed as specified in Annex A, the first slice of a coded picture, in decoding order, shall have slice_id equal to 0 and the value of slice_id shall be incremented by one for each subsequent slice of the coded picture in decoding order.
  - Otherwise (arbitrary slice order is allowed), each slice shall have a unique slice_id value within the set of slices of the coded picture.
- Otherwise (separate_colour_plane_flag is equal to 1), the following applies.
  - If arbitrary slice order is not allowed as specified in Annex A, the first slice of a coded picture having each value of colour_plane_id, in decoding order, shall have slice_id equal to 0 and the value of slice_id shall be incremented by one for each subsequent slice of the coded picture having the same value of colour_plane_id, in decoding order.
  - Otherwise (arbitrary slice order is allowed) each slice shall have a unique slice_id value within each set of slices of the coded picture that have the same value of colour_plane_id.

The range of slice_id is specified as follows.

- If MbaffFrameFlag is equal to 0, slice_id shall be in the range of 0 to PicSizeInMbs - 1, inclusive.
- Otherwise (MbaffFrameFlag is equal to 1), slice_id shall be in the range of 0 to PicSizeInMbs / 2 - 1, inclusive.

##### 7.4.2.9.2 Slice data partition B RBSP semantics

When slice data partitioning is in use, the coded data for a single slice is divided into one to three separate partitions. Slice data partition B contains all syntax elements of category 3.

Category 3 syntax elements include all syntax elements in the residual( ) syntax structure and in syntax structures used within that syntax structure for collective macroblock types I and SI as specified in Table 7-10.

**slice_id** has the same semantics as specified in subclause 7.4.2.9.1.

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**colour_plane_id** specifies the colour plane associated with the current slice RBSP when separate_colour_plane_flag is equal to 1. The value of colour_plane_id shall be in the range of 0 to 2, inclusive. colour_plane_id equal to 0, 1, and 2 correspond to the Y, Cb, and Cr planes, respectively.

NOTE – There is no dependency between the decoding processes of pictures having different values of colour_plane_id.

**redundant_pic_cnt** shall be equal to 0 for slices and slice data partitions belonging to the primary coded picture. The redundant_pic_cnt shall be greater than 0 for coded slices and coded slice data partitions in redundant coded pictures. When redundant_pic_cnt is not present, its value shall be inferred to be equal to 0. The value of redundant_pic_cnt shall be in the range of 0 to 127, inclusive.

The presence of a slice data partition B RBSP is specified as follows.

– If the syntax elements of a slice data partition A RBSP indicate the presence of any syntax elements of category 3 in the slice data for a slice, a slice data partition B RBSP shall be present having the same value of slice_id and redundant_pic_cnt as in the slice data partition A RBSP.

– Otherwise (the syntax elements of a slice data partition A RBSP do not indicate the presence of any syntax elements of category 3 in the slice data for a slice), no slice data partition B RBSP shall be present having the same value of slice_id and redundant_pic_cnt as in the slice data partition A RBSP.

#### 7.4.2.9.3 Slice data partition C RBSP semantics

When slice data partitioning is in use, the coded data for a single slice is divided into three separate partitions. Slice data partition C contains all syntax elements of category 4.

Category 4 syntax elements include all syntax elements in the residual( ) syntax structure and in syntax structures used within that syntax structure for collective macroblock types P and B as specified in Table 7-10.

**slice_id** has the same semantics as specified in subclause 7.4.2.9.1.

**colour_plane_id** has the same semantics as specified in subclause 7.4.2.9.2.

**redundant_pic_cnt** has the same semantics as specified in subclause 7.4.2.9.2.

The presence of a slice data partition C RBSP is specified as follows.

– If the syntax elements of a slice data partition A RBSP indicate the presence of any syntax elements of category 4 in the slice data for a slice, a slice data partition C RBSP shall be present having the same value of slice_id and redundant_pic_cnt as in the slice data partition A RBSP.

– Otherwise (the syntax elements of a slice data partition A RBSP do not indicate the presence of any syntax elements of category 4 in the slice data for a slice), no slice data partition C RBSP shall be present having the same value of slice_id and redundant_pic_cnt as in the slice data partition A RBSP.

### 7.4.2.10 RBSP slice trailing bits semantics

**cabac_zero_word** is a byte-aligned sequence of two bytes equal to 0x0000.

Let NumBytesInVclNALunits be the sum of the values of NumBytesInNALunit for all VCL NAL units of a coded picture.

Let BinCountsInNALunits be the number of times that the parsing process function DecodeBin( ), specified in subclause 9.3.3.2, is invoked to decode the contents of all VCL NAL units of a coded picture. When entropy_coding_mode_flag is equal to 1, BinCountsInNALunits shall not exceed ( 32 ÷ 3 ) * NumBytesInVclNALunits + ( RawMbBits * PicSizeInMbs ) ÷ 32.

NOTE – The constraint on the maximum number of bins resulting from decoding the contents of the slice layer NAL units can be met by inserting a number of cabac_zero_word syntax elements to increase the value of NumBytesInVclNALunits. Each cabac_zero_word is represented in a NAL unit by the three-byte sequence 0x000003 (as a result of the constraints on NAL unit contents that result in requiring inclusion of an emulation_prevention_three_byte for each cabac_zero_word).

### 7.4.2.11 RBSP trailing bits semantics

**rbsp_stop_one_bit** shall be equal to 1.

**rbsp_alignment_zero_bit** shall be equal to 0.

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### 7.4.3 Slice header semantics

When present, the value of the slice header syntax elements pic_parameter_set_id, frame_num, field_pic_flag, bottom_field_flag, idr_pic_id, pic_order_cnt_lsb, delta_pic_order_cnt_bottom, delta_pic_order_cnt[ 0 ], delta_pic_order_cnt[ 1 ], sp_for_switch_flag, and slice_group_change_cycle shall be the same in all slice headers of a coded picture.

**first_mb_in_slice** specifies the address of the first macroblock in the slice. When arbitrary slice order is not allowed as specified in Annex A, the value of first_mb_in_slice is constrained as follows.

– If separate_colour_plane_flag is equal to 0, the value of first_mb_in_slice shall not be less than the value of first_mb_in_slice for any other slice of the current picture that precedes the current slice in decoding order.

– Otherwise (separate_colour_plane_flag is equal to 1), the value of first_mb_in_slice shall not be less than the value of first_mb_in_slice for any other slice of the current picture that precedes the current slice in decoding order and has the same value of colour_plane_id.

The first macroblock address of the slice is derived as follows.

– If MbaffFrameFlag is equal to 0, first_mb_in_slice is the macroblock address of the first macroblock in the slice, and first_mb_in_slice shall be in the range of 0 to PicSizeInMbs – 1, inclusive.

– Otherwise (MbaffFrameFlag is equal to 1), first_mb_in_slice * 2 is the macroblock address of the first macroblock in the slice, which is the top macroblock of the first macroblock pair in the slice, and first_mb_in_slice shall be in the range of 0 to PicSizeInMbs / 2 – 1, inclusive.

**slice_type** specifies the coding type of the slice according to Table 7-6.

**Table 7-6 – Name association to slice_type**

| slice_type | Name of slice_type |
|---|---|
| 0 | P (P slice) |
| 1 | B (B slice) |
| 2 | I (I slice) |
| 3 | SP (SP slice) |
| 4 | SI (SI slice) |
| 5 | P (P slice) |
| 6 | B (B slice) |
| 7 | I (I slice) |
| 8 | SP (SP slice) |
| 9 | SI (SI slice) |

slice_type values in the range 5..9 specify, in addition to the coding type of the current slice, that all other slices of the current coded picture shall have a value of slice_type equal to the current value of slice_type or equal to the current value of slice_type – 5.

When nal_unit_type is equal to 5 (IDR picture), slice_type shall be equal to 2, 4, 7, or 9.

When num_ref_frames is equal to 0, slice_type shall be equal to 2, 4, 7, or 9.

**pic_parameter_set_id** specifies the picture parameter set in use. The value of pic_parameter_set_id shall be in the range of 0 to 255, inclusive.

**colour_plane_id** specifies the colour plane associated with the current slice RBSP when separate_colour_plane_flag is equal to 1. The value of colour_plane_id shall be in the range of 0 to 2, inclusive. colour_plane_id equal to 0, 1, and 2 correspond to the Y, Cb, and Cr planes, respectively.

NOTE 1 – There is no dependency between the decoding processes of pictures having different values of colour_plane_id.

**frame_num** is used as an identifier for pictures and shall be represented by log2_max_frame_num_minus4 + 4 bits in the bitstream. frame_num is constrained as follows:

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The variable PrevRefFrameNum is derived as follows.

– If the current picture is an IDR picture, PrevRefFrameNum is set equal to 0.

– Otherwise (the current picture is not an IDR picture), PrevRefFrameNum is set as follows.

  – If the decoding process for gaps in frame_num specified in subclause 8.2.5.2 was invoked by the decoding process for an access unit that contained a non-reference picture that followed the previous access unit in decoding order that contained a reference picture, PrevRefFrameNum is set equal to the value of frame_num for the last of the "non-existing" reference frames inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2.

  – Otherwise, PrevRefFrameNum is set equal to the value of frame_num for the previous access unit in decoding order that contained a reference picture.

The value of frame_num is constrained as follows.

– If the current picture is an IDR picture, frame_num shall be equal to 0.

– Otherwise (the current picture is not an IDR picture), referring to the primary coded picture in the previous access unit in decoding order that contains a reference picture as the preceding reference picture, the value of frame_num for the current picture shall not be equal to PrevRefFrameNum unless all of the following three conditions are true.

  – the current picture and the preceding reference picture belong to consecutive access units in decoding order

  – the current picture and the preceding reference picture are reference fields having opposite parity

  – one or more of the following conditions is true

    – the preceding reference picture is an IDR picture

    – the preceding reference picture includes a memory_management_control_operation syntax element equal to 5

      NOTE 2 – When the preceding reference picture includes a memory_management_control_operation syntax element equal to 5, PrevRefFrameNum is equal to 0.

    – there is a primary coded picture that precedes the preceding reference picture and the primary coded picture that precedes the preceding reference picture does not have frame_num equal to PrevRefFrameNum

    – there is a primary coded picture that precedes the preceding reference picture and the primary coded picture that precedes the preceding reference picture is not a reference picture

When the value of frame_num is not equal to PrevRefFrameNum, the following applies.

– There shall not be any previous field or frame in decoding order that is currently marked as "used for short-term reference" that has a value of frame_num equal to any value taken on by the variable UnusedShortTermFrameNum in the following:

```
UnusedShortTermFrameNum = ( PrevRefFrameNum + 1 ) % MaxFrameNum
while( UnusedShortTermFrameNum  !=  frame_num )                    (7-22)
    UnusedShortTermFrameNum = ( UnusedShortTermFrameNum + 1 ) % MaxFrameNum
```

– The value of frame_num is constrained as follows.

  – If gaps_in_frame_num_value_allowed_flag is equal to 0, the value of frame_num for the current picture shall be equal to ( PrevRefFrameNum + 1 ) % MaxFrameNum.

  – Otherwise (gaps_in_frame_num_value_allowed_flag is equal to 1), the following applies.

    – If frame_num is greater than PrevRefFrameNum, there shall not be any non-reference pictures in the bitstream that follow the previous reference picture and precede the current picture in decoding order in which either of the following conditions is true.

      – The value of frame_num for the non-reference picture is less than PrevRefFrameNum.

      – The value of frame_num for the non-reference picture is greater than the value of frame_num for the current picture.

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- Otherwise (frame_num is less than PrevRefFrameNum), there shall not be any non-reference pictures in the bitstream that follow the previous reference picture and precede the current picture in decoding order in which both of the following conditions are true.
  - The value of frame_num for the non-reference picture is less than PrevRefFrameNum.
  - The value of frame_num for the non-reference picture is greater than the value of frame_num for the current picture.

A picture including a memory_management_control_operation equal to 5 shall have frame_num constraints as described above and, after the decoding of the current picture and the processing of the memory management control operations, the picture shall be inferred to have had frame_num equal to 0 for all subsequent use in the decoding process, except as specified in subclause 7.4.1.2.4.

NOTE 3 – When the primary coded picture is not an IDR picture and does not contain memory_management_control_operation syntax element equal to 5, the value of frame_num of a corresponding redundant coded picture is the same as the value of frame_num in the primary coded picture. Alternatively, the redundant coded picture includes a memory_management_control_operation syntax element equal to 5 and the corresponding primary coded picture is an IDR picture.

**field_pic_flag** equal to 1 specifies that the slice is a slice of a coded field. field_pic_flag equal to 0 specifies that the slice is a slice of a coded frame. When field_pic_flag is not present it shall be inferred to be equal to 0.

The variable MbaffFrameFlag is derived as follows.

$$MbaffFrameFlag = ( mb_adaptive_frame_field_flag \;\&\&\; !field_pic_flag ) \quad (7\text{-}23)$$

The variable for the picture height in units of macroblocks is derived as follows

$$PicHeightInMbs = FrameHeightInMbs / ( 1 + field_pic_flag ) \quad (7\text{-}24)$$

The variable for picture height for the luma component is derived as follows

$$PicHeightInSamples_L = PicHeightInMbs * 16 \quad (7\text{-}25)$$

The variable for picture height for the chroma component is derived as follows

$$PicHeightInSamples_C = PicHeightInMbs * MbHeightC \quad (7\text{-}26)$$

The variable PicSizeInMbs for the current picture is derived according to:

$$PicSizeInMbs = PicWidthInMbs * PicHeightInMbs \quad (7\text{-}27)$$

The variable MaxPicNum is derived as follows.

- If field_pic_flag is equal to 0, MaxPicNum is set equal to MaxFrameNum.
- Otherwise (field_pic_flag is equal to 1), MaxPicNum is set equal to 2*MaxFrameNum.

The variable CurrPicNum is derived as follows.

- If field_pic_flag is equal to 0, CurrPicNum is set equal to frame_num.
- Otherwise (field_pic_flag is equal to 1), CurrPicNum is set equal to 2 * frame_num + 1.

**bottom_field_flag** equal to 1 specifies that the slice is part of a coded bottom field. bottom_field_flag equal to 0 specifies that the picture is a coded top field. When this syntax element is not present for the current slice, it shall be inferred to be equal to 0.

**idr_pic_id** identifies an IDR picture. The values of idr_pic_id in all the slices of an IDR picture shall remain unchanged. When two consecutive access units in decoding order are both IDR access units, the value of idr_pic_id in the slices of the first such IDR access unit shall differ from the idr_pic_id in the second such IDR access unit. The value of idr_pic_id shall be in the range of 0 to 65535, inclusive.

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**pic_order_cnt_lsb** specifies the picture order count modulo MaxPicOrderCntLsb for the top field of a coded frame or for a coded field. The size of the pic_order_cnt_lsb syntax element is log2_max_pic_order_cnt_lsb_minus4 + 4 bits. The value of the pic_order_cnt_lsb shall be in the range of 0 to MaxPicOrderCntLsb – 1, inclusive.

**delta_pic_order_cnt_bottom** specifies the picture order count difference between the bottom field and the top field of a coded frame as follows.

– If the current picture includes a memory_management_control_operation equal to 5, the value of delta_pic_order_cnt_bottom shall be in the range of ( 1 – MaxPicOrderCntLsb ) to $2^{31}$ - 1, inclusive.

– Otherwise (the current picture does not include a memory_management_control_operation equal to 5), the value of delta_pic_order_cnt_bottom shall be in the range of $-2^{31}$ to $2^{31}$ - 1, inclusive.

When this syntax element is not present in the bitstream for the current slice, it shall be inferred to be equal to 0.

**delta_pic_order_cnt[** 0 **]** specifies the picture order count difference from the expected picture order count for the top field of a coded frame or for a coded field as specified in subclause 8.2.1. The value of delta_pic_order_cnt[ 0 ] shall be in the range of $-2^{31}$ to $2^{31}$ - 1, inclusive. When this syntax element is not present in the bitstream for the current slice, it shall be inferred to be equal to 0.

**delta_pic_order_cnt[** 1 **]** specifies the picture order count difference from the expected picture order count for the bottom field of a coded frame specified in subclause 8.2.1. The value of delta_pic_order_cnt[ 1 ] shall be in the range of $-2^{31}$ to $2^{31}$ - 1, inclusive. When this syntax element is not present in the bitstream for the current slice, it shall be inferred to be equal to 0.

**redundant_pic_cnt** shall be equal to 0 for slices and slice data partitions belonging to the primary coded picture. The value of redundant_pic_cnt shall be greater than 0 for coded slices or coded slice data partitions of a redundant coded picture. When redundant_pic_cnt is not present in the bitstream, its value shall be inferred to be equal to 0. The value of redundant_pic_cnt shall be in the range of 0 to 127, inclusive.

NOTE 4 – Any area of the decoded primary picture and the corresponding area that would result from application of the decoding process specified in clause 8 for any redundant picture in the same access unit should be visually similar in appearance.

The value of pic_parameter_set_id in a coded slice or coded slice data partition of a redundant coded picture shall be such that the value of pic_order_present_flag in the picture parameter set in use in a redundant coded picture is equal to the value of pic_order_present_flag in the picture parameter set in use in the corresponding primary coded picture.

When present in the primary coded picture and any redundant coded picture, the following syntax elements shall have the same value: field_pic_flag, bottom_field_flag, and idr_pic_id.

When the value of nal_ref_idc in one VCL NAL unit of an access unit is equal to 0, the value of nal_ref_idc in all other VCL NAL units of the same access unit shall be equal to 0.

NOTE 5 – The above constraint also has the following implications. If the value of nal_ref_idc for the VCL NAL units of the primary coded picture is equal to 0, the value of nal_ref_idc for the VCL NAL units of any corresponding redundant coded picture are equal to 0; otherwise (the value of nal_ref_idc for the VCL NAL units of the primary coded picture is greater than 0), the value of nal_ref_idc for the VCL NAL units of any corresponding redundant coded picture are also greater than 0.

The marking status of reference pictures and the value of frame_num after the decoded reference picture marking process as specified in subclause 8.2.5 is invoked for the primary coded picture or any redundant coded picture of the same access unit shall be identical regardless whether the primary coded picture or any redundant coded picture (instead of the primary coded picture) of the access unit would be decoded.

NOTE 6 – The above constraint also has the following implications.

If a primary coded picture is not an IDR picture, the contents of the dec_ref_pic_marking( ) syntax structure must be identical in all slice headers of the primary coded picture and all redundant coded pictures corresponding to the primary coded picture.

Otherwise (a primary coded picture is an IDR picture), the following applies.

If a redundant coded picture corresponding to the primary coded picture is an IDR picture, the contents of the dec_ref_pic_marking( ) syntax structure must be identical in all slice headers of the primary coded picture and the redundant coded picture corresponding to the primary coded picture.

Otherwise (a redundant picture corresponding to the primary coded picture is not an IDR picture), all slice headers of the redundant picture must contain a dec_ref_pic_marking syntax( ) structure including a memory_management_control_operation syntax element equal to 5, and the following applies.

If the value of long_term_reference_flag in the primary coded picture is equal to 0, the dec_ref_pic_marking syntax structure of the redundant coded picture must not include a memory_management_control_operation syntax element equal to 6.

Otherwise (the value of long_term_reference_flag in the primary coded picture is equal to 1), the dec_ref_pic_marking syntax structure of the redundant coded picture must include memory_management_control_operation syntax elements equal to 5, 4, and

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6 in decoding order, and the value of max_long_term_frame_idx_plus1 must be equal to 1, and the value of long_term_frame_idx must be equal to 0.

The values of TopFieldOrderCnt and BottomFieldOrderCnt (if applicable) that result after completion of the decoding process for any redundant coded picture or the primary coded picture of the same access unit shall be identical regardless whether the primary coded picture or any redundant coded picture (instead of the primary coded picture) of the access unit would be decoded.

There is no required decoding process for a coded slice or coded slice data partition of a redundant coded picture. When the redundant_pic_cnt in the slice header of a coded slice is greater than 0, the decoder may discard the coded slice. However, a coded slice or coded slice data partition of any redundant coded picture shall obey the same constraints as a coded slice or coded slice data partition of a primary picture.

NOTE 7 – When some of the samples in the decoded primary picture cannot be correctly decoded due to errors or losses in transmission of the sequence and a coded redundant slice can be correctly decoded, the decoder should replace the samples of the decoded primary picture with the corresponding samples of the decoded redundant slice. When more than one redundant slice covers the relevant region of the primary picture, the redundant slice having the lowest value of redundant_pic_cnt should be used.

Redundant slices and slice data partitions having the same value of redundant_pic_cnt belong to the same redundant picture. Decoded slices within the same redundant picture need not cover the entire picture area and shall not overlap.

**direct_spatial_mv_pred_flag** specifies the method used in the decoding process to derive motion vectors and reference indices for inter prediction as follows.

– If direct_spatial_mv_pred_flag is equal to 1, the derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8 in subclause 8.4.1.2 shall use spatial direct mode prediction as specified in subclause 8.4.1.2.2.

– Otherwise (direct_spatial_mv_pred_flag is equal to 0), the derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8 in subclause 8.4.1.2 shall use temporal direct mode prediction as specified in subclause 8.4.1.2.3.

**num_ref_idx_active_override_flag** equal to 0 specifies that the values of the syntax elements num_ref_idx_l0_active_minus1 and num_ref_idx_l1_active_minus1 specified in the referred picture parameter set are in effect. num_ref_idx_active_override_flag equal to 1 specifies that the num_ref_idx_l0_active_minus1 and num_ref_idx_l1_active_minus1 specified in the referred picture parameter set are overridden for the current slice (and only for the current slice) by the following values in the slice header.

When the current slice is a P, SP or B slice and field_pic_flag is equal to 0 and the value of num_ref_idx_l0_active_minus1 in the picture parameter set exceeds 15, num_ref_idx_active_override_flag shall be equal to 1.

When the current slice is a B slice and field_pic_flag is equal to 0 and the value of num_ref_idx_l1_active_minus1 in the picture parameter set exceeds 15, num_ref_idx_active_override_flag shall be equal to 1.

**num_ref_idx_l0_active_minus1** specifies the maximum reference index for reference picture list 0 that shall be used to decode the slice.

The range of num_ref_idx_l0_active_minus1 is specified as follows.

– If field_pic_flag is equal to 0, num_ref_idx_l0_active_minus1 shall be in the range of 0 to 15, inclusive. When MbaffFrameFlag is equal to 1, num_ref_idx_l0_active_minus1 is the maximum index value for the decoding of frame macroblocks and 2 * num_ref_idx_l0_active_minus1 + 1 is the maximum index value for the decoding of field macroblocks.

– Otherwise (field_pic_flag is equal to 1), num_ref_idx_l0_active_minus1 shall be in the range of 0 to 31, inclusive.

**num_ref_idx_l1_active_minus1** has the same semantics as num_ref_idx_l0_active_minus1 with l0 and list 0 replaced by l1 and list 1, respectively.

**cabac_init_idc** specifies the index for determining the initialisation table used in the initialisation process for context variables. The value of cabac_init_idc shall be in the range of 0 to 2, inclusive.

**slice_qp_delta** specifies the initial value of $QP_Y$ to be used for all the macroblocks in the slice until modified by the value of mb_qp_delta in the macroblock layer. The initial $QP_Y$ quantisation parameter for the slice is computed as:

$$SliceQP_Y = 26 + pic_init_qp_minus26 + slice_qp_delta \quad (7\text{-}28)$$

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The value of slice_qp_delta shall be limited such that $SliceQP_Y$ is in the range of $-QpBdOffset_Y$ to +51, inclusive.

**sp_for_switch_flag** specifies the decoding process to be used to decode P macroblocks in an SP slice as follows.

– If sp_for_switch_flag is equal to 0, the P macroblocks in the SP slice shall be decoded using the SP decoding process for non-switching pictures as specified in subclause 8.6.1.

– Otherwise (sp_for_switch_flag is equal to 1), the P macroblocks in the SP slice shall be decoded using the SP and SI decoding process for switching pictures as specified in subclause 8.6.2.

**slice_qs_delta** specifies the value of $QS_Y$ for all the macroblocks in SP and SI slices. The $QS_Y$ quantisation parameter for the slice is computed as:

$$QS_Y = 26 + pic_init_qs_minus26 + slice_qs_delta \quad (7\text{-}29)$$

The value of slice_qs_delta shall be limited such that $QS_Y$ is in the range of 0 to 51, inclusive. This value of $QS_Y$ is used for the decoding of all macroblocks in SI slices with mb_type equal to SI and all macroblocks in SP slices with prediction mode equal to inter.

**disable_deblocking_filter_idc** specifies whether the operation of the deblocking filter shall be disabled across some block edges of the slice and specifies for which edges the filtering is disabled. When disable_deblocking_filter_idc is not present in the slice header, the value of disable_deblocking_filter_idc shall be inferred to be equal to 0.

The value of disable_deblocking_filter_idc shall be in the range of 0 to 2, inclusive.

**slice_alpha_c0_offset_div2** specifies the offset used in accessing the α and $t_{C0}$ deblocking filter tables for filtering operations controlled by the macroblocks within the slice. From this value, the offset that shall be applied when addressing these tables shall be computed as:

$$FilterOffsetA = slice_alpha_c0_offset_div2 << 1 \quad (7\text{-}30)$$

The value of slice_alpha_c0_offset_div2 shall be in the range of -6 to +6, inclusive. When slice_alpha_c0_offset_div2 is not present in the slice header, the value of slice_alpha_c0_offset_div2 shall be inferred to be equal to 0.

**slice_beta_offset_div2** specifies the offset used in accessing the β deblocking filter table for filtering operations controlled by the macroblocks within the slice. From this value, the offset that is applied when addressing the β table of the deblocking filter shall be computed as:

$$FilterOffsetB = slice_beta_offset_div2 << 1 \quad (7\text{-}31)$$

The value of slice_beta_offset_div2 shall be in the range of -6 to +6, inclusive. When slice_beta_offset_div2 is not present in the slice header the value of slice_beta_offset_div2 shall be inferred to be equal to 0.

**slice_group_change_cycle** is used to derive the number of slice group map units in slice group 0 when slice_group_map_type is equal to 3, 4, or 5, as specified by

$$MapUnitsInSliceGroup0 = Min( slice_group_change_cycle * SliceGroupChangeRate, PicSizeInMapUnits ) \quad (7\text{-}32)$$

The value of slice_group_change_cycle is represented in the bitstream by the following number of bits

$$Ceil( Log2( PicSizeInMapUnits \div SliceGroupChangeRate + 1 ) ) \quad (7\text{-}33)$$

The value of slice_group_change_cycle shall be in the range of 0 to Ceil( PicSizeInMapUnits÷SliceGroupChangeRate ), inclusive.

#### 7.4.3.1 Reference picture list reordering semantics

The syntax elements reordering_of_pic_nums_idc, abs_diff_pic_num_minus1, and long_term_pic_num specify the change from the initial reference picture lists to the reference picture lists to be used for decoding the slice.

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**ref_pic_list_reordering_flag_l0** equal to 1 specifies that the syntax element reordering_of_pic_nums_idc is present for specifying reference picture list 0. ref_pic_list_reordering_flag_l0 equal to 0 specifies that this syntax element is not present.

When ref_pic_list_reordering_flag_l0 is equal to 1, the number of times that reordering_of_pic_nums_idc is not equal to 3 following ref_pic_list_reordering_flag_l0 shall not exceed num_ref_idx_l0_active_minus1 + 1.

When RefPicList0[ num_ref_idx_l0_active_minus1 ] in the initial reference picture list produced as specified in subclause 8.2.4.2 is equal to "no reference picture", ref_pic_list_reordering_flag_l0 shall be equal to 1 and reordering_of_pic_nums_idc shall not be equal to 3 until RefPicList0[ num_ref_idx_l0_active_minus1 ] in the reordered list produced as specified in subclause 8.2.4.3 is not equal to "no reference picture".

**ref_pic_list_reordering_flag_l1** equal to 1 specifies that the syntax element reordering_of_pic_nums_idc is present for specifying reference picture list 1. ref_pic_list_reordering_flag_l1 equal to 0 specifies that this syntax element is not present.

When ref_pic_list_reordering_flag_l1 is equal to 1, the number of times that reordering_of_pic_nums_idc is not equal to 3 following ref_pic_list_reordering_flag_l1 shall not exceed num_ref_idx_l1_active_minus1 + 1.

When decoding a slice with slice_type equal to 1 or 6 and RefPicList1[ num_ref_idx_l1_active_minus1 ] in the initial reference picture list produced as specified in subclause 8.2.4.2 is equal to "no reference picture", ref_pic_list_reordering_flag_l1 shall be equal to 1 and reordering_of_pic_nums_idc shall not be equal to 3 until RefPicList1[ num_ref_idx_l1_active_minus1 ] in the reordered list produced as specified in subclause 8.2.4.3 is not equal to "no reference picture".

**reordering_of_pic_nums_idc** together with abs_diff_pic_num_minus1 or long_term_pic_num specifies which of the reference pictures are re-mapped. The values of reordering_of_pic_nums_idc are specified in Table 7-7. The value of the first reordering_of_pic_nums_idc that follows immediately after ref_pic_list_reordering_flag_l0 or ref_pic_list_reordering_flag_l1 shall not be equal to 3.

**Table 7-7 – reordering_of_pic_nums_idc operations for reordering of reference picture lists**

| reordering_of_pic_nums_idc | Reordering specified |
|---|---|
| 0 | abs_diff_pic_num_minus1 is present and corresponds to a difference to subtract from a picture number prediction value |
| 1 | abs_diff_pic_num_minus1 is present and corresponds to a difference to add to a picture number prediction value |
| 2 | long_term_pic_num is present and specifies the long-term picture number for a reference picture |
| 3 | End loop for reordering of the initial reference picture list |

**abs_diff_pic_num_minus1** plus 1 specifies the absolute difference between the picture number of the picture being moved to the current index in the list and the picture number prediction value. abs_diff_pic_num_minus1 shall be in the range of 0 to MaxPicNum – 1. The allowed values of abs_diff_pic_num_minus1 are further restricted as specified in subclause 8.2.4.3.1.

**long_term_pic_num** specifies the long-term picture number of the picture being moved to the current index in the list. When decoding a coded frame, long_term_pic_num shall be equal to a LongTermPicNum assigned to one of the reference frames or complementary reference field pairs marked as "used for long-term reference". When decoding a coded field, long_term_pic_num shall be equal to a LongTermPicNum assigned to one of the reference fields marked as "used for long-term reference".

### 7.4.3.2 Prediction weight table semantics

**luma_log2_weight_denom** is the base 2 logarithm of the denominator for all luma weighting factors. The value of luma_log2_weight_denom shall be in the range of 0 to 7, inclusive.

**chroma_log2_weight_denom** is the base 2 logarithm of the denominator for all chroma weighting factors. The value of chroma_log2_weight_denom shall be in the range of 0 to 7, inclusive.

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**luma_weight_l0_flag** equal to 1 specifies that weighting factors for the luma component of list 0 prediction are present. luma_weight_l0_flag equal to 0 specifies that these weighting factors are not present.

**luma_weight_l0[** i **]** is the weighting factor applied to the luma prediction value for list 0 prediction using RefPicList0[ i ]. When luma_weight_l0_flag is equal to 1, the value of luma_weight_l0[ i ] shall be in the range of –128 to 127, inclusive. When luma_weight_l0_flag is equal to 0, luma_weight_l0[ i ] shall be inferred to be equal to $2^{\text{luma_log2_weight_denom}}$ for RefPicList0[ i ].

**luma_offset_l0[** i **]** is the additive offset applied to the luma prediction value for list 0 prediction using RefPicList0[ i ]. The value of luma_offset_l0[ i ] shall be in the range of –128 to 127, inclusive. When luma_weight_l0_flag is equal to 0, luma_offset_l0[ i ] shall be inferred as equal to 0 for RefPicList0[ i ].

**chroma_weight_l0_flag** equal to 1 specifies that weighting factors for the chroma prediction values of list 0 prediction are present. chroma_weight_l0_flag equal to 0 specifies that these weighting factors are not present.

**chroma_weight_l0[** i **][** j **]** is the weighting factor applied to the chroma prediction values for list 0 prediction using RefPicList0[ i ] with j equal to 0 for Cb and j equal to 1 for Cr. When chroma_weight_l0_flag is equal to 1, the value of chroma_weight_l0[ i ][ j ] shall be in the range of –128 to 127, inclusive. When chroma_weight_l0_flag is equal to 0**,** chroma_weight_l0[ i ][ j ] shall be inferred to be equal to $2^{\text{chroma_log2_weight_denom}}$ for RefPicList0[ i ].

**chroma_offset_l0[** i **][** j **]** is the additive offset applied to the chroma prediction values for list 0 prediction using RefPicList0[ i ] with j equal to 0 for Cb and j equal to 1 for Cr. The value of chroma_offset_l0[ i ][ j ] shall be in the range of -128 to 127, inclusive. When chroma_weight_l0_flag is equal to 0**,** chroma_offset_l0[ i ][ j ] shall be inferred to be equal to 0 for RefPicList0[ i ].

**luma_weight_l1_flag, luma_weight_l1**, **luma_offset_l1**, **chroma_weight_l1_flag**, **chroma_weight_l1**, **chroma_offset_l1** have the same semantics as luma_weight_l0_flag, luma_weight_l0, luma_offset_l0, chroma_weight_l0_flag, chroma_weight_l0, chroma_offset_l0, respectively, with l0, list 0, and List0 replaced by l1, list 1, and List1, respectively.

#### 7.4.3.3 Decoded reference picture marking semantics

The syntax elements no_output_of_prior_pics_flag, long_term_reference_flag, adaptive_ref_pic_marking_mode_flag, memory_management_control_operation, difference_of_pic_nums_minus1, long_term_frame_idx, long_term_pic_num, and max_long_term_frame_idx_plus1 specify marking of the reference pictures.

The marking of a reference picture can be "unused for reference", "used for short-term reference", or "used for long-term reference", but only one among these three. When a reference picture is referred to as being marked as "used for reference", this collectively refers to the picture being marked as "used for short-term reference" or "used for long-term reference" (but not both). A reference picture that is marked as "used for short-term reference" is referred to as a short-term reference picture. A reference picture that is marked as "used for long-term reference" is referred to as a long-term reference picture.

The syntax element adaptive_ref_pic_marking_mode_flag and the content of the decoded reference picture marking syntax structure shall be identical for all coded slices of a coded picture.

The syntax category of the decoded reference picture marking syntax structure shall be inferred as follows.

– If the decoded reference picture marking syntax structure is in a slice header, the syntax category of the decoded reference picture marking syntax structure shall be inferred to be equal to 2.

– Otherwise (the decoded reference picture marking syntax structure is in a decoded reference picture marking repetition SEI message as specified in Annex D), the syntax category of the decoded reference picture marking syntax structure shall be inferred to be equal to 5.

**no_output_of_prior_pics_flag** specifies how the previously-decoded pictures in the decoded picture buffer are treated after decoding of an IDR picture. See Annex C. When the IDR picture is the first IDR picture in the bitstream, the value of no_output_of_prior_pics_flag has no effect on the decoding process. When the IDR picture is not the first IDR picture in the bitstream and the value of PicWidthInMbs, FrameHeightInMbs, or max_dec_frame_buffering derived from the active sequence parameter set is different from the value of PicWidthInMbs, FrameHeightInMbs, or max_dec_frame_buffering derived from the sequence parameter set active for the preceding picture, no_output_of_prior_pics_flag equal to 1 may be inferred by the decoder, regardless of the actual value of no_output_of_prior_pics_flag.

**long_term_reference_flag** equal to 0 specifies that the MaxLongTermFrameIdx variable is set equal to “no long-term frame indices” and that the IDR picture is marked as “used for short-term reference”. long_term_reference_flag equal

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to 1 specifies that the MaxLongTermFrameIdx variable is set equal to 0 and that the current IDR picture is marked “used for long-term reference” and is assigned LongTermFrameIdx equal to 0. When num_ref_frames is equal to 0, long_term_reference_flag shall be equal to 0.

**adaptive_ref_pic_marking_mode_flag** selects the reference picture marking mode of the currently decoded picture as specified in Table 7-8. adaptive_ref_pic_marking_mode_flag shall be equal to 1 when the number of frames, complementary field pairs, and non-paired fields that are currently marked as "used for long-term reference" is equal to Max( num_ref_frames, 1 ).

**Table 7-8 – Interpretation of adaptive_ref_pic_marking_mode_flag**

| adaptive_ref_pic_marking_mode_flag | Reference picture marking mode specified |
|---|---|
| 0 | Sliding window reference picture marking mode: A marking mode providing a first-in first-out mechanism for short-term reference pictures. |
| 1 | Adaptive reference picture marking mode: A reference picture marking mode providing syntax elements to specify marking of reference pictures as “unused for reference” and to assign long-term frame indices. |

**memory_management_control_operation** specifies a control operation to be applied to affect the reference picture marking. The memory_management_control_operation syntax element is followed by data necessary for the operation specified by the value of memory_management_control_operation. The values and control operations associated with memory_management_control_operation are specified in Table 7-9. The memory_management_control_operation syntax elements are processed by the decoding process in the order in which they appear in the slice header, and the semantics constraints expressed for each memory_management_control_operation apply at the specific position in that order at which that individual memory_management_control_operation is processed.

For interpretation of memory_management_control_operation, the term reference picture is interpreted as follows.

– If the current picture is a frame, the term reference picture refers either to a reference frame or a complementary reference field pair.

– Otherwise (the current picture is a field), the term reference picture refers either to a reference field or a field of a reference frame.

memory_management_control_operation shall not be equal to 1 in a slice header unless the specified reference picture is marked as "used for short-term reference" when the memory_management_control_operation is processed by the decoding process.

memory_management_control_operation shall not be equal to 2 in a slice header unless the specified long-term picture number refers to a reference picture that is marked as "used for long-term reference" when the memory_management_control_operation is processed by the decoding process.

memory_management_control_operation shall not be equal to 3 in a slice header unless the specified reference picture is marked as "used for short-term reference" when the memory_management_control_operation is processed by the decoding process.

memory_management_control_operation shall not be equal to 3 or 6 if the value of the variable MaxLongTermFrameIdx is equal to "no long-term frame indices" when the memory_management_control_operation is processed by the decoding process.

Not more than one memory_management_control_operation equal to 4 shall be present in a slice header.

Not more than one memory_management_control_operation equal to 5 shall be present in a slice header.

Not more than one memory_management_control_operation equal to 6 shall be present in a slice header.

memory_management_control_operation shall not be equal to 5 in a slice header unless no memory_management_control_operation in the range of 1 to 3 is present in the same decoded reference picture marking syntax structure.

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A memory_management_control_operation equal to 5 shall not follow a memory_management_control_operation equal to 6 in the same slice header.

When a memory_management_control_operation equal to 6 is present, any memory_management_control_operation equal to 2, 3, or 4 that follows the memory_management_control_operation equal to 6 within the same slice header shall not specify the current picture to be marked as "unused for reference".

NOTE 1 – These constraints prohibit any combination of multiple memory_management_control_operation syntax elements that would specify the current picture to be marked as "unused for reference". However, some other combinations of memory_management_control_operation syntax elements are permitted that may affect the marking status of other reference pictures more than once in the same slice header. In particular, it is permitted for a memory_management_control_operation equal to 3 that specifies a long-term frame index to be assigned to a particular short-term reference picture to be followed in the same slice header by a memory_management_control_operation equal to 2, 3, 4 or 6 that specifies the same reference picture to subsequently be marked as "unused for reference".

**Table 7-9 – Memory management control operation (memory_management_control_operation) values**

| memory_management_control_operation | Memory Management Control Operation |
|---|---|
| 0 | End memory_management_control_operation syntax element loop |
| 1 | Mark a short-term reference picture as “unused for reference” |
| 2 | Mark a long-term reference picture as “unused for reference” |
| 3 | Mark a short-term reference picture as "used for long-term reference" and assign a long-term frame index to it |
| 4 | Specify the maximum long-term frame index and mark all long-term reference pictures having long-term frame indices greater than the maximum value as "unused for reference" |
| 5 | Mark all reference pictures as "unused for reference" and set the MaxLongTermFrameIdx variable to "no long-term frame indices" |
| 6 | Mark the current picture as "used for long-term reference" and assign a long-term frame index to it |

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When decoding a field and a memory_management_control_operation command equal to 3 is present that assigns a long-term frame index to a field that is part of a short-term reference frame or part of a short-term complementary reference field pair, another memory_management_control_operation command to assign the same long-term frame index to the other field of the same frame or complementary reference field pair shall be present in the same decoded reference picture marking syntax structure.

NOTE 2 – The above requirement must be fulfilled even when the field referred to by the memory_management_control_operation equal to 3 is subsequently marked as "unused for reference" (for example when a memory_management_control_operation equal to 2 is present in the same slice header that causes the field to be marked as "unused for reference").

When the first field (in decoding order) of a complementary reference field pair includes a long_term_reference_flag equal to 1 or a memory_management_control_operation command equal to 6, the decoded reference picture marking syntax structure for the other field of the complementary reference field pair shall contain a memory_management_control_operation command equal to 6 that assigns the same long-term frame index to the other field.

NOTE 3 – The above requirement must be fulfilled even when the first field of the complementary reference field pair is subsequently marked as "unused for reference" (for example, when a memory_management_control_operation equal to 2 is present in the slice header of the second field that causes the first field to be marked as "unused for reference").

**difference_of_pic_nums_minus1** is used (with memory_management_control_operation equal to 3 or 1) to assign a long-term frame index to a short-term reference picture or to mark a short-term reference picture as “unused for


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reference". When the associated memory_management_control_operation is processed by the decoding process, the resulting picture number derived from difference_of_pic_nums_minus1 shall be a picture number assigned to one of the reference pictures marked as "used for reference" and not previously assigned to a long-term frame index.

The resulting picture number is constrained as follows.

– If field_pic_flag is equal to 0, the resulting picture number shall be one of the set of picture numbers assigned to reference frames or complementary reference field pairs.

NOTE 4 – When field_pic_flag is equal to 0, the resulting picture number must be a picture number assigned to a complementary reference field pair in which both fields are marked as "used for reference" or a frame in which both fields are marked as "used for reference". In particular, when field_pic_flag is equal to 0, the marking of a non-paired field or a frame in which a single field is marked as "used for reference" cannot be affected by a memory_management_control_operation equal to 1.

– Otherwise (field_pic_flag is equal to 1), the resulting picture number shall be one of the set of picture numbers assigned to reference fields.

**long_term_pic_num** is used (with memory_management_control_operation equal to 2) to mark a long-term reference picture as "unused for reference". When the associated memory_management_control_operation is processed by the decoding process, long_term_pic_num shall be equal to a long-term picture number assigned to one of the reference pictures that is currently marked as "used for long-term reference".

The resulting long-term picture number is constrained as follows.

– If field_pic_flag is equal to 0, the resulting long-term picture number shall be one of the set of long-term picture numbers assigned to reference frames or complementary reference field pairs.

NOTE 5 – When field_pic_flag is equal to 0, the resulting long-term picture number must be a long-term picture number assigned to a complementary reference field pair in which both fields are marked as "used for reference" or a frame in which both fields are marked as "used for reference". In particular, when field_pic_flag is equal to 0, the marking of a non-paired field or a frame in which a single field is marked as "used for reference" cannot be affected by a memory_management_control_operation equal to 2.

– Otherwise (field_pic_flag is equal to 1), the resulting long-term picture number shall be one of the set of long-term picture numbers assigned to reference fields.

**long_term_frame_idx** is used (with memory_management_control_operation equal to 3 or 6) to assign a long-term frame index to a picture. When the associated memory_management_control_operation is processed by the decoding process, the value of long_term_frame_idx shall be in the range of 0 to MaxLongTermFrameIdx, inclusive.

**max_long_term_frame_idx_plus1** minus 1 specifies the maximum value of long-term frame index allowed for long-term reference pictures (until receipt of another value of max_long_term_frame_idx_plus1). The value of max_long_term_frame_idx_plus1 shall be in the range of 0 to num_ref_frames, inclusive.

### 7.4.4 Slice data semantics

**cabac_alignment_one_bit** is a bit equal to 1.

**mb_skip_run** specifies the number of consecutive skipped macroblocks for which, when decoding a P or SP slice, mb_type shall be inferred to be P_Skip and the macroblock type is collectively referred to as a P macroblock type, or for which, when decoding a B slice, mb_type shall be inferred to be B_Skip and the macroblock type is collectively referred to as a B macroblock type. The value of mb_skip_run shall be in the range of 0 to PicSizeInMbs – CurrMbAddr, inclusive.

**mb_skip_flag** equal to 1 specifies that for the current macroblock, when decoding a P or SP slice, mb_type shall be inferred to be P_Skip and the macroblock type is collectively referred to as P macroblock type, or for which, when decoding a B slice, mb_type shall be inferred to be B_Skip and the macroblock type is collectively referred to as B macroblock type. mb_skip_flag equal to 0 specifies that the current macroblock is not skipped.

**mb_field_decoding_flag** equal to 0 specifies that the current macroblock pair is a frame macroblock pair. mb_field_decoding_flag equal to 1 specifies that the macroblock pair is a field macroblock pair. Both macroblocks of a frame macroblock pair are referred to in the text as frame macroblocks, whereas both macroblocks of a field macroblock pair are referred to in the text as field macroblocks.

When mb_field_decoding_flag is not present for either macroblock of a macroblock pair, the value of mb_field_decoding_flag is derived as follows.

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– If there is a neighbouring macroblock pair immediately to the left of the current macroblock pair in the same slice, the value of mb_field_decoding_flag shall be inferred to be equal to the value of mb_field_decoding_flag for the neighbouring macroblock pair immediately to the left of the current macroblock pair,
– Otherwise, if there is no neighbouring macroblock pair immediately to the left of the current macroblock pair in the same slice and there is a neighbouring macroblock pair immediately above the current macroblock pair in the same slice, the value of mb_field_decoding_flag shall be inferred to be equal to the value of mb_field_decoding_flag for the neighbouring macroblock pair immediately above the current macroblock pair,
– Otherwise (there is no neighbouring macroblock pair either immediately to the left or immediately above the current macroblock pair in the same slice), the value of mb_field_decoding_flag shall be inferred to be equal to 0.

**end_of_slice_flag** equal to 0 specifies that another macroblock is following in the slice. end_of_slice_flag equal to 1 specifies the end of the slice and that no further macroblock follows.

The function NextMbAddress( ) used in the slice data syntax table is specified in subclause 8.2.2.

### 7.4.5 Macroblock layer semantics

**mb_type** specifies the macroblock type. The semantics of mb_type depend on the slice type.

Tables and semantics are specified for the various macroblock types for I, SI, P, SP, and B slices. Each table presents the value of mb_type, the name of mb_type, the number of macroblock partitions used (given by the NumMbPart( mb_type ) function), the prediction mode of the macroblock (when it is not partitioned) or the first partition (given by the MbPartPredMode( mb_type, 0 ) function) and the prediction mode of the second partition (given by the MbPartPredMode( mb_type, 1 ) function). When a value is not applicable it is designated by “na”. In the text, the value of mb_type may be referred to as the macroblock type and a value X of MbPartPredMode( ) may be referred to in the text by "X macroblock (partition) prediction mode" or as “X prediction macroblocks”.

Table 7-10 shows the allowed collective macroblock types for each slice type.

NOTE 1 – There are some macroblock types with Pred_L0 prediction mode that are classified as B macroblock types.

**Table 7-10 – Allowed collective macroblock types for slice_type**

| slice_type | allowed collective macroblock types |
|---|---|
| I (slice) | I (see Table 7-11) (macroblock types) |
| P (slice) | P (see Table 7-13) and I (see Table 7-11) (macroblock types) |
| B (slice) | B (see Table 7-14) and I (see Table 7-11) (macroblock types) |
| SI (slice) | SI (see Table 7-12) and I (see Table 7-11) (macroblock types) |
| SP (slice) | P (see Table 7-13) and I (see Table 7-11) (macroblock types) |

**transform_size_8x8_flag** equal to 1 specifies that for the current macroblock the transform coefficient decoding process and picture construction process prior to deblocking filter process for residual 8x8 blocks shall be invoked for luma samples, and when ChromaArrayType == 3 also for Cb and Cr samples. transform_size_8x8_flag equal to 0 specifies that for the current macroblock the transform coefficient decoding process and picture construction process prior to deblocking filter process for residual 4x4 blocks shall be invoked for luma samples, and when ChromaArrayType == 3 also for Cb and Cr samples. When transform_size_8x8_flag is not present in the bitstream, it shall be inferred to be equal to 0.

NOTE 2 – When the current macroblock prediction mode MbPartPredMode( mb_type, 0 ) is equal to Intra_16x16, transform_size_8x8_flag is not present in the bitstream and then inferred to be equal to 0.

When sub_mb_type[ mbPartIdx ] (see subclause 7.4.5.2) is present in the bitstream for all 8x8 blocks indexed by mbPartIdx = 0..3, the variable noSubMbPartSizeLessThan8x8Flag indicates whether for each of the four 8x8 blocks the corresponding SubMbPartWidth( sub_mb_type[ mbPartIdx ] ) and SubMbPartHeight( sub_mb_type[ mbPartIdx ] ) are both equal to 8.

NOTE 3 – When noSubMbPartSizeLessThan8x8Flag is equal to 0 and the current macroblock type is not equal to I_NxN, transform_size_8x8_flag is not present in the bitstream and then inferred to be equal to 0.

Macroblock types that may be collectively referred to as I macroblock types are specified in Table 7-11.

The macroblock types for I slices are all I macroblock types.

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**Table 7-11 – Macroblock types for I slices**

| mb_type | Name of mb_type | transform_size_8x8_flag | MbPartPredMode ( mb_type, 0 ) | Intra16x16PredMode | CodedBlockPatternChroma | CodedBlockPatternLuma |
|---|---|---|---|---|---|---|
| 0 | I_NxN | 0 | Intra_4x4 | na | Equation 7-34 | Equation 7-34 |
| 0 | I_NxN | 1 | Intra_8x8 | na | Equation 7-34 | Equation 7-34 |
| 1 | I_16x16_0_0_0 | na | Intra_16x16 | 0 | 0 | 0 |
| 2 | I_16x16_1_0_0 | na | Intra_16x16 | 1 | 0 | 0 |
| 3 | I_16x16_2_0_0 | na | Intra_16x16 | 2 | 0 | 0 |
| 4 | I_16x16_3_0_0 | na | Intra_16x16 | 3 | 0 | 0 |
| 5 | I_16x16_0_1_0 | na | Intra_16x16 | 0 | 1 | 0 |
| 6 | I_16x16_1_1_0 | na | Intra_16x16 | 1 | 1 | 0 |
| 7 | I_16x16_2_1_0 | na | Intra_16x16 | 2 | 1 | 0 |
| 8 | I_16x16_3_1_0 | na | Intra_16x16 | 3 | 1 | 0 |
| 9 | I_16x16_0_2_0 | na | Intra_16x16 | 0 | 2 | 0 |
| 10 | I_16x16_1_2_0 | na | Intra_16x16 | 1 | 2 | 0 |
| 11 | I_16x16_2_2_0 | na | Intra_16x16 | 2 | 2 | 0 |
| 12 | I_16x16_3_2_0 | na | Intra_16x16 | 3 | 2 | 0 |
| 13 | I_16x16_0_0_1 | na | Intra_16x16 | 0 | 0 | 15 |
| 14 | I_16x16_1_0_1 | na | Intra_16x16 | 1 | 0 | 15 |
| 15 | I_16x16_2_0_1 | na | Intra_16x16 | 2 | 0 | 15 |
| 16 | I_16x16_3_0_1 | na | Intra_16x16 | 3 | 0 | 15 |
| 17 | I_16x16_0_1_1 | na | Intra_16x16 | 0 | 1 | 15 |
| 18 | I_16x16_1_1_1 | na | Intra_16x16 | 1 | 1 | 15 |
| 19 | I_16x16_2_1_1 | na | Intra_16x16 | 2 | 1 | 15 |
| 20 | I_16x16_3_1_1 | na | Intra_16x16 | 3 | 1 | 15 |
| 21 | I_16x16_0_2_1 | na | Intra_16x16 | 0 | 2 | 15 |
| 22 | I_16x16_1_2_1 | na | Intra_16x16 | 1 | 2 | 15 |
| 23 | I_16x16_2_2_1 | na | Intra_16x16 | 2 | 2 | 15 |
| 24 | I_16x16_3_2_1 | na | Intra_16x16 | 3 | 2 | 15 |
| 25 | I_PCM | na | na | na | na | na |

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The following semantics are assigned to the macroblock types in Table 7-11.

I_NxN: A mnemonic name for mb_type equal to 0 with MbPartPredMode( mb_type, 0 ) equal to Intra_4x4 or Intra_8x8.

I_16x16_0_0_0, I_16x16_1_0_0, I_16x16_2_0_0, I_16x16_3_0_0, I_16x16_0_1_0, I_16x16_1_1_0, I_16x16_2_1_0, I_16x16_3_1_0, I_16x16_0_2_0, I_16x16_1_2_0, I_16x16_2_2_0, I_16x16_3_2_0, I_16x16_0_0_1, I_16x16_1_0_1, I_16x16_2_0_1, I_16x16_3_0_1, I_16x16_0_1_1, I_16x16_1_1_1, I_16x16_2_1_1, I_16x16_3_1_1, I_16x16_0_2_1, I_16x16_1_2_1, I_16x16_2_2_1, I_16x16_3_2_1: the macroblock is coded as an Intra_16x16 prediction mode macroblock.

To each Intra_16x16 prediction macroblock, an Intra16x16PredMode is assigned, which specifies the Intra_16x16 prediction mode, and values of CodedBlockPatternLuma and CodedBlockPatternChroma are assigned as specified in Table 7-11.

Intra_4x4 specifies the macroblock prediction mode and specifies that the Intra_4x4 prediction process is invoked as specified in subclause 8.3.1. Intra_4x4 is an Intra macroblock prediction mode.

Intra_8x8 specifies the macroblock prediction mode and specifies that the Intra_8x8 prediction process is invoked as specified in subclause 8.3.2. Intra_8x8 is an Intra macroblock prediction mode.

Intra_16x16 specifies the macroblock prediction mode and specifies that the Intra_16x16 prediction process is invoked as specified in subclause 8.3.3. Intra_16x16 is an Intra macroblock prediction mode.

For a macroblock coded with mb_type equal to I_PCM, the Intra macroblock prediction mode shall be inferred.

A macroblock type that may be referred to as SI macroblock type is specified in Table 7-12.

The macroblock types for SI slices are specified in Table 7-12 and 7-11. The mb_type value 0 is specified in Table 7-12 and the mb_type values 1 to 26 are specified in Table 7-11, indexed by subtracting 1 from the value of mb_type.

**Table 7-12 – Macroblock type with value 0 for SI slices**

| mb_type | Name of mb_type | MbPartPredMode ( mb_type, 0 ) | Intra16x16PredMode | CodedBlockPatternChroma | CodedBlockPatternLuma |
|---|---|---|---|---|---|
| 0 | SI | Intra_4x4 | na | Equation 7-34 | Equation 7-34 |

The following semantics are assigned to the macroblock type in Table 7-12. The SI macroblock is coded as Intra_4x4 prediction macroblock.

Macroblock types that may be collectively referred to as P macroblock types are specified in Table 7-13.

The macroblock types for P and SP slices are specified in Table 7-13 and 7-11. mb_type values 0 to 4 are specified in Table 7-13 and mb_type values 5 to 30 are specified in Table 7-11, indexed by subtracting 5 from the value of mb_type.

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**Table 7-13 – Macroblock type values 0 to 4 for P and SP slices**

| mb_type | Name of mb_type | NumMbPart ( mb_type ) | MbPartPredMode ( mb_type, 0 ) | MbPartPredMode ( mb_type, 1 ) | MbPartWidth ( mb_type ) | MbPartHeight ( mb_type ) |
|---|---|---|---|---|---|---|
| 0 | P_L0_16x16 | 1 | Pred_L0 | na | 16 | 16 |
| 1 | P_L0_L0_16x8 | 2 | Pred_L0 | Pred_L0 | 16 | 8 |
| 2 | P_L0_L0_8x16 | 2 | Pred_L0 | Pred_L0 | 8 | 16 |
| 3 | P_8x8 | 4 | na | na | 8 | 8 |
| 4 | P_8x8ref0 | 4 | na | na | 8 | 8 |
| inferred | P_Skip | 1 | Pred_L0 | na | 16 | 16 |

The following semantics are assigned to the macroblock types in Table 7-13.

– P_L0_16x16: the samples of the macroblock are predicted with one luma macroblock partition of size 16x16 luma samples and associated chroma samples.

– P_L0_L0_MxN, with MxN being replaced by 16x8 or 8x16: the samples of the macroblock are predicted using two luma partitions of size MxN equal to 16x8, or two luma partitions of size MxN equal to 8x16, and associated chroma samples, respectively.

– P_8x8: for each sub-macroblock an additional syntax element (sub_mb_type) is present in the bitstream that specifies the type of the corresponding sub-macroblock (see subclause 7.4.5.2).

– P_8x8ref0: has the same semantics as P_8x8 but no syntax element for the reference index (ref_idx_l0) is present in the bitstream and ref_idx_l0[ mbPartIdx ] shall be inferred to be equal to 0 for all sub-macroblocks of the macroblock (with indices mbPartIdx equal to 0..3).

– P_Skip: no further data is present for the macroblock in the bitstream.

The following semantics are assigned to the macroblock prediction modes (MbPartPredMode( )) in Table 7-13.

– Pred_L0: specifies that the inter prediction process is invoked using list 0 prediction. Pred_L0 is an Inter macroblock prediction mode.

Macroblock types that may be collectively referred to as B macroblock types are specified in Table 7-14.

The macroblock types for B slices are specified in Table 7-14 and 7-11. The mb_type values 0 to 22 are specified in Table 7-14 and the mb_type values 23 to 48 are specified in Table 7-11, indexed by subtracting 23 from the value of mb_type.

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**Table 7-14 – Macroblock type values 0 to 22 for B slices**

| mb_type | Name of mb_type | NumMbPart ( mb_type ) | MbPartPredMode ( mb_type, 0 ) | MbPartPredMode ( mb_type, 1 ) | MbPartWidth ( mb_type ) | MbPartHeight ( mb_type ) |
|---|---|---|---|---|---|---|
| 0 | B_Direct_16x16 | na | Direct | na | 8 | 8 |
| 1 | B_L0_16x16 | 1 | Pred_L0 | na | 16 | 16 |
| 2 | B_L1_16x16 | 1 | Pred_L1 | na | 16 | 16 |
| 3 | B_Bi_16x16 | 1 | BiPred | na | 16 | 16 |
| 4 | B_L0_L0_16x8 | 2 | Pred_L0 | Pred_L0 | 16 | 8 |
| 5 | B_L0_L0_8x16 | 2 | Pred_L0 | Pred_L0 | 8 | 16 |
| 6 | B_L1_L1_16x8 | 2 | Pred_L1 | Pred_L1 | 16 | 8 |
| 7 | B_L1_L1_8x16 | 2 | Pred_L1 | Pred_L1 | 8 | 16 |
| 8 | B_L0_L1_16x8 | 2 | Pred_L0 | Pred_L1 | 16 | 8 |
| 9 | B_L0_L1_8x16 | 2 | Pred_L0 | Pred_L1 | 8 | 16 |
| 10 | B_L1_L0_16x8 | 2 | Pred_L1 | Pred_L0 | 16 | 8 |
| 11 | B_L1_L0_8x16 | 2 | Pred_L1 | Pred_L0 | 8 | 16 |
| 12 | B_L0_Bi_16x8 | 2 | Pred_L0 | BiPred | 16 | 8 |
| 13 | B_L0_Bi_8x16 | 2 | Pred_L0 | BiPred | 8 | 16 |
| 14 | B_L1_Bi_16x8 | 2 | Pred_L1 | BiPred | 16 | 8 |
| 15 | B_L1_Bi_8x16 | 2 | Pred_L1 | BiPred | 8 | 16 |
| 16 | B_Bi_L0_16x8 | 2 | BiPred | Pred_L0 | 16 | 8 |
| 17 | B_Bi_L0_8x16 | 2 | BiPred | Pred_L0 | 8 | 16 |
| 18 | B_Bi_L1_16x8 | 2 | BiPred | Pred_L1 | 16 | 8 |
| 19 | B_Bi_L1_8x16 | 2 | BiPred | Pred_L1 | 8 | 16 |
| 20 | B_Bi_Bi_16x8 | 2 | BiPred | BiPred | 16 | 8 |
| 21 | B_Bi_Bi_8x16 | 2 | BiPred | BiPred | 8 | 16 |
| 22 | B_8x8 | 4 | na | na | 8 | 8 |
| inferred | B_Skip | na | Direct | na | 8 | 8 |

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The following semantics are assigned to the macroblock types in Table 7-14:

– B_Direct_16x16: no motion vector differences or reference indices are present for the macroblock in the bitstream. The functions MbPartWidth( B_Direct_16x16 ), and MbPartHeight( B_Direct_16x16 ) are used in the derivation process for motion vectors and reference frame indices in subclause 8.4.1 for direct mode prediction.


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– B_X_16x16 with X being replaced by L0, L1, or Bi: the samples of the macroblock are predicted with one luma macroblock partition of size 16x16 luma samples and associated chroma samples. For a macroblock with type B_X_16x16 with X being replaced by either L0 or L1, one motion vector difference and one reference index is present in the bitstream for the macroblock. For a macroblock with type B_X_16x16 with X being replaced by Bi, two motion vector differences and two reference indices are present in the bitstream for the macroblock.

– B_X0_X1_MxN, with X0, X1 referring to the first and second macroblock partition and being replaced by L0, L1, or Bi, and MxN being replaced by 16x8 or 8x16: the samples of the macroblock are predicted using two luma partitions of size MxN equal to 16x8, or two luma partitions of size MxN equal to 8x16, and associated chroma samples, respectively. For a macroblock partition X0 or X1 with X0 or X1 being replaced by either L0 or L1, one motion vector difference and one reference index is present in the bitstream. For a macroblock partition X0 or X1 with X0 or X1 being replaced by Bi, two motion vector differences and two reference indices are present in the bitstream for the macroblock partition.

– B_8x8: for each sub-macroblock an additional syntax element (sub_mb_type) is present in the bitstream that specifies the type of the corresponding sub-macroblock (see subclause 7.4.5.2).

– B_Skip: no further data is present for the macroblock in the bitstream. The functions MbPartWidth( B_Skip ), and MbPartHeight( B_Skip ) are used in the derivation process for motion vectors and reference frame indices in subclause 8.4.1 for direct mode prediction.

The following semantics are assigned to the macroblock prediction modes (MbPartPredMode( )) in Table 7-14.

– Direct: no motion vector differences or reference indices are present for the macroblock (in case of B_Skip or B_Direct_16x16) in the bitstream. Direct is an Inter macroblock prediction mode.

– Pred_L0: see semantics for Table 7-13.

– Pred_L1: specifies that the Inter prediction process is invoked using list 1 prediction. Pred_L1 is an Inter macroblock prediction mode.

– BiPred: specifies that the Inter prediction process is invoked using list 0 and list 1 prediction. BiPred is an Inter macroblock prediction mode.

**pcm_alignment_zero_bit** is a bit equal to 0.

**pcm_sample_luma**[ i ] is a sample value. The first pcm_sample_luma[ i ] values represent luma sample values in the raster scan within the macroblock. The number of bits used to represent each of these samples is $BitDepth_Y$. When profile_idc is not equal to 44, 100, 110, 122, or 244, pcm_sample_luma[ i ] shall not be equal to 0.

**pcm_sample_chroma**[ i ] is a sample value. The first MbWidthC * MbHeightC pcm_sample_chroma[ i ] values represent Cb sample values in the raster scan within the macroblock and the remaining MbWidthC * MbHeightC pcm_sample_chroma[ i ] values represent Cr sample values in the raster scan within the macroblock. The number of bits used to represent each of these samples is $BitDepth_C$. When profile_idc is not equal to 44, 100, 110, 122, or 244, pcm_sample_chroma[ i ] shall not be equal to 0.

**coded_block_pattern** specifies which of the four 8x8 luma blocks and associated chroma blocks of a macroblock may contain non-zero transform coefficient levels. When coded_block_pattern is present in the bitstream, the variables CodedBlockPatternLuma and CodedBlockPatternChroma are derived as follows.

```
CodedBlockPatternLuma = coded_block_pattern % 16
CodedBlockPatternChroma = coded_block_pattern / 16                    (7-34)
```

When the macroblock type is not equal to I_PCM, the following applies.

– If the macroblock prediction mode is equal Intra_16x16, the following applies.
  – If ChromaArrayType is not equal to 3, the value of CodedBlockPatternLuma distinguishes between the following cases.
    – If CodedBlockPatternLuma is equal to 0, all AC transform coefficient levels of the luma component of the macroblock are equal to 0 for all 16 of the 4x4 blocks in the 16x16 luma block.

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  - Otherwise (CodedBlockPatternLuma is not equal to 0), CodedBlockPatternLuma is equal to 15, at least one of the AC transform coefficient levels of the luma component of the macroblock shall be non-zero, and the AC transform coefficient levels are scanned for all 16 of the 4x4 blocks in the 16x16 block.
- Otherwise (ChromaArrayType is equal to 3), the value of CodedBlockPatternLuma distinguishes between the following cases.
  - If CodedBlockPatternLuma is equal to 0, all AC transform coefficient levels of the luma, Cb, and Cr components of the macroblock are equal to 0 for all 16 of the 4x4 blocks in the luma, Cb, and Cr components of the macroblock.
  - Otherwise (CodedBlockPatternLuma is not equal to 0), CodedBlockPatternLuma is equal to 15, at least one of the AC transform coefficient levels of the luma, Cb, or Cr components of the macroblock shall be non-zero, and the AC transform coefficient levels are scanned for all 16 of the 4x4 blocks in the luma, Cb, and Cr components of the macroblock.

– Otherwise (the macroblock prediction mode is not equal to Intra_16x16), coded_block_pattern is present in the bitstream, and the following applies.
  - If ChromaArrayType is not equal to 3, each of the four LSBs of CodedBlockPatternLuma distinguishes, for one of the four 8x8 luma blocks of the macroblock, between the following cases.
    - If the corresponding bit of CodedBlockPatternLuma is equal to 0, all transform coefficient levels of the luma transform blocks in the 8x8 luma block are equal to zero.
    - Otherwise (the corresponding bit of CodedBlockPatternLuma is equal to 1), one or more transform coefficient levels of one or more of the luma transform blocks in the 8x8 luma block shall be non-zero valued and the transform coefficient levels of the corresponding transform blocks are scanned.
  - Otherwise (ChromaArrayType is equal to 3), each of the four LSBs of CodedBlockPatternLuma distinguishes, for one of the four 8x8 luma blocks of the macroblock, between the following cases.
    - If the corresponding bit of CodedBlockPatternLuma is equal to 0, all transform coefficient levels of the luma, Cb, and Cr transform blocks in the 8x8 luma block are equal to zero.
    - Otherwise (the corresponding bit of CodedBlockPatternLuma is equal to 1), one or more transform coefficient levels of one or more of the luma, Cb, or Cr transform blocks in the 8x8 luma block shall be non-zero valued and the transform coefficient levels of the corresponding transform blocks are scanned.

When the macroblock type is not equal to I_PCM, CodedBlockPatternChroma is interpreted as follows.

– If ChromaArrayType is not equal to 0 or 3, CodedBlockPatternChroma is specified in Table 7-15.

– Otherwise (ChromaArrayType is equal to 0 or 3), the bitstream shall not contain data that results in a derived value of CodedBlockPatternChroma that is not equal to 0.

**Table 7-15 – Specification of CodedBlockPatternChroma values**

| CodedBlockPatternChroma | Description |
|---|---|
| 0 | All chroma transform coefficient levels are equal to 0. |
| 1 | One or more chroma DC transform coefficient levels shall be non-zero valued. All chroma AC transform coefficient levels are equal to 0. |
| 2 | Zero or more chroma DC transform coefficient levels are non-zero valued. One or more chroma AC transform coefficient levels shall be non-zero valued. |

**mb_qp_delta** can change the value of $QP_Y$ in the macroblock layer. The decoded value of mb_qp_delta shall be in the range of $-( 26 + QpBdOffset_Y / 2)$ to $+( 25 + QpBdOffset_Y / 2 )$, inclusive. mb_qp_delta shall be inferred to be equal to 0 when it is not present for any macroblock (including P_Skip and B_Skip macroblock types).

The value of $QP_Y$ is derived as

$$QP_Y = ( ( QP_{Y,PREV} + mb_qp_delta + 52 + 2 * QpBdOffset_Y ) \% ( 52 + QpBdOffset_Y ) ) - QpBdOffset_Y \quad (7\text{-}35)$$

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where $QP_{Y,PREV}$ is the luma quantisation parameter, $QP_Y$, of the previous macroblock in decoding order in the current slice. For the first macroblock in the slice $QP_{Y,PREV}$ is initially set equal to $SliceQP_Y$ derived in Equation 7-28 at the start of each slice.

The value of $QP'_Y$ is derived as

$$QP'_Y = QP_Y + QpBdOffset_Y \tag{7-36}$$

### 7.4.5.1 Macroblock prediction semantics

All samples of the macroblock are predicted. The prediction modes are derived using the following syntax elements.

**prev_intra4x4_pred_mode_flag[** luma4x4BlkIdx **]** and **rem_intra4x4_pred_mode[** luma4x4BlkIdx **]** specify the Intra_4x4 prediction of the 4x4 luma block with index luma4x4BlkIdx = 0..15. When ChromaArrayType is equal to 3, prev_intra4x4_pred_mode_flag[ luma4x4BlkIdx ] and rem_intra4x4_pred_mode[ luma4x4BlkIdx ] also specify the Intra_4x4 prediction of the 4x4 Cb block with luma4x4BlkIdx equal to cb4x4BlkIdx for cb4x4BlkIdx = 0..15 and the Intra_4x4 prediction of the 4x4 Cr block with luma4x4BlkIdx equal to cr4x4BlkIdx for cr4x4BlkIdx = 0..15.

**prev_intra8x8_pred_mode_flag**[ luma8x8BlkIdx ] and **rem_intra8x8_pred_mode**[ luma8x8BlkIdx ] specify the Intra_8x8 prediction of the 8x8 luma block with index luma8x8BlkIdx = 0..3. When ChromaArrayType is equal to 3, prev_intra8x8_pred_mode_flag[ luma8x8BlkIdx ] and rem_intra8x8_pred_mode[ luma8x8BlkIdx ] also specify the Intra_8x8 prediction of the 8x8 Cb block with luma8x8BlkIdx equal to cb8x8BlkIdx for cb8x8BlkIdx = 0..3 and the Intra_8x8 prediction of the 8x8 Cr block with index luma8x8BlkIdx equal to cr8x8BlkIdx for cr8x8BlkIdx = 0..3.

**intra_chroma_pred_mode** specifies the type of spatial prediction used for chroma in macroblocks using Intra_4x4 or Intra_16x16 prediction, as shown in Table 7-16. The value of intra_chroma_pred_mode shall be in the range of 0 to 3, inclusive.

**Table 7-16 – Relationship between intra_chroma_pred_mode and spatial prediction modes**

| intra_chroma_pred_mode | Intra Chroma Prediction Mode |
|---|---|
| 0 | DC |
| 1 | Horizontal |
| 2 | Vertical |
| 3 | Plane |

**ref_idx_l0[** mbPartIdx **]** when present, specifies the index in reference picture list 0 of the reference picture to be used for prediction.

The range of ref_idx_l0[ mbPartIdx ], the index in list 0 of the reference picture, and, if applicable, the parity of the field within the reference picture used for prediction are specified as follows.

– If MbaffFrameFlag is equal to 0 or mb_field_decoding_flag is equal to 0, the value of ref_idx_l0[ mbPartIdx ] shall be in the range of 0 to num_ref_idx_l0_active_minus1, inclusive.

– Otherwise (MbaffFrameFlag is equal to 1 and mb_field_decoding_flag is equal to 1), the value of ref_idx_l0[ mbPartIdx ] shall be in the range of 0 to 2 * num_ref_idx_l0_active_minus1 + 1, inclusive.

When only one reference picture is used for inter prediction, the values of ref_idx_l0[ mbPartIdx ] shall be inferred to be equal to 0.

**ref_idx_l1[** mbPartIdx **]** has the same semantics as ref_idx_l0, with l0 and list 0 replaced by l1 and list 1, respectively.

**mvd_l0[** mbPartIdx **][** 0 **][** compIdx **]** specifies the difference between a vector component to be used and its prediction. The index mbPartIdx specifies to which macroblock partition mvd_l0 is assigned. The partitioning of the macroblock is specified by mb_type. The horizontal motion vector component difference is decoded first in decoding order and is assigned CompIdx = 0. The vertical motion vector component is decoded second in decoding order and is assigned CompIdx = 1. The range of the components of mvd_l0[ mbPartIdx ][ 0 ][ compIdx ] is specified by constraints on the motion vector variable values derived from it as specified in Annex A.

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**mvd_l1[** mbPartIdx **][** 0 **][** compIdx **]** has the same semantics as mvd_l0, with l0 and L0 replaced by l1 and L1, respectively.

#### 7.4.5.2 Sub-macroblock prediction semantics

**sub_mb_type[** mbPartIdx **]** specifies the sub-macroblock types.

Tables and semantics are specified for the various sub-macroblock types for P, and B macroblock types. Each table presents the value of sub_mb_type, the name of sub_mb_type, the number of sub-macroblock partitions used (given by the NumSubMbPart( sub_mb_type ) function), and the prediction mode of the sub-macroblock (given by the SubMbPredMode( sub_mb_type ) function). In the text, the value of sub_mb_type may be referred to by "sub-macroblock type". In the text, the value of SubMbPredMode( ) may be referred to by "sub-macroblock prediction mode".

The interpretation of sub_mb_type[ mbPartIdx ] for P macroblock types is specified in Table 7-17, where the row for "inferred" specifies values inferred when sub_mb_type[ mbPartIdx ] is not present.

**Table 7-17 – Sub-macroblock types in P macroblocks**

| sub_mb_type[ mbPartIdx ] | Name of sub_mb_type[ mbPartIdx ] | NumSubMbPart ( sub_mb_type[ mbPartIdx ] ) | SubMbPredMode ( sub_mb_type[ mbPartIdx ] ) | SubMbPartWidth ( sub_mb_type[ mbPartIdx ] ) | SubMbPartHeight ( sub_mb_type[ mbPartIdx ] ) |
|---|---|---|---|---|---|
| inferred | na | na | na | na | na |
| 0 | P_L0_8x8 | 1 | Pred_L0 | 8 | 8 |
| 1 | P_L0_8x4 | 2 | Pred_L0 | 8 | 4 |
| 2 | P_L0_4x8 | 2 | Pred_L0 | 4 | 8 |
| 3 | P_L0_4x4 | 4 | Pred_L0 | 4 | 4 |

The following semantics are assigned to the sub-macroblock types in Table 7-17.

– P_L0_MxN, with MxN being replaced by 8x8, 8x4, 4x8, or 4x4: the samples of the sub-macroblock are predicted using one luma partition of size MxN equal to 8x8, two luma partitions of size MxN equal to 8x4, or two luma partitions of size MxN equal to 4x8, or four luma partitions of size MxN equal to 4x4, and associated chroma samples, respectively.

The following semantics are assigned to the sub-macroblock prediction modes (SubMbPredMode( )) in Table 7-17.

– Pred_L0: see semantics for Table 7-13.

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The interpretation of sub_mb_type[ mbPartIdx ] for B macroblock types is specified in Table 7-18, where the row for "inferred" specifies values inferred when sub_mb_type[ mbPartIdx ] is not present, and the inferred value "mb_type" specifies that the name of sub_mb_type[ mbPartIdx ] is the same as the name of mb_type for this case.

**Table 7-18 – Sub-macroblock types in B macroblocks**

| sub_mb_type[ mbPartIdx ] | Name of sub_mb_type[ mbPartIdx ] | NumSubMbPart ( sub_mb_type[ mbPartIdx ] ) | SubMbPredMode ( sub_mb_type[ mbPartIdx ] ) | SubMbPartWidth ( sub_mb_type[ mbPartIdx ] ) | SubMbPartHeight ( sub_mb_type[ mbPartIdx ] ) |
|---|---|---|---|---|---|
| inferred | mb_type | 4 | Direct | 4 | 4 |
| 0 | B_Direct_8x8 | 4 | Direct | 4 | 4 |
| 1 | B_L0_8x8 | 1 | Pred_L0 | 8 | 8 |
| 2 | B_L1_8x8 | 1 | Pred_L1 | 8 | 8 |
| 3 | B_Bi_8x8 | 1 | BiPred | 8 | 8 |
| 4 | B_L0_8x4 | 2 | Pred_L0 | 8 | 4 |
| 5 | B_L0_4x8 | 2 | Pred_L0 | 4 | 8 |
| 6 | B_L1_8x4 | 2 | Pred_L1 | 8 | 4 |
| 7 | B_L1_4x8 | 2 | Pred_L1 | 4 | 8 |
| 8 | B_Bi_8x4 | 2 | BiPred | 8 | 4 |
| 9 | B_Bi_4x8 | 2 | BiPred | 4 | 8 |
| 10 | B_L0_4x4 | 4 | Pred_L0 | 4 | 4 |
| 11 | B_L1_4x4 | 4 | Pred_L1 | 4 | 4 |
| 12 | B_Bi_4x4 | 4 | BiPred | 4 | 4 |

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The following semantics are assigned to the sub-macroblock types in Table 7-18:

– B_Skip and B_Direct_16x16: no motion vector differences or reference indices are present for the sub-macroblock in the bitstream. The functions SubMbPartWidth( ) and SubMbPartHeight( ) are used in the derivation process for motion vectors and reference frame indices in subclause 8.4.1 for direct mode prediction.

– B_Direct_8x8: no motion vector differences or reference indices are present for the sub-macroblock in the bitstream. The functions SubMbPartWidth( B_Direct_8x8 ) and SubMbPartHeight( B_Direct_8x8 ) are used in the derivation process for motion vectors and reference frame indices in subclause 8.4.1 for direct mode prediction.

– B_X_MxN, with X being replaced by L0, L1, or Bi, and MxN being replaced by 8x8, 8x4, 4x8 or 4x4: the samples of the sub-macroblock are predicted using one luma partition of size MxN equal to 8x8, or the samples of the sub-macroblock are predicted using two luma partitions of size MxN equal to 8x4, or the samples of the sub-macroblock are predicted using two luma partitions of size MxN equal to 4x8, or the samples of the sub-macroblock are predicted using four luma partitions of size MxN equal to 4x4, and associated chroma samples, respectively. All sub-macroblock partitions share the same reference index. For an MxN sub-macroblock partition in a sub-macroblock with sub_mb_type being B_X_MxN with X being replaced by either L0 or L1, one motion vector

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difference is present in the bitstream. For an MxN sub-macroblock partition in a sub-macroblock with sub_mb_type being B_Bi_MxN, two motion vector difference are present in the bitstream.

The following semantics are assigned to the sub-macroblock prediction modes (SubMbPredMode( )) in Table 7-18.

– Direct: see semantics for Table 7-14.

– Pred_L0: see semantics for Table 7-13.

– Pred_L1: see semantics for Table 7-14.

– BiPred: see semantics for Table 7-14.

**ref_idx_l0[** mbPartIdx **]** has the same semantics as ref_idx_l0 in subclause 7.4.5.1.

**ref_idx_l1[** mbPartIdx **]** has the same semantics as ref_idx_l1 in subclause 7.4.5.1.

**mvd_l0[** mbPartIdx **][** subMbPartIdx **][** compIdx **]** has the same semantics as mvd_l0 in subclause 7.4.5.1, except that it is applied to the sub-macroblock partition index with subMbPartIdx. The indices mbPartIdx and subMbPartIdx specify to which macroblock partition and sub-macroblock partition mvd_l0 is assigned.

**mvd_l1[** mbPartIdx **][** subMbPartIdx **][** compIdx **]** has the same semantics as mvd_l1 in subclause 7.4.5.1.

#### 7.4.5.3 Residual data semantics

The syntax structure residual_block( ), which is used for parsing the transform coefficient levels, is assigned as follows.

– If entropy_coding_mode_flag is equal to 0, residual_block is set equal to residual_block_cavlc, which is used for parsing the syntax elements for transform coefficient levels.

– Otherwise (entropy_coding_mode_flag is equal to 1), residual_block is set equal to residual_block_cabac, which is used for parsing the syntax elements for transform coefficient levels.

The syntax structure residual_luma( i16x16DClevel, i16x16AClevel, level, level8x8 ) is used with the variables in brackets being its output and being assigned as follows.

Intra16x16DCLevel is set equal to i16x16DClevel, Intra16x16ACLevel is set equal to i16x16AClevel, LumaLevel is set equal to level, and LumaLevel8x8 is set equal to level8x8.

When ChromaArrayType is equal to 1 or 2, the following applies.

– For each chroma component, indexed by iCbCr = 0..1, the DC transform coefficient levels of the 4 * NumC8x8 4x4 chroma blocks are parsed into the iCbCr-th list ChromaDCLevel[ iCbCr ].

– For each of the 4x4 chroma blocks, indexed by i4x4 = 0..3 and i8x8 = 0..NumC8x8 – 1, of each chroma component, indexed by iCbCr = 0..1, the 15 AC transform coefficient levels are parsed into the (i8x8*4 + i4x4)-th list of the iCbCr-th chroma component ChromaACLevel[ iCbCr ][ i8x8*4 + i4x4 ].

When ChromaArrayType is equal to 3, the following applies.

– The syntax structure residual_luma( i16x16DClevel, i16x16AClevel, level, level8x8 ) is used for the Cb component with the variables in brackets being its output and being assigned as follows. CbIntra16x16DCLevel is set equal to i16x16DClevel, CbIntra16x16ACLevel is set equal to i16x16AClevel, CbLevel is set equal to level, and CbLevel8x8 is set equal to level8x8.

– The syntax structure residual_luma( i16x16DClevel, i16x16AClevel, level, level8x8 ) is used for the Cr component with the variables in brackets being its output and being assigned as follows. CrIntra16x16DCLevel is set equal to i16x16DClevel, CrIntra16x16ACLevel is set equal to i16x16AClevel, CrLevel is set equal to level, and CrLevel8x8 is set equal to level8x8.

##### 7.4.5.3.1 Residual luma data semantics

Output of this syntax structure are the variables i16x16DClevel, i16x16AClevel, level, and level8x8.

The syntax structure residual_block( ), which is used for parsing the transform coefficient levels, is assigned as follows.

– If entropy_coding_mode_flag is equal to 0, residual_block is set equal to residual_block_cavlc, which is used for parsing the syntax elements for transform coefficient levels.

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– Otherwise (entropy_coding_mode_flag is equal to 1), residual_block is set equal to residual_block_cabac, which is used for parsing the syntax elements for transform coefficient levels.

Depending on mb_type, the syntax structure residual_block( coeffLevel, maxNumCoeff ) is used with the arguments coeffLevel, which is a list containing the maxNumCoeff transform coefficient levels that are parsed in residual_block( ) and maxNumCoeff as follows.

Depending on MbPartPredMode( mb_type, 0 ), the following applies.

– If MbPartPredMode( mb_type, 0 ) is equal to Intra_16x16, the transform coefficient levels are parsed into the list i16x16DClevel and into the 16 lists i16x16AClevel[ i ]. i16x16DClevel contains the 16 transform coefficient levels of the DC transform coefficient levels for each 4x4 luma block. For each of the 16 4x4 luma blocks indexed by i = 0..15, the 15 AC transform coefficients levels of the i-th block are parsed into the i-th list i16x16AClevel[ i ].

– Otherwise (MbPartPredMode( mb_type, 0 ) is not equal to Intra_16x16), the following applies.
  – If transform_size_8x8_flag is equal to 0, for each of the 16 4x4 luma blocks indexed by i = 0..15, the 16 transform coefficient levels of the i-th block are parsed into the i-th list level[ i ].
  – Otherwise (transform_size_8x8_flag is equal to 1), for each of the 4 8x8 luma blocks indexed by i8x8 = 0..3, the following applies.
    – If entropy_coding_mode_flag is equal to 0, first for each of the 4 4x4 luma blocks indexed by i4x4 = 0..3, the 16 transform coefficient levels of the i4x4-th block are parsed into the (i8x8 * 4 + i4x4)-th list level[ i8x8 * 4 + i4x4 ]. Then, the 64 transform coefficient levels of the i8x8-th 8x8 luma block which are indexed by 4 * i + i4x4, where i = 0..15 and i4x4 = 0..3, are derived as level8x8[ i8x8 ][ 4 * i + i4x4 ] = level[ i8x8 * 4 + i4x4 ][ i ].

      NOTE – The 4x4 luma blocks with luma4x4BlkIdx = i8x8 * 4 + i4x4 containing every fourth transform coefficient level of the corresponding i8x8-th 8x8 luma block with offset i4x4 are assumed to represent spatial locations given by the inverse 4x4 luma block scanning process in subclause 6.4.3.

    – Otherwise (entropy_coding_mode_flag is equal to 1), the 64 transform coefficient levels of the i8x8-th block are parsed into the i8x8-th list level8x8[ i8x8 ].

#### 7.4.5.3.2 Residual block CAVLC semantics

The function TotalCoeff( coeff_token ) that is used in subclause 7.3.5.3.2 returns the number of non-zero transform coefficient levels derived from coeff_token.

The function TrailingOnes( coeff_token ) that is used in subclause 7.3.5.3.2 returns the trailing ones derived from coeff_token.

**coeff_token** specifies the total number of non-zero transform coefficient levels and the number of trailing one transform coefficient levels in a transform coefficient level scan. A trailing one transform coefficient level is one of up to three consecutive non-zero transform coefficient levels having an absolute value equal to 1 at the end of a scan of non-zero transform coefficient levels. The range of coeff_token is specified in subclause 9.2.1.

**trailing_ones_sign_flag** specifies the sign of a trailing one transform coefficient level as follows.

– If trailing_ones_sign_flag is equal to 0, the corresponding transform coefficient level is decoded as +1.

– Otherwise (trailing_ones_sign_flag equal to 1), the corresponding transform coefficient level is decoded as -1.

**level_prefix** and **level_suffix** specify the value of a non-zero transform coefficient level. The range of level_prefix and level_suffix is specified in subclause 9.2.2.

**total_zeros** specifies the total number of zero-valued transform coefficient levels that are located before the position of the last non-zero transform coefficient level in a scan of transform coefficient levels. The range of total_zeros is specified in subclause 9.2.3.

**run_before** specifies the number of consecutive transform coefficient levels in the scan with zero value before a non-zero valued transform coefficient level. The range of run_before is specified in subclause 9.2.3.

coeffLevel contains maxNumCoeff transform coefficient levels for the current list of transform coefficient levels.

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#### 7.4.5.3.3 Residual block CABAC semantics

**coded_block_flag** specifies whether the block contains non-zero transform coefficient levels as follows.

– If coded_block_flag is equal to 0, the block contains no non-zero transform coefficient levels.

– Otherwise (coded_block_flag is equal to 1), the block contains at least one non-zero transform coefficient level.

When coded_block_flag is not present, it is inferred to be equal to 1.

**significant_coeff_flag[** i **]** specifies whether the transform coefficient level at scanning position i is non-zero as follows.

– If significant_coeff_flag[ i ] is equal to 0, the transform coefficient level at scanning position i is set equal to 0;

– Otherwise (significant_coeff_flag[ i ] is equal to 1), the transform coefficient level at scanning position i has a non-zero value.

**last_significant_coeff_flag[** i **]** specifies for the scanning position i whether there are non-zero transform coefficient levels for subsequent scanning positions i + 1 to maxNumCoeff – 1 as follows.

– If last_significant_coeff_flag[ i ] is equal to 1, all following transform coefficient levels (in scanning order) of the block have value equal to 0.

– Otherwise (last_significant_coeff_flag[ i ] is equal to 0), there are further non-zero transform coefficient levels along the scanning path.

**coeff_abs_level_minus1[** i **]** is the absolute value of a transform coefficient level minus 1. The value of coeff_abs_level_minus1 is constrained by the limits in subclause 8.5.

**coeff_sign_flag[** i **]** specifies the sign of a transform coefficient level as follows.

– If coeff_sign_flag is equal to 0, the corresponding transform coefficient level has a positive value.

– Otherwise (coeff_sign_flag is equal to 1), the corresponding transform coefficient level has a negative value.

coeffLevel contains maxNumCoeff transform coefficient levels for the current list of transform coefficient levels.

## 8 Decoding process

Outputs of this process are decoded samples of the current picture (sometimes referred to by the variable CurrPic).

Depending on the value of chroma_format_idc, the number of sample arrays of the current picture is as follows.

– If chroma_format_idc is equal to 0, the current picture consists of 1 sample array $S_L$.

– Otherwise (chroma_format_idc is not equal to 0), the current picture consists of 3 sample arrays $S_L$, $S_{Cb}$, $S_{Cr}$.

This clause describes the decoding process, given syntax elements and upper-case variables from clause 7.

The decoding process is specified such that all decoders shall produce numerically identical results. Any decoding process that produces identical results to the process described here conforms to the decoding process requirements of this International Standard.

Each picture referred to in this clause is a complete or part of a primary coded picture. Each slice referred to in this clause is a slice of a primary coded picture. Each slice data partition referred to in this clause is a slice data partition of a primary coded picture.

Depending on the value of separate_colour_plane_flag, the decoding process is structured as follows.

– If separate_colour_plane_flag is equal to 0, the decoding process is invoked a single time with the current picture being the output.

– Otherwise (separate_colour_plane_flag is equal to 1), the decoding process is invoked three times. Inputs to the decoding process are all NAL units of the primary coded picture with identical value of colour_plane_id. The decoding process of NAL units with a particular value of colour_plane_id is specified as if only a coded video sequence with monochrome colour format with that particular value of colour_plane_id would be present in the bitstream. The output of each of the three decoding processes is assigned to the 3 sample arrays of the current picture with the NAL units with colour_plane_id equal to 0 being assigned to $S_L$, the NAL units with

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colour_plane_id equal to 1 being assigned to $S_{Cb}$, and the NAL units with colour_plane_id equal to 2 being assigned to $S_{Cr}$.

NOTE - The variable ChromaArrayType is derived as 0 when separate_colour_plane_flag is equal to 1 and chroma_format_idc is equal to 3. In the decoding process, the value of this variable is evaluated resulting in operations identical to that of monochrome pictures with chroma_format_idc being equal to 0.

An overview of the decoding process is given as follows.

– The decoding of NAL units is specified in subclause 8.1.

– The processes in subclause 8.2 specify decoding processes using syntax elements in the slice layer and above.

  – Variables and functions relating to picture order count are derived in subclause 8.2.1. (only needed to be invoked for one slice of a picture)

  – Variables and functions relating to the macroblock to slice group map are derived in subclause 8.2.2. (only needed to be invoked for one slice of a picture)

  – The method of combining the various partitions when slice data partitioning is used is described in subclause 8.2.3.

  – When the frame_num of the current picture is not equal to PrevRefFrameNum and is not equal to ( PrevRefFrameNum + 1 ) % MaxFrameNum, the decoding process for gaps in frame_num is performed according to subclause 8.2.5.2 prior to the decoding of any slices of the current picture.

  – At the beginning of the decoding process for each P, SP, or B slice, the decoding process for reference picture lists construction specified in 8.2.4 performed for derivation of reference picture list 0 (RefPicList0), and when decoding a B slice, reference picture list 1 (RefPicList1).

  – When the current picture is a reference picture and after all slices of the current picture have been decoded, the decoded reference picture marking process in subclause 8.2.5 specifies how the current picture is used in the decoding process of inter prediction in later decoded pictures.

– The processes in subclauses 8.3, 8.4, 8.5, 8.6, and 8.7 specify decoding processes using syntax elements in the macroblock layer and above.

  – The intra prediction process for I and SI macroblocks, except for I_PCM macroblocks as specified in subclause 8.3, has intra prediction samples as its output. For I_PCM macroblocks subclause 8.3 directly specifies a picture construction process. The output are the constructed samples prior to the deblocking filter process.

  – The inter prediction process for P and B macroblocks is specified in subclause 8.4 with inter prediction samples being the output.

  – The transform coefficient decoding process and picture construction process prior to deblocking filter process are specified in subclause 8.5. That process derives samples for I and B macroblocks and for P macroblocks in P slices. The output are constructed samples prior to the deblocking filter process.

  – The decoding process for P macroblocks in SP slices or SI macroblocks is specified in subclause 8.6. That process derives samples for P macroblocks in SP slices and for SI macroblocks. The output are constructed samples prior to the deblocking filter process.

  – The constructed samples prior to the deblocking filter process that are next to the edges of blocks and macroblocks are processed by a deblocking filter as specified in subclause 8.7 with the output being the decoded samples.

## 8.1 NAL unit decoding process

Inputs to this process are NAL units.

Outputs of this process are the RBSP syntax structures encapsulated within the NAL units.

The decoding process for each NAL unit extracts the RBSP syntax structure from the NAL unit and then operates the decoding processes specified for the RBSP syntax structure in the NAL unit as follows.

Subclause 8.2 describes the decoding process for NAL units with nal_unit_type equal to 1 through 5.

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Subclauses 8.3 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1, 2, and 5.

Subclause 8.4 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1 and 2.

Subclause 8.5 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1 and 3 to 5.

Subclause 8.6 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1 and 3 to 5.

Subclause 8.7 describes the decoding process for a macroblock or part of a macroblock coded in NAL units with nal_unit_type equal to 1 to 5.

NAL units with nal_unit_type equal to 7 and 8 contain sequence parameter sets and picture parameter sets, respectively. Picture parameter sets are used in the decoding processes of other NAL units as determined by reference to a picture parameter set within the slice headers of each picture. Sequence parameter sets are used in the decoding processes of other NAL units as determined by reference to a sequence parameter set within the picture parameter sets of each sequence.

No normative decoding process is specified for NAL units with nal_unit_type equal to 6, 9, 10, 11, and 12.

## 8.2 Slice decoding process

### 8.2.1 Decoding process for picture order count

Outputs of this process are TopFieldOrderCnt (if applicable) and BottomFieldOrderCnt (if applicable).

Picture order counts are used to determine initial picture orderings for reference pictures in the decoding of B slices (see subclauses 8.2.4.2.3 and 8.2.4.2.4), to represent picture order differences between frames or fields for motion vector derivation in temporal direct mode (see subclause 8.4.1.2.3), for implicit mode weighted prediction in B slices (see subclause 8.4.2.3.2), and for decoder conformance checking (see subclause C.4).

Picture order count information is derived for every frame, field (whether decoded from a coded field or as a part of a decoded frame), or complementary field pair as follows:

– Each coded frame is associated with two picture order counts, called TopFieldOrderCnt and BottomFieldOrderCnt for its top field and bottom field, respectively.

– Each coded field is associated with a picture order count, called TopFieldOrderCnt for a coded top field and BottomFieldOrderCnt for a bottom field.

– Each complementary field pair is associated with two picture order counts, which are the TopFieldOrderCnt for its coded top field and the BottomFieldOrderCnt for its coded bottom field, respectively.

TopFieldOrderCnt and BottomFieldOrderCnt indicate the picture order of the corresponding top field or bottom field relative to the first output field of the previous IDR picture or the previous reference picture including a memory_management_control_operation equal to 5 in decoding order.

TopFieldOrderCnt and BottomFieldOrderCnt are derived by invoking one of the decoding processes for picture order count type 0, 1, and 2 in subclauses 8.2.1.1, 8.2.1.2, and 8.2.1.3, respectively. When the current picture includes a memory management control operation equal to 5, after the decoding of the current picture, tempPicOrderCnt is set equal to PicOrderCnt( CurrPic ), TopFieldOrderCnt of the current picture (if any) is set equal to TopFieldOrderCnt - tempPicOrderCnt, and BottomFieldOrderCnt of the current picture (if any) is set equal to BottomFieldOrderCnt - tempPicOrderCnt.

The bitstream shall not contain data that results in Min( TopFieldOrderCnt, BottomFieldOrderCnt ) not equal to 0 for a coded IDR frame, TopFieldOrderCnt not equal to 0 for a coded IDR top field, or BottomFieldOrderCnt not equal to 0 for a coded IDR bottom field. Thus, at least one of TopFieldOrderCnt and BottomFieldOrderCnt shall be equal to 0 for the fields of a coded IDR frame.

When the current picture is not an IDR picture, the following applies.

– Consider the list variable listD containing as elements the TopFieldOrderCnt and BottomFieldOrderCnt values associated with the list of pictures including all of the following

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- the first picture in the list is the previous picture of any of the following types
  - an IDR picture
  - a picture containing a memory_management_control_operation equal to 5
- the following additional pictures.
  - If pic_order_cnt_type is equal to 0, all other pictures that follow in decoding order after the first picture in the list and are not "non-existing" frames inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2 and either precede the current picture in decoding order or are the current picture. When pic_order_cnt_type is equal to 0 and the current picture is not a "non-existing" frame inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2, the current picture is included in listD prior to the invoking of the decoded reference picture marking process.

    Otherwise (pic_order_cnt_type is not equal to 0), all other pictures that follow in decoding order after the first picture in the list and either precede the current picture in decoding order or are the current picture. When pic_order_cnt_type is not equal to 0, the current picture is included in listD prior to the invoking of the decoded reference picture marking process.

- Consider the list variable listO which contains the elements of listD sorted in ascending order. listO shall not contain any of the following.
  - a pair of TopFieldOrderCnt and BottomFieldOrderCnt for a frame or complementary field pair that are not at consecutive positions in listO.
  - a TopFieldOrderCnt that has a value equal to another TopFieldOrderCnt.
  - a BottomFieldOrderCnt that has a value equal to another BottomFieldOrderCnt.
  - a BottomFieldOrderCnt that has a value equal to a TopFieldOrderCnt unless the BottomFieldOrderCnt and TopFieldOrderCnt belong to the same coded frame or complementary field pair.

The bitstream shall not contain data that results in values of TopFieldOrderCnt, BottomFieldOrderCnt, PicOrderCntMsb, or FrameNumOffset used in the decoding process as specified in subclauses 8.2.1.1 to 8.2.1.3 that exceed the range of values from $-2^{31}$ to $2^{31}-1$, inclusive.

The function PicOrderCnt( picX ) is specified as follows:

```
if( picX is a frame or a complementary field pair )
    PicOrderCnt( picX ) = Min( TopFieldOrderCnt, BottomFieldOrderCnt ) of the frame or complementary field
pair picX
else if( picX is a top field )
    PicOrderCnt( picX ) = TopFieldOrderCnt of field picX                                    (8-1)
else if( picX is a bottom field )
    PicOrderCnt( picX ) = BottomFieldOrderCnt of field picX
```

Then DiffPicOrderCnt( picA, picB ) is specified as follows:

```
DiffPicOrderCnt( picA, picB ) = PicOrderCnt( picA ) - PicOrderCnt( picB )                  (8-2)
```

The bitstream shall not contain data that results in values of DiffPicOrderCnt( picA, picB ) used in the decoding process that exceed the range of $-2^{15}$ to $2^{15} - 1$, inclusive.

NOTE 1 – Let X be the current picture and Y and Z be two other pictures in the same sequence, Y and Z are considered to be in the same output order direction from X when both DiffPicOrderCnt( X, Y ) and DiffPicOrderCnt( X, Z ) are positive or both are negative.

NOTE 2 – Many applications assign PicOrderCnt( X ) proportional to the sampling time of the picture X relative to the sampling time of an IDR picture.

When the current picture includes a memory_management_control_operation equal to 5, PicOrderCnt( CurrPic ) shall be greater than PicOrderCnt( any other picture in listD ).

#### 8.2.1.1 Decoding process for picture order count type 0

This process is invoked when pic_order_cnt_type is equal to 0.

Input to this process is PicOrderCntMsb of the previous reference picture in decoding order as specified in this subclause.

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Outputs of this process are either or both TopFieldOrderCnt or BottomFieldOrderCnt.

The variables prevPicOrderCntMsb and prevPicOrderCntLsb are derived as follows.

– If the current picture is an IDR picture, prevPicOrderCntMsb is set equal to 0 and prevPicOrderCntLsb is set equal to 0.

– Otherwise (the current picture is not an IDR picture), the following applies.

  – If the previous reference picture in decoding order included a memory_management_control_operation equal to 5, the following applies.

    – If the previous reference picture in decoding order is not a bottom field, prevPicOrderCntMsb is set equal to 0 and prevPicOrderCntLsb is set equal to the value of TopFieldOrderCnt for the previous reference picture in decoding order.

    – Otherwise (the previous reference picture in decoding order is a bottom field), prevPicOrderCntMsb is set equal to 0 and prevPicOrderCntLsb is set equal to 0.

  – Otherwise (the previous reference picture in decoding order did not include a memory_management_control_operation equal to 5), prevPicOrderCntMsb is set equal to PicOrderCntMsb of the previous reference picture in decoding order and prevPicOrderCntLsb is set equal to the value of pic_order_cnt_lsb of the previous reference picture in decoding order.

PicOrderCntMsb of the current picture is derived as follows:

```
if( ( pic_order_cnt_lsb  <  prevPicOrderCntLsb )  &&
    ( ( prevPicOrderCntLsb – pic_order_cnt_lsb )  >=  ( MaxPicOrderCntLsb / 2 ) ) )
     PicOrderCntMsb = prevPicOrderCntMsb + MaxPicOrderCntLsb                    (8-3)
else if( ( pic_order_cnt_lsb  >  prevPicOrderCntLsb )  &&
         ( ( pic_order_cnt_lsb – prevPicOrderCntLsb )  >  ( MaxPicOrderCntLsb / 2 ) ) )
     PicOrderCntMsb = prevPicOrderCntMsb – MaxPicOrderCntLsb
else
     PicOrderCntMsb = prevPicOrderCntMsb
```

When the current picture is not a bottom field, TopFieldOrderCnt is derived as follows:

```
if( !field_pic_flag  ||  !bottom_field_flag )
     TopFieldOrderCnt = PicOrderCntMsb + pic_order_cnt_lsb                      (8-4)
```

When the current picture is not a top field, BottomFieldOrderCnt is derived as follows:

```
if( !field_pic_flag )
     BottomFieldOrderCnt = TopFieldOrderCnt + delta_pic_order_cnt_bottom
else if( bottom_field_flag )                                                    (8-5)
     BottomFieldOrderCnt = PicOrderCntMsb + pic_order_cnt_lsb
```

#### 8.2.1.2 Decoding process for picture order count type 1

This process is invoked when pic_order_cnt_type is equal to 1.

Input to this process is FrameNumOffset of the previous picture in decoding order as specified in this subclause.

Outputs of this process are either or both TopFieldOrderCnt or BottomFieldOrderCnt.

The values of TopFieldOrderCnt and BottomFieldOrderCnt are derived as specified in this subclause. Let prevFrameNum be equal to the frame_num of the previous picture in decoding order.

When the current picture is not an IDR picture, the variable prevFrameNumOffset is derived as follows.

– If the previous picture in decoding order included a memory_management_control_operation equal to 5, prevFrameNumOffset is set equal to 0.

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– Otherwise (the previous picture in decoding order did not include a memory_management_control_operation equal to 5), prevFrameNumOffset is set equal to the value of FrameNumOffset of the previous picture in decoding order.

NOTE – When gaps_in_frame_num_value_allowed_flag is equal to 1, the previous picture in decoding order may be a "non-existing" frame inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2.

The derivation proceeds in the following ordered steps.

1. The variable FrameNumOffset is derived as follows:

```
if( nal_unit_type == 5 )
    FrameNumOffset = 0
else if( prevFrameNum > frame_num )
    FrameNumOffset = prevFrameNumOffset + MaxFrameNum
else
    FrameNumOffset = prevFrameNumOffset
```
(8-6)

2. The variable absFrameNum is derived as follows:

```
if( num_ref_frames_in_pic_order_cnt_cycle != 0 )
    absFrameNum = FrameNumOffset + frame_num
else
    absFrameNum = 0
if( nal_ref_idc == 0 && absFrameNum > 0 )
    absFrameNum = absFrameNum – 1
```
(8-7)

3. When absFrameNum > 0, picOrderCntCycleCnt and frameNumInPicOrderCntCycle are derived as follows:

```
if( absFrameNum > 0 ) {
    picOrderCntCycleCnt = ( absFrameNum – 1 ) / num_ref_frames_in_pic_order_cnt_cycle
    frameNumInPicOrderCntCycle = ( absFrameNum – 1 ) % num_ref_frames_in_pic_order_cnt_cycle
}
```
(8-8)

4. The variable expectedDeltaPerPicOrderCntCycle is derived as follows:

```
expectedDeltaPerPicOrderCntCycle = 0
for( i = 0; i < num_ref_frames_in_pic_order_cnt_cycle; i++ )
    expectedDeltaPerPicOrderCntCycle += offset_for_ref_frame[ i ]
```
(8-9)

5. The variable expectedPicOrderCnt is derived as follows:

```
if( absFrameNum > 0 ){
    expectedPicOrderCnt = picOrderCntCycleCnt * expectedDeltaPerPicOrderCntCycle
    for( i = 0; i <= frameNumInPicOrderCntCycle; i++ )
        expectedPicOrderCnt = expectedPicOrderCnt + offset_for_ref_frame[ i ]
} else
    expectedPicOrderCnt = 0
if( nal_ref_idc == 0 )
    expectedPicOrderCnt = expectedPicOrderCnt + offset_for_non_ref_pic
```
(8-10)

6. The variables TopFieldOrderCnt or BottomFieldOrderCnt are derived as follows:

```
if( !field_pic_flag ) {
    TopFieldOrderCnt = expectedPicOrderCnt + delta_pic_order_cnt[ 0 ]
    BottomFieldOrderCnt = TopFieldOrderCnt +
            offset_for_top_to_bottom_field + delta_pic_order_cnt[ 1 ]
} else if( !bottom_field_flag )
    TopFieldOrderCnt = expectedPicOrderCnt + delta_pic_order_cnt[ 0 ]
else
    BottomFieldOrderCnt = expectedPicOrderCnt + offset_for_top_to_bottom_field + delta_pic_order_cnt[ 0 ]
```
(8-11)

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#### 8.2.1.3 Decoding process for picture order count type 2

This process is invoked when pic_order_cnt_type is equal to 2.

Outputs of this process are either or both TopFieldOrderCnt or BottomFieldOrderCnt.

Let prevFrameNum be equal to the frame_num of the previous picture in decoding order.

When the current picture is not an IDR picture, the variable prevFrameNumOffset is derived as follows.

– If the previous picture in decoding order included a memory_management_control_operation equal to 5, prevFrameNumOffset is set equal to 0.

– Otherwise (the previous picture in decoding order did not include a memory_management_control_operation equal to 5), prevFrameNumOffset is set equal to the value of FrameNumOffset of the previous picture in decoding order.

NOTE 1 – When gaps_in_frame_num_value_allowed_flag is equal to 1, the previous picture in decoding order may be a "non-existing" frame inferred by the decoding process for gaps in frame_num specified in subclause 8.2.5.2.

The variable FrameNumOffset is derived as follows.

```
if( nal_unit_type == 5 )
    FrameNumOffset = 0
else if( prevFrameNum > frame_num )                                    (8-12)
    FrameNumOffset = prevFrameNumOffset + MaxFrameNum
else
    FrameNumOffset = prevFrameNumOffset
```

The variable tempPicOrderCnt is derived as follows:

```
if( nal_unit_type == 5 )
    tempPicOrderCnt = 0
else if( nal_ref_idc == 0 )                                            (8-13)
    tempPicOrderCnt = 2 * ( FrameNumOffset + frame_num ) – 1
else
    tempPicOrderCnt = 2 * ( FrameNumOffset + frame_num )
```

The variables TopFieldOrderCnt or BottomFieldOrderCnt are derived as follows:

```
if( !field_pic_flag ) {
    TopFieldOrderCnt = tempPicOrderCnt
    BottomFieldOrderCnt = tempPicOrderCnt                              (8-14)
} else if( bottom_field_flag )
    BottomFieldOrderCnt = tempPicOrderCnt
else
    TopFieldOrderCnt = tempPicOrderCnt
```

NOTE 2 – Picture order count type 2 cannot be used in a coded video sequence that contains consecutive non-reference pictures that would result in more than one of these pictures having the same value of TopFieldOrderCnt or more than one of these pictures having the same value of BottomFieldOrderCnt.

NOTE 3 – Picture order count type 2 results in an output order that is the same as the decoding order.

### 8.2.2 Decoding process for macroblock to slice group map

Inputs to this process are the active picture parameter set and the slice header of the slice to be decoded.

Output of this process is a macroblock to slice group map MbToSliceGroupMap.

This process is invoked at the start of every slice.

NOTE – The output of this process is equal for all slices of a picture.

When num_slice_groups_minus1 is equal to 1 and slice_group_map_type is equal to 3, 4, or 5, slice groups 0 and 1 have a size and shape determined by slice_group_change_direction_flag as shown in Table 8-1 and specified in subclauses 8.2.2.4 to 8.2.2.6.

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**Table 8-1 – Refined slice group map type**

| slice_group_map_type | slice_group_change_direction_flag | refined slice group map type |
|---|---|---|
| 3 | 0 | Box-out clockwise |
| 3 | 1 | Box-out counter-clockwise |
| 4 | 0 | Raster scan |
| 4 | 1 | Reverse raster scan |
| 5 | 0 | Wipe right |
| 5 | 1 | Wipe left |

In such a case, MapUnitsInSliceGroup0 slice group map units in the specified growth order are allocated for slice group 0 and the remaining PicSizeInMapUnits – MapUnitsInSliceGroup0 slice group map units of the picture are allocated for slice group 1.

When num_slice_groups_minus1 is equal to 1 and slice_group_map_type is equal to 4 or 5, the variable sizeOfUpperLeftGroup is defined as follows:

$$\text{sizeOfUpperLeftGroup} = ( \text{slice_group_change_direction_flag} ? ( \text{PicSizeInMapUnits} - \text{MapUnitsInSliceGroup0} ) : \text{MapUnitsInSliceGroup0} ) \quad (8\text{-}15)$$

The variable mapUnitToSliceGroupMap is derived as follows.

– If num_slice_groups_minus1 is equal to 0, the map unit to slice group map is generated for all i ranging from 0 to PicSizeInMapUnits – 1, inclusive, as specified by:

$$\text{mapUnitToSliceGroupMap}[ i ] = 0 \quad (8\text{-}16)$$

– Otherwise (num_slice_groups_minus1 is not equal to 0), mapUnitToSliceGroupMap is derived as follows.
  – If slice_group_map_type is equal to 0, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.1 applies.
  – Otherwise, if slice_group_map_type is equal to 1, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.2 applies.
  – Otherwise, if slice_group_map_type is equal to 2, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.3 applies.
  – Otherwise, if slice_group_map_type is equal to 3, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.4 applies.
  – Otherwise, if slice_group_map_type is equal to 4, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.5 applies.
  – Otherwise, if slice_group_map_type is equal to 5, the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.6 applies.
  – Otherwise (slice_group_map_type is equal to 6), the derivation of mapUnitToSliceGroupMap as specified in subclause 8.2.2.7 applies.

After derivation of the mapUnitToSliceGroupMap, the process specified in subclause 8.2.2.8 is invoked to convert the map unit to slice group map mapUnitToSliceGroupMap to the macroblock to slice group map MbToSliceGroupMap. After derivation of the macroblock to slice group map as specified in subclause 8.2.2.8, the function NextMbAddress( n ) is defined as the value of the variable nextMbAddress derived as specified by:

```
i = n + 1
while( i < PicSizeInMbs  &&  MbToSliceGroupMap[ i ]  !=  MbToSliceGroupMap[ n ] )
    i++;
nextMbAddress = i
```
(8-17)

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#### 8.2.2.1 Specification for interleaved slice group map type

The specifications in this subclause apply when slice_group_map_type is equal to 0.

The map unit to slice group map is generated as specified by:

```
i = 0
do
    for( iGroup = 0; iGroup <= num_slice_groups_minus1 && i < PicSizeInMapUnits;
          i += run_length_minus1[ iGroup++ ] + 1 )
        for( j = 0; j <= run_length_minus1[ iGroup ] && i + j < PicSizeInMapUnits; j++ )
            mapUnitToSliceGroupMap[ i + j ] = iGroup                                    (8-18)
while( i < PicSizeInMapUnits )
```

#### 8.2.2.2 Specification for dispersed slice group map type

The specifications in this subclause apply when slice_group_map_type is equal to 1.

The map unit to slice group map is generated as specified by:

```
for( i = 0; i < PicSizeInMapUnits; i++ )
    mapUnitToSliceGroupMap[ i ] = ( ( i % PicWidthInMbs ) +
                                    ( ( ( i / PicWidthInMbs ) * ( num_slice_groups_minus1 + 1 ) ) / 2 ) )
                                  % ( num_slice_groups_minus1 + 1 )                     (8-19)
```

#### 8.2.2.3 Specification for foreground with left-over slice group map type

The specifications in this subclause apply when slice_group_map_type is equal to 2.

The map unit to slice group map is generated as specified by:

```
for( i = 0; i < PicSizeInMapUnits; i++ )
    mapUnitToSliceGroupMap[ i ] = num_slice_groups_minus1
for( iGroup = num_slice_groups_minus1 – 1; iGroup >= 0; iGroup-- ) {
    yTopLeft = top_left[ iGroup ] / PicWidthInMbs
    xTopLeft = top_left[ iGroup ] % PicWidthInMbs
    yBottomRight = bottom_right[ iGroup ] / PicWidthInMbs
    xBottomRight = bottom_right[ iGroup ] % PicWidthInMbs
    for( y = yTopLeft; y <= yBottomRight; y++ )
        for( x = xTopLeft; x <= xBottomRight; x++ )
            mapUnitToSliceGroupMap[ y * PicWidthInMbs + x ] = iGroup                    (8-20)
}
```

NOTE – The rectangles may overlap. Slice group 0 contains the macroblocks that are within the rectangle specified by top_left[ 0 ] and bottom_right[ 0 ]. A slice group having slice group ID greater than 0 and less than num_slice_groups_minus1 contains the macroblocks that are within the specified rectangle for that slice group that are not within the rectangle specified for any slice group having a smaller slice group ID. The slice group with slice group ID equal to num_slice_groups_minus1 contains the macroblocks that are not in the other slice groups.

#### 8.2.2.4 Specification for box-out slice group map types

The specifications in this subclause apply when slice_group_map_type is equal to 3.

The map unit to slice group map is generated as specified by:

```
for( i = 0; i < PicSizeInMapUnits; i++ )
    mapUnitToSliceGroupMap[ i ] = 1
x = ( PicWidthInMbs – slice_group_change_direction_flag ) / 2
y = ( PicHeightInMapUnits – slice_group_change_direction_flag ) / 2
( leftBound, topBound ) = ( x, y )
( rightBound, bottomBound ) = ( x, y )
( xDir, yDir ) = ( slice_group_change_direction_flag – 1, slice_group_change_direction_flag )
for( k = 0; k < MapUnitsInSliceGroup0; k += mapUnitVacant ) {
```

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```
        mapUnitVacant = ( mapUnitToSliceGroupMap[ y * PicWidthInMbs + x ] == 1 )
        if( mapUnitVacant )
            mapUnitToSliceGroupMap[ y * PicWidthInMbs + x ] = 0                    (8-21)
        if( xDir == –1 && x == leftBound ) {
            leftBound = Max( leftBound – 1, 0 )
            x = leftBound
            ( xDir, yDir ) = ( 0, 2 * slice_group_change_direction_flag – 1 )
        } else if( xDir == 1 && x == rightBound ) {
            rightBound = Min( rightBound + 1, PicWidthInMbs – 1 )
            x = rightBound
            ( xDir, yDir ) = ( 0, 1 – 2 * slice_group_change_direction_flag )
        } else if( yDir == –1 && y == topBound ) {
            topBound = Max( topBound – 1, 0 )
            y = topBound
            ( xDir, yDir ) = ( 1 – 2 * slice_group_change_direction_flag, 0 )
        } else if( yDir == 1 && y == bottomBound ) {
            bottomBound = Min( bottomBound + 1, PicHeightInMapUnits – 1 )
            y = bottomBound
            ( xDir, yDir ) = ( 2 * slice_group_change_direction_flag – 1, 0 )
        } else
            ( x, y ) = ( x + xDir, y + yDir )
    }
```

#### 8.2.2.5 Specification for raster scan slice group map types

The specifications in this subclause apply when slice_group_map_type is equal to 4.

The map unit to slice group map is generated as specified by:

```
    for( i = 0; i < PicSizeInMapUnits; i++ )
        if( i < sizeOfUpperLeftGroup )
            mapUnitToSliceGroupMap[ i ] = slice_group_change_direction_flag
        else                                                                       (8-22)
            mapUnitToSliceGroupMap[ i ] = 1 – slice_group_change_direction_flag
```

#### 8.2.2.6 Specification for wipe slice group map types

The specifications in this subclause apply when slice_group_map_type is equal to 5.

The map unit to slice group map is generated as specified by:

```
    k = 0;
    for( j = 0; j < PicWidthInMbs; j++ )
        for( i = 0; i < PicHeightInMapUnits; i++ )
            if( k++ < sizeOfUpperLeftGroup )
                mapUnitToSliceGroupMap[ i * PicWidthInMbs + j ] = slice_group_change_direction_flag
            else                                                                   (8-23)
                mapUnitToSliceGroupMap[ i * PicWidthInMbs + j ] = 1 – slice_group_change_direction_flag
```

#### 8.2.2.7 Specification for explicit slice group map type

The specifications in this subclause apply when slice_group_map_type is equal to 6.

The map unit to slice group map is generated as specified by:

```
        mapUnitToSliceGroupMap[ i ] = slice_group_id[ i ]                          (8-24)
```

for all i ranging from 0 to PicSizeInMapUnits – 1, inclusive.

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#### 8.2.2.8 Specification for conversion of map unit to slice group map to macroblock to slice group map

For each value of i ranging from 0 to PicSizeInMbs – 1, inclusive, the macroblock to slice group map is specified as follows.

— If frame_mbs_only_flag is equal to 1 or field_pic_flag is equal to 1, the macroblock to slice group map is specified by:

$$MbToSliceGroupMap[ i ] = mapUnitToSliceGroupMap[ i ] \quad (8\text{-}25)$$

– Otherwise, if MbaffFrameFlag is equal to 1, the macroblock to slice group map is specified by:

$$MbToSliceGroupMap[ i ] = mapUnitToSliceGroupMap[ i / 2 ] \quad (8\text{-}26)$$

– Otherwise (frame_mbs_only_flag is equal to 0 and mb_adaptive_frame_field_flag is equal to 0 and field_pic_flag is equal to 0), the macroblock to slice group map is specified by:

$$MbToSliceGroupMap[ i ] = mapUnitToSliceGroupMap[ ( i / ( 2 * PicWidthInMbs ) ) * PicWidthInMbs + ( i \% PicWidthInMbs ) ] \quad (8\text{-}27)$$

### 8.2.3 Decoding process for slice data partitioning

Inputs to this process are

– a slice data partition A layer RBSP,

– when syntax elements of category 3 are present in the slice data, a slice data partition B layer RBSP having the same slice_id as in the slice data partition A layer RBSP, and

– when syntax elements of category 4 are present in the slice data, a slice data partition C layer RBSP having the same slice_id as in the slice data partition A layer RBSP.

NOTE 1 – The slice data partition B layer RBSP and slice data partition C layer RBSP need not be present.

Output of this process is a coded slice.

When slice data partitioning is not used, coded slices are represented by a slice layer without partitioning RBSP that contains a slice header followed by a slice data syntax structure that contains all the syntax elements of categories 2, 3, and 4 (see category column in subclause 7.3) of the macroblock data for the macroblocks of the slice.

When slice data partitioning is used, the macroblock data of a slice is partitioned into one to three partitions contained in separate NAL units. Partition A contains a slice data partition A header, and all syntax elements of category 2. Partition B, when present, contains a slice data partition B header and all syntax elements of category 3. Partition C, when present, contains a slice data partition C header and all syntax elements of category 4.

When slice data partitioning is used, the syntax elements of each category are parsed from a separate NAL unit, which need not be present when no symbols of the respective category exist. The decoding process shall process the slice data partitions of a coded slice in a manner equivalent to processing a corresponding slice layer without partitioning RBSP by extracting each syntax element from the slice data partition in which the syntax element appears depending on the slice data partition assignment in the syntax tables in subclause 7.3.

NOTE 2 – Syntax elements of category 3 are relevant to the decoding of residual data of I and SI macroblock types. Syntax elements of category 4 are relevant to the decoding of residual data of P and B macroblock types. Category 2 encompasses all other syntax elements related to the decoding of macroblocks, and their information is often denoted as header information. The slice data partition A header contains all the syntax elements of the slice header, and additionally a slice_id that are used to associate the slice data partitions B and C with the slice data partition A. The slice data partition B and C headers contain the slice_id syntax element that establishes their association with the slice data partition A of the slice.

### 8.2.4 Decoding process for reference picture lists construction

This process is invoked at the beginning of decoding of each P, SP, or B slice.

Decoded reference pictures are marked as "used for short-term reference" or "used for long-term reference" as specified by the bitstream and specified in subclause 8.2.5. Short-term reference pictures are identified by the value of frame_num. Long-term reference pictures are assigned a long-term frame index as specified by the bitstream and specified in subclause 8.2.5.

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Subclause 8.2.4.1 is invoked to specify

– the assignment of variables FrameNum, FrameNumWrap, and PicNum to each of the short-term reference pictures, and

– the assignment of variable LongTermPicNum to each of the long-term reference pictures.

Reference pictures are addressed through reference indices as specified in subclause 8.4.2.1. A reference index is an index into a reference picture list. When decoding a P or SP slice, there is a single reference picture list RefPicList0. When decoding a B slice, there is a second independent reference picture list RefPicList1 in addition to RefPicList0.

At the beginning of decoding of each slice, reference picture list RefPicList0, and for B slices RefPicList1, are derived as follows.

– An initial reference picture list RefPicList0 and for B slices RefPicList1 are derived as specified in subclause 8.2.4.2.

– The initial reference picture list RefPicList0 and for B slices RefPicList1 are modified as specified in subclause 8.2.4.3.

NOTE – The reordering process for reference picture lists specified in subclause 8.2.4.3 allows the contents of RefPicList0 and for B slices RefPicList1 to be modified in a flexible fashion. In particular, it is possible for a picture that is currently marked "used for reference" to be inserted into RefPicList0 and for B slices RefPicList1 even when the picture is not in the initial reference picture list derived as specified in subclause 8.2.4.2.

The number of entries in the modified reference picture list RefPicList0 is num_ref_idx_l0_active_minus1 + 1, and for B slices the number of entries in the modified reference picture list RefPicList1 is num_ref_idx_l1_active_minus1 + 1. A reference picture may appear at more than one index in the modified reference picture lists RefPicList0 or RefPicList1.

### 8.2.4.1 Decoding process for picture numbers

This process is invoked when the decoding process for reference picture lists construction specified in subclause 8.2.4 or the decoded reference picture marking process specified in subclause 8.2.5 is invoked.

The variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and LongTermPicNum are used for the initialisation process for reference picture lists in subclause 8.2.4.2, the modification process for reference picture lists in subclause 8.2.4.3, and for the decoded reference picture marking process in subclause 8.2.5.

To each short-term reference picture the variables FrameNum and FrameNumWrap are assigned as follows. First, FrameNum is set equal to the syntax element frame_num that has been decoded in the slice header(s) of the corresponding short-term reference picture. Then the variable FrameNumWrap is derived as

```
if( FrameNum > frame_num )
    FrameNumWrap = FrameNum – MaxFrameNum                    (8-28)
else
    FrameNumWrap = FrameNum
```

where the value of frame_num used in Equation 8-28 is the frame_num in the slice header(s) for the current picture.

Each long-term reference picture has an associated value of LongTermFrameIdx (that was assigned to it as specified in subclause 8.2.5).

To each short-term reference picture a variable PicNum is assigned, and to each long-term reference picture a variable LongTermPicNum is assigned. The values of these variables depend on the value of field_pic_flag and bottom_field_flag for the current picture and they are set as follows.

– If field_pic_flag is equal to 0, the following applies.

  – For each short-term reference frame or complementary reference field pair:

    PicNum = FrameNumWrap (8-29)

  – For each long-term reference frame or long-term complementary reference field pair:

    LongTermPicNum = LongTermFrameIdx (8-30)

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NOTE – When decoding a frame the value of MbaffFrameFlag has no influence on the derivations in subclauses 8.2.4.2, 8.2.4.3, and 8.2.5.

– Otherwise (field_pic_flag is equal to 1), the following applies.
  – For each short-term reference field the following applies.
    – If the reference field has the same parity as the current field

$$PicNum = 2 * FrameNumWrap + 1 \quad (8\text{-}31)$$

    – Otherwise (the reference field has the opposite parity of the current field),

$$PicNum = 2 * FrameNumWrap \quad (8\text{-}32)$$

  – For each long-term reference field the following applies.
    – If the reference field has the same parity as the current field

$$LongTermPicNum = 2 * LongTermFrameIdx + 1 \quad (8\text{-}33)$$

    – Otherwise (the reference field has the opposite parity of the current field),

$$LongTermPicNum = 2 * LongTermFrameIdx \quad (8\text{-}34)$$

#### 8.2.4.2 Initialisation process for reference picture lists

This initialisation process is invoked when decoding a P, SP, or B slice header.

RefPicList0 and RefPicList1 have initial entries as specified in subclauses 8.2.4.2.1 through 8.2.4.2.5.

When the number of entries in the initial RefPicList0 or RefPicList1 produced as specified in subclauses 8.2.4.2.1 through 8.2.4.2.5 is greater than num_ref_idx_l0_active_minus1 + 1 or num_ref_idx_l1_active_minus1 + 1, respectively, the extra entries past position num_ref_idx_l0_active_minus1 or num_ref_idx_l1_active_minus1 are discarded from the initial reference picture list.

When the number of entries in the initial RefPicList0 or RefPicList1 produced as specified in subclauses 8.2.4.2.1 through 8.2.4.2.5 is less than num_ref_idx_l0_active_minus1 + 1 or num_ref_idx_l1_active_minus1 + 1, respectively, the remaining entries in the initial reference picture list are set equal to "no reference picture".

##### 8.2.4.2.1 Initialisation process for the reference picture list for P and SP slices in frames

This initialisation process is invoked when decoding a P or SP slice in a coded frame.

When this process is invoked, there shall be at least one reference frame or complementary reference field pair that is currently marked as "used for short-term reference" or "used for long-term reference".

The reference picture list RefPicList0 is ordered so that short-term reference frames and short-term complementary reference field pairs have lower indices than long-term reference frames and long-term complementary reference field pairs.

The short-term reference frames and complementary reference field pairs are ordered starting with the frame or complementary field pair with the highest PicNum value and proceeding through in descending order to the frame or complementary field pair with the lowest PicNum value.

The long-term reference frames and complementary reference field pairs are ordered starting with the frame or complementary field pair with the lowest LongTermPicNum value and proceeding through in ascending order to the frame or complementary field pair with the highest LongTermPicNum value.

NOTE – A non-paired reference field is not used for inter prediction for decoding a frame, regardless of the value of MbaffFrameFlag.

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For example, when three reference frames are marked as "used for short-term reference" with PicNum equal to 300, 302, and 303 and two reference frames are marked as "used for long-term reference" with LongTermPicNum equal to 0 and 3, the initial index order is:

– RefPicList0[0] is set equal to the short-term reference picture with PicNum = 303,

– RefPicList0[1] is set equal to the short-term reference picture with PicNum = 302,

– RefPicList0[2] is set equal to the short-term reference picture with PicNum = 300,

– RefPicList0[3] is set equal to the long-term reference picture with LongTermPicNum = 0, and

– RefPicList0[4] is set equal to the long-term reference picture with LongTermPicNum = 3.

#### 8.2.4.2.2 Initialisation process for the reference picture list for P and SP slices in fields

This initialisation process is invoked when decoding a P or SP slice in a coded field.

Each field included in the reference picture list RefPicList0 has a separate index in the reference picture list RefPicList0.

NOTE – When decoding a field, there are effectively at least twice as many pictures available for referencing as there would be when decoding a frame at the same position in decoding order.

Two ordered lists of reference frames, refFrameList0ShortTerm and refFrameList0LongTerm, are derived as follows. For purposes of the formation of this list of frames, decoded reference frames, complementary reference field pairs, non-paired reference fields and reference frames in which a single field is marked "used for short-term reference" or "used for long-term reference" are all considered reference frames.

– All frames having one or more fields marked "used for short-term reference" are included in the list of short-term reference frames refFrameList0ShortTerm. When the current field is the second field (in decoding order) of a complementary reference field pair and the first field is marked as "used for short-term reference", the first field is included in the list of short-term reference frames refFrameList0ShortTerm. refFrameList0ShortTerm is ordered starting with the reference frame with the highest FrameNumWrap value and proceeding through in descending order to the reference frame with the lowest FrameNumWrap value.

– All frames having one or more fields marked "used for long-term reference" are included in the list of long-term reference frames refFrameList0LongTerm. When the current field is the second field (in decoding order) of a complementary reference field pair and the first field is marked as "used for long-term reference, the first field is included in the list of long-term reference frames refFrameList0LongTerm. refFrameList0LongTerm is ordered starting with the reference frame with the lowest LongTermFrameIdx value and proceeding through in ascending order to the reference frame with the highest LongTermFrameIdx value.

The process specified in subclause 8.2.4.2.5 is invoked with refFrameList0ShortTerm and refFrameList0LongTerm given as input and the output is assigned to RefPicList0.

#### 8.2.4.2.3 Initialisation process for reference picture lists for B slices in frames

This initialisation process is invoked when decoding a B slice in a coded frame.

For purposes of the formation of the reference picture lists RefPicList0 and RefPicList1 the term reference entry refers in the following to decoded reference frames or complementary reference field pairs.

When this process is invoked, there shall be at least one reference entry that is currently marked as "used for short-term reference" or "used for long-term reference".

For B slices, the order of short-term reference entries in the reference picture lists RefPicList0 and RefPicList1 depends on output order, as given by PicOrderCnt( ). When pic_order_cnt_type is equal to 0, reference pictures that are marked as "non-existing" as specified in subclause 8.2.5.2 are not included in either RefPicList0 or RefPicList1.

NOTE 1 – When gaps_in_frame_num_value_allowed_flag is equal to 1, encoders should use reference picture list reordering to ensure proper operation of the decoding process (particularly when pic_order_cnt_type is equal to 0, in which case PicOrderCnt( ) is not inferred for "non-existing" frames).

The reference picture list RefPicList0 is ordered such that short-term reference entries have lower indices than long-term reference entries. It is ordered as follows.

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– Let entryShortTerm be a variable ranging over all reference entries that are currently marked as "used for short-term reference". When some values of entryShortTerm are present having PicOrderCnt( entryShortTerm ) less than PicOrderCnt( CurrPic ), these values of entryShortTerm are placed at the beginning of refPicList0 in descending order of PicOrderCnt( entryShortTerm ). All of the remaining values of entryShortTerm (when present) are then appended to refPicList0 in ascending order of PicOrderCnt( entryShortTerm ).

– The long-term reference entries are ordered starting with the long-term reference entry that has the lowest LongTermPicNum value and proceeding through in ascending order to the long-term reference entry that has the highest LongTermPicNum value.

The reference picture list RefPicList1 is ordered so that short-term reference entries have lower indices than long-term reference entries. It is ordered as follows.

– Let entryShortTerm be a variable ranging over all reference entries that are currently marked as "used for short-term reference". When some values of entryShortTerm are present having PicOrderCnt( entryShortTerm ) greater than PicOrderCnt( CurrPic ), these values of entryShortTerm are placed at the beginning of refPicList1 in ascending order of PicOrderCnt( entryShortTerm ). All of the remaining values of entryShortTerm (when present) are then appended to refPicList1 in descending order of PicOrderCnt( entryShortTerm ).

– Long-term reference entries are ordered starting with the long-term reference frame or complementary reference field pair that has the lowest LongTermPicNum value and proceeding through in ascending order to the long-term reference entry that has the highest LongTermPicNum value.

– When the reference picture list RefPicList1 has more than one entry and RefPicList1 is identical to the reference picture list RefPicList0, the first two entries RefPicList1[ 0 ] and RefPicList1[ 1 ] are switched.

NOTE 2 – A non-paired reference field is not used for inter prediction of frames (independent of the value of MbaffFrameFlag).

#### 8.2.4.2.4 Initialisation process for reference picture lists for B slices in fields

This initialisation process is invoked when decoding a B slice in a coded field.

When decoding a field, each field of a stored reference frame is identified as a separate reference picture with a unique index. The order of short-term reference pictures in the reference picture lists RefPicList0 and RefPicList1 depend on output order, as given by PicOrderCnt( ). When pic_order_cnt_type is equal to 0, reference pictures that are marked as "non-existing" as specified in subclause 8.2.5.2 are not included in either RefPicList0 or RefPicList1.

NOTE 1 – When gaps_in_frame_num_value_allowed_flag is equal to 1, encoders should use reference picture list reordering to ensure proper operation of the decoding process (particularly when pic_order_cnt_type is equal to 0, in which case PicOrderCnt( ) is not inferred for "non-existing" frames).

NOTE 2 – When decoding a field, there are effectively at least twice as many pictures available for referencing as there would be when decoding a frame at the same position in decoding order.

Three ordered lists of reference frames, refFrameList0ShortTerm, refFrameList1ShortTerm and refFrameListLongTerm, are derived as follows. For purposes of the formation of these lists of frames the term reference entry refers in the following to decoded reference frames, complementary reference field pairs, or non-paired reference fields. When pic_order_cnt_type is equal to 0, the term reference entry does not refer to frames that are marked as "non-existing" as specified in subclause 8.2.5.2.

– Let entryShortTerm be a variable ranging over all reference entries that are currently marked as "used for short-term reference". When some values of entryShortTerm are present having PicOrderCnt( entryShortTerm ) less than or equal to PicOrderCnt( CurrPic ), these values of entryShortTerm are placed at the beginning of refFrameList0ShortTerm in descending order of PicOrderCnt( entryShortTerm ). All of the remaining values of entryShortTerm (when present) are then appended to refFrameList0ShortTerm in ascending order of PicOrderCnt( entryShortTerm ).

NOTE 3 – When the current field follows in decoding order a coded field fldPrev with which together it forms a complementary reference field pair, fldPrev is included into the list refFrameList0ShortTerm using PicOrderCnt( fldPrev ) and the ordering method described in the previous sentence is applied.

– Let entryShortTerm be a variable ranging over all reference entries that are currently marked as "used for short-term reference". When some values of entryShortTerm are present having PicOrderCnt( entryShortTerm ) greater than PicOrderCnt( CurrPic ), these values of entryShortTerm are placed at the beginning of refFrameList1ShortTerm in ascending order of PicOrderCnt( entryShortTerm ). All of the remaining values of entryShortTerm (when present) are then appended to refFrameList1ShortTerm in descending order of PicOrderCnt( entryShortTerm ).

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NOTE 4 – When the current field follows in decoding order a coded field fldPrev with which together it forms a complementary reference field pair, fldPrev is included into the list refFrameList1ShortTerm using PicOrderCnt( fldPrev ) and the ordering method described in the previous sentence is applied.

– refFrameListLongTerm is ordered starting with the reference entry having the lowest LongTermFrameIdx value and proceeding through in ascending order to the reference entry having highest LongTermFrameIdx value.

NOTE 5 – When the complementary field of the current picture is marked "used for long-term reference" it is included into the list refFrameListLongTerm. A reference entry in which only one field is marked as “used for long-term reference” is included into the list refFrameListLongTerm.

The process specified in subclause 8.2.4.2.5 is invoked with refFrameList0ShortTerm and refFrameListLongTerm given as input and the output is assigned to RefPicList0.

The process specified in subclause 8.2.4.2.5 is invoked with refFrameList1ShortTerm and refFrameListLongTerm given as input and the output is assigned to RefPicList1.

When the reference picture list RefPicList1 has more than one entry and RefPicList1 is identical to the reference picture list RefPicList0, the first two entries RefPicList1[0] and RefPicList1[1] are switched.

#### 8.2.4.2.5 Initialisation process for reference picture lists in fields

Inputs of this process are the reference frame lists refFrameListXShortTerm (with X may be 0 or 1) and refFrameListLongTerm.

The reference picture list RefPicListX is a list ordered such that short-term reference fields have lower indices than long-term reference fields. Given the reference frame lists refFrameListXShortTerm and refFrameListLongTerm, it is derived as follows.

– Short-term reference fields are ordered by selecting reference fields from the ordered list of frames refFrameListXShortTerm by alternating between fields of differing parity, starting with a field that has the same parity as the current field (when present). When one field of a reference frame was not decoded or is not marked as “used for short-term reference”, the missing field is ignored and instead the next available stored reference field of the chosen parity from the ordered list of frames refFrameListXShortTerm is inserted into RefPicListX. When there are no more short-term reference fields of the alternate parity in the ordered list of frames refFrameListXShortTerm, the next not yet indexed fields of the available parity are inserted into RefPicListX in the order in which they occur in the ordered list of frames refFrameListXShortTerm.

– Long-term reference fields are ordered by selecting reference fields from the ordered list of frames refFrameListLongTerm by alternating between fields of differing parity, starting with a field that has the same parity as the current field (when present). When one field of a reference frame was not decoded or is not marked as “used for long-term reference”, the missing field is ignored and instead the next available stored reference field of the chosen parity from the ordered list of frames refFrameListLongTerm is inserted into RefPicListX. When there are no more long-term reference fields of the alternate parity in the ordered list of frames refFrameListLongTerm, the next not yet indexed fields of the available parity are inserted into RefPicListX in the order in which they occur in the ordered list of frames refFrameListLongTerm.

### 8.2.4.3 Reordering process for reference picture lists

When ref_pic_list_reordering_flag_l0 is equal to 1, the following applies.

– Let refIdxL0 be an index into the reference picture list RefPicList0. It is initially set equal to 0.

– The corresponding syntax elements reordering_of_pic_nums_idc are processed in the order they occur in the bitstream. For each of these syntax elements, the following applies.

  – If reordering_of_pic_nums_idc is equal to 0 or equal to 1, the process specified in subclause 8.2.4.3.1 is invoked with refIdxL0 as input, and the output is assigned to refIdxL0.

  – Otherwise, if reordering_of_pic_nums_idc is equal to 2, the process specified in subclause 8.2.4.3.2 is invoked with refIdxL0 as input, and the output is assigned to refIdxL0.

  – Otherwise (reordering_of_pic_nums_idc is equal to 3), the reordering process for reference picture list RefPicList0 is finished.

When ref_pic_list_reordering_flag_l1 is equal to 1, the following applies.

– Let refIdxL1 be an index into the reference picture list RefPicList1. It is initially set equal to 0.

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– The corresponding syntax elements reordering_of_pic_nums_idc are processed in the order they occur in the bitstream. For each of these syntax elements, the following applies.
  – If reordering_of_pic_nums_idc is equal to 0 or equal to 1, the process specified in subclause 8.2.4.3.1 is invoked with refIdxL1 as input, and the output is assigned to refIdxL1.
  – Otherwise, if reordering_of_pic_nums_idc is equal to 2, the process specified in subclause 8.2.4.3.2 is invoked with refIdxL1 as input, and the output is assigned to refIdxL1.
  – Otherwise (reordering_of_pic_nums_idc is equal to 3), the reordering process for reference picture list RefPicList1 is finished.

#### 8.2.4.3.1 Reordering process of reference picture lists for short-term reference pictures

Input to this process is an index refIdxLX (with X being 0 or 1).

Output of this process is an incremented index refIdxLX.

The variable picNumLXNoWrap is derived as follows.

– If reordering_of_pic_nums_idc is equal to 0

```
if( picNumLXPred – ( abs_diff_pic_num_minus1 + 1 ) < 0 )
      picNumLXNoWrap = picNumLXPred – ( abs_diff_pic_num_minus1 + 1 ) + MaxPicNum          (8-35)
else
      picNumLXNoWrap = picNumLXPred – ( abs_diff_pic_num_minus1 + 1 )
```

– Otherwise (reordering_of_pic_nums_idc is equal to 1),

```
if( picNumLXPred + ( abs_diff_pic_num_minus1 + 1 ) >= MaxPicNum )
      picNumLXNoWrap = picNumLXPred + ( abs_diff_pic_num_minus1 + 1 ) – MaxPicNum          (8-36)
else
      picNumLXNoWrap = picNumLXPred + ( abs_diff_pic_num_minus1 + 1 )
```

picNumLXPred is the prediction value for the variable picNumLXNoWrap. When the process specified in this subclause is invoked the first time for a slice (that is, for the first occurrence of reordering_of_pic_nums_idc equal to 0 or 1 in the ref_pic_list_reordering( ) syntax), picNumL0Pred and picNumL1Pred are initially set equal to CurrPicNum. After each assignment of picNumLXNoWrap, the value of picNumLXNoWrap is assigned to picNumLXPred.

The variable picNumLX is derived as follows

```
if( picNumLXNoWrap > CurrPicNum )
      picNumLX = picNumLXNoWrap – MaxPicNum                                              (8-37)
else
      picNumLX = picNumLXNoWrap
```

picNumLX shall be equal to the PicNum of a reference picture that is marked as “used for short-term reference” and shall not be equal to the PicNum of a short-term reference picture that is marked as "non-existing".

The following procedure is conducted to place the picture with short-term picture number picNumLX into the index position refIdxLX, shift the position of any other remaining pictures to later in the list, and increment the value of refIdxLX.

```
for( cIdx = num_ref_idx_lX_active_minus1 + 1; cIdx > refIdxLX; cIdx-- )
    RefPicListX[ cIdx ] = RefPicListX[ cIdx – 1]
RefPicListX[ refIdxLX++ ] = short-term reference picture with PicNum equal to picNumLX
nIdx = refIdxLX
for( cIdx = refIdxLX; cIdx <= num_ref_idx_lX_active_minus1 + 1; cIdx++ )               (8-38)
    if( PicNumF( RefPicListX[ cIdx ] ) != picNumLX )
        RefPicListX[ nIdx++ ] = RefPicListX[ cIdx ]
```

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where the function PicNumF( RefPicListX[ cIdx ] ) is derived as follows:

– If the picture RefPicListX[ cIdx ] is marked as "used for short-term reference", PicNumF( RefPicListX[ cIdx ] ) is the PicNum of the picture RefPicListX[ cIdx ].

– Otherwise (the picture RefPicListX[ cIdx ] is not marked as "used for short-term reference"), PicNumF( RefPicListX[ cIdx ] ) is equal to MaxPicNum.

NOTE 1 – A value of MaxPicNum can never be equal to picNumLX.

NOTE 2 – Within this pseudo-code procedure, the length of the list RefPicListX is temporarily made one element longer than the length needed for the final list. After the execution of this procedure, only elements 0 through num_ref_idx_lX_active_minus1 of the list need to be retained.

#### 8.2.4.3.2 Reordering process of reference picture lists for long-term reference pictures

Input to this process is an index refIdxLX (with X being 0 or 1).

Output of this process is an incremented index refIdxLX.

The following procedure is conducted to place the picture with long-term picture number long_term_pic_num into the index position refIdxLX, shift the position of any other remaining pictures to later in the list, and increment the value of refIdxLX.

```
for( cIdx = num_ref_idx_lX_active_minus1 + 1; cIdx > refIdxLX; cIdx-- )
    RefPicListX[ cIdx ] = RefPicListX[ cIdx – 1]
RefPicListX[ refIdxLX++ ] = long-term reference picture with LongTermPicNum equal to long_term_pic_num
nIdx = refIdxLX
for( cIdx = refIdxLX; cIdx <= num_ref_idx_lX_active_minus1 + 1; cIdx++ )                    (8-39)
    if( LongTermPicNumF( RefPicListX[ cIdx ] ) != long_term_pic_num )
        RefPicListX[ nIdx++ ] = RefPicListX[ cIdx ]
```

where the function LongTermPicNumF( RefPicListX[ cIdx ] ) is derived as follows:

– If the picture RefPicListX[ cIdx ] is marked as "used for long-term reference", LongTermPicNumF( RefPicListX[ cIdx ] ) is the LongTermPicNum of the picture RefPicListX[ cIdx ].

– Otherwise (the picture RefPicListX[ cIdx ] is not marked as "used for long-term reference"), LongTermPicNumF( RefPicListX[ cIdx ] ) is equal to 2 * ( MaxLongTermFrameIdx + 1 ).

NOTE 1 – A value of 2 * ( MaxLongTermFrameIdx + 1 ) can never be equal to long_term_pic_num.

NOTE 2 – Within this pseudo-code procedure, the length of the list RefPicListX is temporarily made one element longer than the length needed for the final list. After the execution of this procedure, only elements 0 through num_ref_idx_lX_active_minus1 of the list need to be retained.

### 8.2.5 Decoded reference picture marking process

This process is invoked for decoded pictures when nal_ref_idc is not equal to 0.

NOTE – The decoding process for gaps in frame_num that is specified in subclause 8.2.5.2 may also be invoked when nal_ref_idc is equal to 0, as specified in clause 8.

A decoded picture with nal_ref_idc not equal to 0, referred to as a reference picture, is marked as “used for short-term reference” or "used for long-term reference". For a decoded reference frame, both of its fields are marked the same as the frame. For a complementary reference field pair, the pair is marked the same as both of its fields. A picture that is marked as "used for short-term reference" is identified by its FrameNum and, when it is a field, by its parity. A picture that is marked as "used for long-term reference" is identified by its LongTermFrameIdx and, when it is a field, by its parity.

Frames or complementary field pairs marked as “used for short-term reference” or as "used for long-term reference" can be used as a reference for inter prediction when decoding a frame until the frame, the complementary field pair, or one of its constituent fields is marked as “unused for reference”. A field marked as “used for short-term reference” or as "used for long-term reference" can be used as a reference for inter prediction when decoding a field until marked as “unused for reference”.

A picture can be marked as "unused for reference" by the sliding window reference picture marking process, a first-in, first-out mechanism specified in subclause 8.2.5.3 or by the adaptive memory control reference picture marking process, a customised adaptive marking operation specified in subclause 8.2.5.4.

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A short-term reference picture is identified for use in the decoding process by its variables FrameNum and FrameNumWrap and its picture number PicNum, and a long-term reference picture is identified for use in the decoding process by its long-term picture number LongTermPicNum. When the current picture is not an IDR picture, subclause 8.2.4.1 is invoked to specify the assignment of the variables FrameNum, FrameNumWrap, PicNum and LongTermPicNum.

#### 8.2.5.1 Sequence of operations for decoded reference picture marking process

Decoded reference picture marking proceeds in the following ordered steps.

1. All slices of the current picture are decoded.
2. Depending on whether the current picture is an IDR picture, the following applies.
   - If the current picture is an IDR picture, the following applies.
     - All reference pictures are marked as "unused for reference"
     - Depending on long_term_reference_flag, the following applies.
       - If long_term_reference_flag is equal to 0, the IDR picture is marked as "used for short-term reference" and MaxLongTermFrameIdx is set equal to “no long-term frame indices”.
       - Otherwise (long_term_reference_flag is equal to 1), the IDR picture is marked as "used for long-term reference", the LongTermFrameIdx for the IDR picture is set equal to 0, and MaxLongTermFrameIdx is set equal to 0.
   - Otherwise (the current picture is not an IDR picture), the following applies.
     - If adaptive_ref_pic_marking_mode_flag is equal to 0, the process specified in subclause 8.2.5.3 is invoked.
     - Otherwise (adaptive_ref_pic_marking_mode_flag is equal to 1), the process specified in subclause 8.2.5.4 is invoked.
3. When the current picture is not an IDR picture and it was not marked as "used for long-term reference" by memory_management_control_operation equal to 6, it is marked as "used for short-term reference".

After marking the current decoded reference picture, the total number of frames with at least one field marked as “used for reference”, plus the number of complementary field pairs with at least one field marked as “used for reference”, plus the number of non-paired fields marked as “used for reference” shall not be greater than Max( num_ref_frames, 1 ).

#### 8.2.5.2 Decoding process for gaps in frame_num

This process is invoked when frame_num is not equal to PrevRefFrameNum and is not equal to ( PrevRefFrameNum + 1 ) % MaxFrameNum.

NOTE 1 – Although this process is specified as a subclause within subclause 8.2.5 (which defines a process that is invoked only when nal_ref_idc is not equal to 0), this process may also be invoked when nal_ref_idc is equal to 0 (as specified in clause 8). The reasons for the location of this subclause within the structure of this International Standard are historical.

NOTE 2 – This process can only be invoked for a conforming bitstream when gaps_in_frame_num_value_allowed_flag is equal to 1. When gaps_in_frame_num_value_allowed_flag is equal to 0 and frame_num is not equal to PrevRefFrameNum and is not equal to ( PrevRefFrameNum + 1 ) % MaxFrameNum, the decoding process should infer an unintentional loss of pictures.

When this process is invoked, a set of values of frame_num pertaining to “non-existing” pictures is derived as all values taken on by UnusedShortTermFrameNum in Equation 7-22 except the value of frame_num for the current picture.

The decoding process generates and marks a frame for each of the values of frame_num pertaining to “non-existing” pictures, in the order in which the values of UnusedShortTermFrameNum are generated by Equation 7-22, using the “sliding window” picture marking process as specified in subclause 8.2.5.3. The generated frames are also marked as “non-existing” and “used for short-term reference”. The sample values of the generated frames may be set to any value. The bitstream shall not contain data that results in a reference to these generated frames which are marked as “non-existing” in the inter prediction process, a reference to these frames in the reordering commands for reference picture lists for short-term reference pictures (subclause 8.2.4.3.1), or a reference to these frames in the assignment process of a LongTermFrameIdx to a short-term reference picture (subclause 8.2.5.4.3).

When pic_order_cnt_type is not equal to 0, TopFieldOrderCnt and BottomFieldOrderCnt are derived for each of the "non-existing" frames by invoking the decoding process for picture order count in subclause 8.2.1. When invoking the process in subclause 8.2.1 for a particular "non-existing" frame, the current picture is considered to be a picture

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considered having frame_num inferred to be equal to UnusedShortTermFrameNum, nal_ref_idc inferred to be not equal to 0, nal_unit_type inferred to be not equal to 5, field_pic_flag inferred to be equal to 0, adaptive_ref_pic_marking_mode_flag inferred to be equal to 0, delta_pic_order_cnt[ 0 ] (if needed) inferred to be equal to 0, and delta_pic_order_cnt[ 1 ] (if needed) inferred to be equal to 0.

NOTE 3 – The decoding process should infer an unintentional picture loss when any of these values of frame_num pertaining to "non-existing" pictures is referred to in the inter prediction process, is referred to in the reordering commands for reference picture lists for short-term reference pictures (subclause 8.2.4.3.1), or is referred to in the assignment process of a LongTermFrameIdx to a short-term reference picture (subclause 8.2.5.4.3). The decoding process should not infer an unintentional picture loss when a memory management control operation not equal to 3 is applied to a frame marked as "non-existing".

#### 8.2.5.3 Sliding window decoded reference picture marking process

This process is invoked when adaptive_ref_pic_marking_mode_flag is equal to 0.

Depending on the properties of the current picture as specified below, the following applies.

– If the current picture is a coded field that is the second field in decoding order of a complementary reference field pair, and the first field has been marked as "used for short-term reference", the current picture is also marked as "used for short-term reference".

– Otherwise, the following applies.

  – Let numShortTerm be the total number of reference frames, complementary reference field pairs and non-paired reference fields for which at least one field is marked as "used for short-term reference". Let numLongTerm be the total number of reference frames, complementary reference field pairs and non-paired reference fields for which at least one field is marked as "used for long-term reference".

  – When numShortTerm + numLongTerm is equal to Max( num_ref_frames, 1 ), the condition that numShortTerm is greater than 0 shall be fulfilled, and the short-term reference frame, complementary reference field pair or non-paired reference field that has the smallest value of FrameNumWrap is marked as "unused for reference". When it is a frame or a complementary field pair, both of its fields are also marked as "unused for reference".

#### 8.2.5.4 Adaptive memory control decoded reference picture marking process

This process is invoked when adaptive_ref_pic_marking_mode_flag is equal to 1.

The memory_management_control_operation commands with values of 1 to 6 are processed in the order they occur in the bitstream after the current picture has been decoded. For each of these memory_management_control_operation commands, one of the processes specified in subclauses 8.2.5.4.1 to 8.2.5.4.5 is invoked depending on the value of memory_management_control_operation. The memory_management_control_operation command with value of 0 specifies the end of memory_management_control_operation commands.

Memory management control operations are applied to pictures as follows.

– If field_pic_flag is equal to 0, memory_management_control_operation commands are applied to the frames or complementary reference field pairs specified.

– Otherwise (field_pic_flag is equal to 1), memory_management_control_operation commands are applied to the individual reference fields specified.

##### 8.2.5.4.1 Marking process of a short-term reference picture as "unused for reference"

This process is invoked when memory_management_control_operation is equal to 1.

Let picNumX be specified by

$$picNumX = CurrPicNum - ( difference_of_pic_nums_minus1 + 1 ). \quad (8\text{-}40)$$

Depending on field_pic_flag the value of picNumX is used to mark a short-term reference picture as "unused for reference" as follows.

– If field_pic_flag is equal to 0, the short-term reference frame or short-term complementary reference field pair specified by picNumX and both of its fields are marked as "unused for reference".

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– Otherwise (field_pic_flag is equal to 1), the short-term reference field specified by picNumX is marked as “unused for reference”. When that reference field is part of a reference frame or a complementary reference field pair, the frame or complementary field pair is also marked as "unused for reference", but the marking of the other field is not changed.

#### 8.2.5.4.2 Marking process of a long-term reference picture as “unused for reference”

This process is invoked when memory_management_control_operation is equal to 2.

Depending on field_pic_flag the value of LongTermPicNum is used to mark a long-term reference picture as “unused for reference” as follows.

– If field_pic_flag is equal to 0, the long-term reference frame or long-term complementary reference field pair having LongTermPicNum equal to long_term_pic_num and both of its fields are marked as “unused for reference”.

– Otherwise (field_pic_flag is equal to 1), the long-term reference field specified by LongTermPicNum equal to long_term_pic_num is marked as “unused for reference”. When that reference field is part of a reference frame or a complementary reference field pair, the frame or complementary field pair is also marked as "unused for reference", but the marking of the other field is not changed.

#### 8.2.5.4.3 Assignment process of a LongTermFrameIdx to a short-term reference picture

This process is invoked when memory_management_control_operation is equal to 3.

Given the syntax element difference_of_pic_nums_minus1, the variable picNumX is obtained as specified in subclause 8.2.5.4.1. picNumX shall refer to a frame or complementary reference field pair or non-paired reference field marked as "used for short-term reference" and not marked as "non-existing".

When LongTermFrameIdx equal to long_term_frame_idx is already assigned to a long-term reference frame or a long-term complementary reference field pair, that frame or complementary field pair and both of its fields are marked as "unused for reference". When LongTermFrameIdx is already assigned to a non-paired reference field, and the field is not the complementary field of the picture specified by picNumX, that field is marked as “unused for reference”.

Depending on field_pic_flag the value of LongTermFrameIdx is used to mark a picture from "used for short-term reference" to "used for long-term reference" as follows.

– If field_pic_flag is equal to 0, the marking of the short-term reference frame or short-term complementary reference field pair specified by picNumX and both of its fields are changed from "used for short-term reference" to "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

– Otherwise (field_pic_flag is equal to 1), the marking of the short-term reference field specified by picNumX is changed from "used for short-term reference" to "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx. When the field is part of a reference frame or a complementary reference field pair, and the other field of the same reference frame or complementary reference field pair is also marked as "used for long-term reference", the reference frame or complementary reference field pair is also marked as "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

#### 8.2.5.4.4 Decoding process for MaxLongTermFrameIdx

This process is invoked when memory_management_control_operation is equal to 4.

All pictures for which LongTermFrameIdx is greater than max_long_term_frame_idx_plus1 – 1 and that are marked as "used for long-term reference" are marked as “unused for reference”.

The variable MaxLongTermFrameIdx is derived as follows.

– If max_long_term_frame_idx_plus1 is equal to 0, MaxLongTermFrameIdx is set equal to “no long-term frame indices”.

– Otherwise (max_long_term_frame_idx_plus1 is greater than 0), MaxLongTermFrameIdx is set equal to max_long_term_frame_idx_plus1 – 1.

NOTE – The memory_management_control_operation command equal to 4 can be used to mark long-term reference pictures as “unused for reference”. The frequency of transmitting max_long_term_frame_idx_plus1 is not specified by this International Standard. However, the encoder should send a memory_management_control_operation command equal to 4 upon receiving an error message, such as an intra refresh request message.

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#### 8.2.5.4.4.1 Marking process of all reference pictures as “unused for reference” and setting MaxLongTermFrameIdx to “no long-term frame indices”

This process is invoked when memory_management_control_operation is equal to 5.

All reference pictures are marked as “unused for reference” and the variable MaxLongTermFrameIdx is set equal to “no long-term frame indices”.

#### 8.2.5.4.5 Process for assigning a long-term frame index to the current picture

This process is invoked when memory_management_control_operation is equal to 6.

When a variable LongTermFrameIdx equal to long_term_frame_idx is already assigned to a long-term reference frame or a long-term complementary reference field pair, that frame or complementary field pair and both of its fields are marked as "unused for reference". When LongTermFrameIdx is already assigned to a non-paired reference field, and the field is not the complementary field of the current picture, that field is marked as “unused for reference”.

The current picture is marked as "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

When field_pic_flag is equal to 0, both its fields are also marked as "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

When field_pic_flag is equal to 1 and the current picture is the second field (in decoding order) of a complementary reference field pair, and the first field of the complementary reference field pair is also currently marked as "used for long-term reference), the complementary reference field pair is also marked as "used for long-term reference" and assigned LongTermFrameIdx equal to long_term_frame_idx.

After marking the current decoded reference picture, the total number of frames with at least one field marked as “used for reference”, plus the number of complementary field pairs with at least one field marked as “used for reference”, plus the number of non-paired fields marked as “used for reference” shall not be greater than Max( num_ref_frames, 1 ).

NOTE – Under some circumstances, the above statement may impose a constraint on the order in which a memory_management_control_operation syntax element equal to 6 can appear in the decoded reference picture marking syntax relative to a memory_management_control_operation syntax element equal to 1, 2, or 4.

## 8.3 Intra prediction process

This process is invoked for I and SI macroblock types.

Inputs to this process are constructed samples prior to the deblocking filter process and, for Intra_NxN prediction modes (where NxN is equal to 4x4 or 8x8), the values of IntraNxNPredMode from neighbouring macroblocks.

Outputs of this process are specified as follows.

– If the macroblock prediction mode is Intra_4x4 or Intra_8x8, the outputs are constructed luma samples prior to the deblocking filter process and (when ChromaArrayType is not equal to 0) chroma prediction samples of the macroblock $pred_C$, where C is equal to Cb and Cr.

– Otherwise, if mb_type is not equal to I_PCM, the outputs are luma prediction samples of the macroblock $pred_L$ and (when ChromaArrayType is not equal to 0) chroma prediction samples of the macroblock $pred_C$, where C is equal to Cb and Cr.

– Otherwise (mb_type is equal to I_PCM), the outputs are constructed luma and (when ChromaArrayType is not equal to 0) chroma samples prior to the deblocking filter process.

The variable MvCnt is set equal to 0.

Depending on the value of mb_type the following applies.

– If mb_type is equal to I_PCM, the sample construction process for I_PCM macroblocks as specified in subclause 8.3.5 is invoked.

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– Otherwise (mb_type is not equal to I_PCM), the following applies.
  – The decoding processes for Intra prediction modes are described for the luma component as follows.
    – If the macroblock prediction mode is equal to Intra_4x4, the Intra_4x4 prediction process for luma samples as specified in subclause 8.3.1 is invoked.
    – Otherwise, if the macroblock prediction mode is equal to Intra_8x8, the Intra_8x8 prediction process as specified in subclause 8.3.2 is invoked.
    – Otherwise (the macroblock prediction mode is equal to Intra_16x16), the Intra_16x16 prediction process as specified in subclause 8.3.3 is invoked with $S'_L$ as the input and the outputs are luma prediction samples of the macroblock $pred_L$.
  – When ChromaArrayType is not equal to 0, the Intra prediction process for chroma samples as specified in subclause 8.3.4 is invoked with $S'_{Cb}$, and $S'_{Cr}$ as the inputs and the outputs are chroma prediction samples of the macroblock $pred_{Cb}$ and $pred_{Cr}$.

Samples used in the Intra prediction process are the sample values prior to alteration by any deblocking filter operation.

### 8.3.1 Intra_4x4 prediction process for luma samples

This process is invoked when the macroblock prediction mode is equal to Intra_4x4.

Inputs to this process are the values of Intra4x4PredMode (if available) or Intra8x8PredMode (if available) from neighbouring macroblocks or macroblock pairs.

The luma component of a macroblock consists of 16 blocks of 4x4 luma samples. These blocks are inverse scanned using the 4x4 luma block inverse scanning process as specified in subclause 6.4.3.

For all 4x4 luma blocks of the luma component of a macroblock with luma4x4BlkIdx = 0..15, the derivation process for the Intra4x4PredMode as specified in subclause 8.3.1.1 is invoked with luma4x4BlkIdx as well as Intra4x4PredMode and Intra8x8PredMode that are previously (in decoding order) derived for adjacent macroblocks as the input and the variable Intra4x4PredMode[ luma4x4BlkIdx ] as the output.

For each luma block of 4x4 samples indexed using luma4x4BlkIdx = 0..15,

1. The Intra_4x4 sample prediction process in subclause 8.3.1.2 is invoked with luma4x4BlkIdx and the array $S'_L$ containing constructed luma samples prior to the deblocking filter process from adjacent luma blocks as the inputs and the outputs are the Intra_4x4 luma prediction samples $pred4x4_L[ x, y ]$ with x, y = 0..3.
2. The position of the upper-left sample of a 4x4 luma block with index luma4x4BlkIdx inside the current macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to ( xO, yO ) and x, y = 0..3.

$$pred_L[ xO + x, yO + y ] = pred4x4_L[ x, y ] \quad (8\text{-}41)$$

3. The transform coefficient decoding process and picture construction process prior to deblocking filter process in subclause 8.5 is invoked with $pred_L$ and luma4x4BlkIdx as the input and the constructed samples for the current 4x4 luma block $S'_L$ as the output.

#### 8.3.1.1 Derivation process for the Intra4x4PredMode

Inputs to this process are the index of the 4x4 luma block luma4x4BlkIdx and variable arrays Intra4x4PredMode (if available) and Intra8x8PredMode (if available) that are previously (in decoding order) derived for adjacent macroblocks.

Output of this process is the variable Intra4x4PredMode[ luma4x4BlkIdx ].

Table 8-2 specifies the values for Intra4x4PredMode[ luma4x4BlkIdx ] and the associated names.

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**Table 8-2 – Specification of Intra4x4PredMode[ luma4x4BlkIdx ] and associated names**

| Intra4x4PredMode[ luma4x4BlkIdx ] | Name of Intra4x4PredMode[ luma4x4BlkIdx ] |
|---|---|
| 0 | Intra_4x4_Vertical (prediction mode) |
| 1 | Intra_4x4_Horizontal (prediction mode) |
| 2 | Intra_4x4_DC (prediction mode) |
| 3 | Intra_4x4_Diagonal_Down_Left (prediction mode) |
| 4 | Intra_4x4_Diagonal_Down_Right (prediction mode) |
| 5 | Intra_4x4_Vertical_Right (prediction mode) |
| 6 | Intra_4x4_Horizontal_Down (prediction mode) |
| 7 | Intra_4x4_Vertical_Left (prediction mode) |
| 8 | Intra_4x4_Horizontal_Up (prediction mode) |

Intra4x4PredMode[ luma4x4BlkIdx ] labelled 0, 1, 3, 4, 5, 6, 7, and 8 represent directions of predictions as illustrated in Figure 8-1.

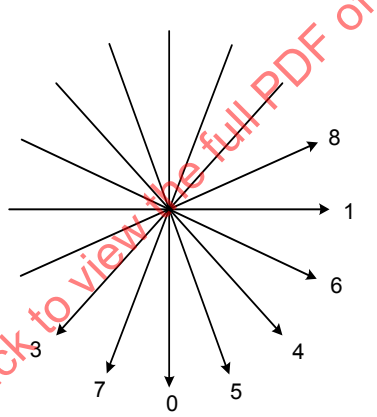


**Figure 8-1 – Intra_4x4 prediction mode directions (informative)**

Intra4x4PredMode[ luma4x4BlkIdx ] is derived as follows.

– The process specified in subclause 6.4.10.4 is invoked with luma4x4BlkIdx given as input and the output is assigned to mbAddrA, luma4x4BlkIdxA, mbAddrB, and luma4x4BlkIdxB.

– The variable dcPredModePredictedFlag is derived as follows.

  – If any of the following conditions are true, dcPredModePredictedFlag is set equal to 1

    – the macroblock with address mbAddrA is not available

    – the macroblock with address mbAddrB is not available

    – the macroblock with address mbAddrA is available and coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1

    – the macroblock with address mbAddrB is available and coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1

  – Otherwise, dcPredModePredictedFlag is set equal to 0.

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– For N being either replaced by A or B, the variables intraMxMPredModeN are derived as follows.

  – If dcPredModePredictedFlag is equal to 1 or the macroblock with address mbAddrN is not coded in Intra_4x4 or Intra_8x8 macroblock prediction mode, intraMxMPredModeN is set equal to 2 (Intra_4x4_DC prediction mode).

  – Otherwise (dcPredModePredictedFlag is equal to 0 and (the macroblock with address mbAddrN is coded in Intra_4x4 macroblock prediction mode or the macroblock with address mbAddrN is coded in Intra_8x8 macroblock prediction mode)), the following applies.

    – If the macroblock with address mbAddrN is coded in Intra_4x4 macroblock mode, intraMxMPredModeN is set equal to Intra4x4PredMode[ luma4x4BlkIdxN ], where Intra4x4PredMode is the variable array assigned to the macroblock mbAddrN.

    – Otherwise (the macroblock with address mbAddrN is coded in Intra_8x8 macroblock mode), intraMxMPredModeN is set equal to Intra8x8PredMode[ luma4x4BlkIdxN >> 2 ], where Intra8x8PredMode is the variable array assigned to the macroblock mbAddrN.

– Intra4x4PredMode[ luma4x4BlkIdx ] is derived by applying the following procedure.

```
predIntra4x4PredMode = Min( intraMxMPredModeA, intraMxMPredModeB )
if( prev_intra4x4_pred_mode_flag[ luma4x4BlkIdx ] )
    Intra4x4PredMode[ luma4x4BlkIdx ] = predIntra4x4PredMode
else                                                                    (8-42)
    if( rem_intra4x4_pred_mode[ luma4x4BlkIdx ] < predIntra4x4PredMode )
        Intra4x4PredMode[ luma4x4BlkIdx ] = rem_intra4x4_pred_mode[ luma4x4BlkIdx ]
    else
        Intra4x4PredMode[ luma4x4BlkIdx ] = rem_intra4x4_pred_mode[ luma4x4BlkIdx ] + 1
```

#### 8.3.1.2 Intra_4x4 sample prediction

This process is invoked for each 4x4 luma block of a macroblock with prediction mode equal to Intra_4x4 followed by the transform decoding process and picture construction process prior to deblocking for each 4x4 luma block.

Inputs to this process are

– the index of a 4x4 luma block luma4x4BlkIdx,

– an (PicWidthInSamples$_L$)x(PicHeightInSamples$_L$) array $cS_L$ containing constructed luma samples prior to the deblocking filter process of neighbouring macroblocks.

Output of this process are the prediction samples $pred4x4_L$[ x, y ], with x, y = 0..3 for the 4x4 luma block with index luma4x4BlkIdx.

The position of the upper-left sample of a 4x4 luma block with index luma4x4BlkIdx inside the current macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to ( xO, yO ).

The 13 neighbouring samples p[ x, y ] that are constructed luma samples prior to the deblocking filter process, with x = -1, y = -1..3 and x = 0..7, y = -1, are derived as follows.

– The luma location ( xN, yN ) is specified by

$$xN = xO + x \tag{8-43}$$

$$yN = yO + y \tag{8-44}$$

– The derivation process for neighbouring locations in subclause 6.4.11 is invoked for luma locations with ( xN, yN ) as input and mbAddrN and ( xW, yW ) as output.

– Each sample p[ x, y ] with x = -1, y = -1..3 and x = 0..7, y = -1 is derived as follows.

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- If any of the following conditions is true, the sample p[ x, y ] is marked as "not available for Intra_4x4 prediction"
  - mbAddrN is not available,
  - the macroblock mbAddrN is coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1.
  - the macroblock mbAddrN has mb_type equal to SI and constrained_intra_pred_flag is equal to 1 and the current macroblock does not have mb_type equal to SI.
  - x is greater than 3 and luma4x4BlkIdx is equal to 3 or 11
- Otherwise, the sample p[ x, y ] is marked as "available for Intra_4x4 prediction" and the value of the sample p[ x, y ] is derived as follows.
  - The location of the upper-left luma sample of the macroblock mbAddrN is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with mbAddrN as the input and the output is assigned to ( xM, yM ).
  - Depending on the variable MbaffFrameFlag and the macroblock mbAddrN, the sample value p[ x, y ] is derived as follows.
    - If MbaffFrameFlag is equal to 1 and the macroblock mbAddrN is a field macroblock,

      $$p[ x, y ] = cS_L[ xM + xW, yM + 2 * yW ] \quad (8\text{-}45)$$

    - Otherwise (MbaffFrameFlag is equal to 0 or the macroblock mbAddrN is a frame macroblock),

      $$p[ x, y ] = cS_L[ xM + xW, yM + yW ] \quad (8\text{-}46)$$

When samples p[ x, -1 ], with x = 4..7 are marked as "not available for Intra_4x4 prediction," and the sample p[ 3, -1 ] is marked as "available for Intra_4x4 prediction," the sample value of p[ 3, -1 ] is substituted for sample values p[ x, -1 ], with x = 4..7 and samples p[ x, -1 ], with x = 4..7 are marked as "available for Intra_4x4 prediction".

NOTE – Each block is assumed to be constructed into a picture array prior to decoding of the next block.

Depending on Intra4x4PredMode[ luma4x4BlkIdx ], one of the Intra_4x4 prediction modes specified in subclauses 8.3.1.2.1 to 8.3.1.2.9 is invoked.

#### 8.3.1.2.1 Specification of Intra_4x4_Vertical prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[ luma4x4BlkIdx ] is equal to 0.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..3 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0..3 are derived by

$$pred4x4_L[ x, y ] = p[ x, -1 ], \text{ with } x, y = 0..3 \quad (8\text{-}47)$$

#### 8.3.1.2.2 Specification of Intra_4x4_Horizontal prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[ luma4x4BlkIdx ] is equal to 1.

This mode shall be used only when the samples p[ -1, y ], with y = 0..3 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0..3 are derived by

$$pred4x4_L[ x, y ] = p[ -1, y ], \text{ with } x,y = 0..3 \quad (8\text{-}48)$$

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#### 8.3.1.2.3 Specification of Intra_4x4_DC prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[ luma4x4BlkIdx ] is equal to 2.

The values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0..3 are derived as follows.

– If all samples p[ x, -1 ], with x = 0..3 and p[ -1, y ], with y = 0..3 are marked as "available for Intra_4x4 prediction", the values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0..3 are derived by

$$pred4x4_L[ x, y ] = ( p[ 0, -1 ] + p[ 1, -1 ] + p[ 2, -1 ] + p[ 3, -1 ] + p[ -1, 0 ] + p[ -1, 1 ] + p[ -1, 2 ] + p[ -1, 3 ] + 4 ) >> 3 \quad (8\text{-}49)$$

– Otherwise, if any samples p[ x, -1 ], with x = 0..3 are marked as "not available for Intra_4x4 prediction" and all samples p[ -1, y ], with y = 0..3 are marked as "available for Intra_4x4 prediction", the values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0..3 are derived by

$$pred4x4_L[ x, y ] = ( p[ -1, 0 ] + p[ -1, 1 ] + p[ -1, 2 ] + p[ -1, 3 ] + 2 ) >> 2 \quad (8\text{-}50)$$

– Otherwise, if any samples p[ -1, y ], with y = 0..3 are marked as "not available for Intra_4x4 prediction" and all samples p[ x, -1 ], with x = 0 .. 3 are marked as "available for Intra_4x4 prediction", the values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0 .. 3 are derived by

$$pred4x4_L[ x, y ] = ( p[ 0, -1 ] + p[ 1, -1 ] + p[ 2, -1 ] + p[ 3, -1 ] + 2 ) >> 2 \quad (8\text{-}51)$$

– Otherwise (some samples p[ x, -1 ], with x = 0..3 and some samples p[ -1, y ], with y = 0..3 are marked as "not available for Intra_4x4 prediction"), the values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0..3 are derived by

$$pred4x4_L[ x, y ] = ( 1 << ( BitDepth_Y - 1 ) ) \quad (8\text{-}52)$$

NOTE – A 4x4 luma block can always be predicted using this mode.

#### 8.3.1.2.4 Specification of Intra_4x4_Diagonal_Down_Left prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[ luma4x4BlkIdx ] is equal to 3.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..7 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0..3 are derived as follows.

– If x is equal to 3 and y is equal to 3,

$$pred4x4_L[ x, y ] = ( p[ 6, -1 ] + 3 * p[ 7, -1 ] + 2 ) >> 2 \quad (8\text{-}53)$$

– Otherwise (x is not equal to 3 or y is not equal to 3),

$$pred4x4_L[ x, y ] = ( p[ x + y, -1 ] + 2 * p[ x + y + 1, -1 ] + p[ x + y + 2, -1 ] + 2 ) >> 2 \quad (8\text{-}54)$$

#### 8.3.1.2.5 Specification of Intra_4x4_Diagonal_Down_Right prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[ luma4x4BlkIdx ] is equal to 4.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..3 and p[ -1, y ] with y = -1..3 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0..3 are derived as follows.

– If x is greater than y,

$$pred4x4_L[ x, y ] = ( p[ x - y - 2, -1] + 2 * p[ x - y - 1, -1 ] + p[ x - y, -1 ] + 2 ) >> 2 \quad (8\text{-}55)$$

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– Otherwise if x is less than y,

$$pred4x4_L[ x, y ] = ( p[ -1, y - x - 2 ] + 2 * p[ -1, y - x - 1 ] + p[ -1, y - x ] + 2 ) >> 2 \quad (8\text{-}56)$$

– Otherwise (x is equal to y),

$$pred4x4_L[ x, y ] = ( p[ 0, -1 ] + 2 * p[ -1, -1 ] + p[ -1, 0 ] + 2 ) >> 2 \quad (8\text{-}57)$$

#### 8.3.1.2.6 Specification of Intra_4x4_Vertical_Right prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[ luma4x4BlkIdx ] is equal to 5.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..3 and p[ -1, y ] with y = -1..3 are marked as "available for Intra_4x4 prediction".

Let the variable zVR be set equal to 2 * x – y.

The values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0..3 are derived as follows.

– If zVR is equal to 0, 2, 4, or 6,

$$pred4x4_L[ x, y ] = ( p[ x - ( y >> 1 ) - 1, -1 ] + p[ x - ( y >> 1 ), -1 ] + 1 ) >> 1 \quad (8\text{-}58)$$

– Otherwise, if zVR is equal to 1, 3, or 5,

$$pred4x4_L[ x, y ] = ( p[ x - ( y >> 1 ) - 2, -1] + 2 * p[ x - ( y >> 1 ) - 1, -1 ] + p[ x - ( y >> 1 ), -1 ] + 2 ) >> 2 \quad (8\text{-}59)$$

– Otherwise, if zVR is equal to -1,

$$pred4x4_L[ x, y ] = ( p[ -1, 0 ] + 2 * p[ -1, -1 ] + p[ 0, -1 ] + 2 ) >> 2 \quad (8\text{-}60)$$

– Otherwise (zVR is equal to -2 or -3),

$$pred4x4_L[ x, y ] = ( p[ -1, y - 1 ] + 2 * p[ -1, y - 2 ] + p[ -1, y - 3 ] + 2 ) >> 2 \quad (8\text{-}61)$$

#### 8.3.1.2.7 Specification of Intra_4x4_Horizontal_Down prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[ luma4x4BlkIdx ] is equal to 6.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..3 and p[ -1, y ] with y = -1..3 are marked as "available for Intra_4x4 prediction".

Let the variable zHD be set equal to 2 * y – x.

The values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0..3 are derived as follows.

– If zHD is equal to 0, 2, 4, or 6,

$$pred4x4_L[ x, y ] = ( p[ -1, y -( x >> 1 ) - 1 ] + p[ -1, y - ( x >> 1 ) ] + 1 ) >> 1 \quad (8\text{-}62)$$

– Otherwise, if zHD is equal to 1, 3, or 5,

$$pred4x4_L[ x, y ] = ( p[ -1, y - ( x >> 1 ) - 2 ] + 2 * p[ -1, y - ( x >> 1 ) - 1 ] + p[ -1, y - ( x >> 1 ) ] + 2 ) >> 2 \quad (8\text{-}63)$$

– Otherwise, if zHD is equal to -1,

$$pred4x4_L[ x, y ] = ( p[ -1, 0 ] + 2 * p[ -1, -1 ] + p[ 0, -1 ] + 2 ) >> 2 \quad (8\text{-}64)$$

– Otherwise (zHD is equal to -2 or -3),

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$$pred4x4_L[ x, y ] = ( p[ x - 1, -1 ] + 2 * p[ x - 2, -1 ] + p[ x - 3, -1 ] + 2 ) >> 2 \quad (8\text{-}65)$$

#### 8.3.1.2.8 Specification of Intra_4x4_Vertical_Left prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[ luma4x4BlkIdx ] is equal to 7.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..7 are marked as "available for Intra_4x4 prediction".

The values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0..3 are derived as follows.

– If y is equal to 0 or 2,

$$pred4x4_L[ x, y ] = ( p[ x + ( y >> 1 ), -1 ] + p[ x + ( y >> 1 ) + 1, -1 ] + 1) >> 1 \quad (8\text{-}66)$$

– Otherwise (y is equal to 1 or 3),

$$pred4x4_L[ x, y ] = ( p[ x + ( y >> 1 ), -1 ] + 2 * p[ x + ( y >> 1 ) + 1, -1 ] + p[ x + ( y >> 1 ) + 2, -1 ] + 2 ) >> 2 \quad (8\text{-}67)$$

#### 8.3.1.2.9 Specification of Intra_4x4_Horizontal_Up prediction mode

This Intra_4x4 prediction mode is invoked when Intra4x4PredMode[ luma4x4BlkIdx ] is equal to 8.

This mode shall be used only when the samples p[ -1, y ] with y = 0..3 are marked as "available for Intra_4x4 prediction".

Let the variable zHU be set equal to x + 2 * y.

The values of the prediction samples $pred4x4_L[ x, y ]$, with x, y = 0..3 are derived as follows:

– If zHU is equal to 0, 2, or 4

$$pred4x4_L[ x, y ] = ( p[ -1, y + ( x >> 1 ) ] + p[ -1, y + ( x >> 1 ) + 1 ] + 1 ) >> 1 \quad (8\text{-}68)$$

– Otherwise, if zHU is equal to 1 or 3

$$pred4x4_L[ x, y ] = ( p[ -1, y + ( x >> 1 ) ] + 2 * p[ -1, y + ( x >> 1 ) + 1 ] + p[ -1, y + ( x >> 1 ) + 2 ] + 2 ) >> 2 \quad (8\text{-}69)$$

– Otherwise, if zHU is equal to 5,

$$pred4x4_L[ x, y ] = ( p[ -1, 2 ] + 3 * p[ -1, 3 ] + 2 ) >> 2 \quad (8\text{-}70)$$

– Otherwise (zHU is greater than 5),

$$pred4x4_L[ x, y ] = p[ -1, 3 ] \quad (8\text{-}71)$$

### 8.3.2 Intra_8x8 prediction process for luma samples

This process is invoked when the macroblock prediction mode is equal to Intra_8x8.

Inputs to this process are the values of Intra4x4PredMode (if available) or Intra8x8PredMode (if available) from the neighbouring macroblocks or macroblock pairs.

Outputs of this process are 8x8 luma sample arrays as part of the 16x16 luma array of prediction samples of the macroblock $pred_L$.

The luma component of a macroblock consists of 4 blocks of 8x8 luma samples. These blocks are inverse scanned using the inverse 8x8 luma block scanning process as specified in subclause 6.4.5.

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For all 8x8 luma blocks of the luma component of a macroblock with luma8x8BlkIdx = 0..3, the derivation process for Intra8x8PredMode as specified in subclause 8.3.2.1 is invoked with luma8x8BlkIdx as well as Intra4x4PredMode and Intra8x8PredMode that are previously (in decoding order) derived for adjacent macroblocks as the input and the variable Intra8x8PredMode[ luma8x8BlkIdx ] as the output.

For each luma block of 8x8 samples indexed using luma8x8BlkIdx = 0..3, the following applies.

– The Intra_8x8 sample prediction process in subclause 8.3.2.2 is invoked with luma8x8BlkIdx and the array $S'_L$ containing constructed samples prior to the deblocking filter process from adjacent luma blocks as the input and the output are the Intra_8x8 luma prediction samples $pred8x8_L[ x, y ]$ with x, y = 0..7.

– The position of the upper-left sample of an 8x8 luma block with index luma8x8BlkIdx inside the current macroblock is derived by invoking the inverse 8x8 luma block scanning process in subclause 6.4.5 with luma8x8BlkIdx as the input and the output being assigned to ( xO, yO ) and x, y = 0..7.

$$pred_L[ xO + x, yO + y ] = pred8x8_L[ x, y ] \quad (8\text{-}72)$$

– The transform coefficient decoding process and picture construction process prior to deblocking filter process in subclause 8.5 is invoked with $pred_L$ and luma8x8BlkIdx as the input and the constructed samples for the current 8x8 luma block $S'_L$ as the output.

### 8.3.2.1 Derivation process for Intra8x8PredMode

Inputs to this process are the index of the 8x8 luma block luma8x8BlkIdx and variable arrays Intra4x4PredMode (if available) and Intra8x8PredMode (if available) that are previously (in decoding order) derived for adjacent macroblocks.

Output of this process is the variable Intra8x8PredMode[ luma8x8BlkIdx ].

Table 8-3 specifies the values for Intra8x8PredMode[ luma8x8BlkIdx ] and the associated mnemonic names.

**Table 8-3 – Specification of Intra8x8PredMode[ luma8x8BlkIdx ] and associated names**

| Intra8x8PredMode[ luma8x8BlkIdx ] | Name of Intra8x8PredMode[ luma8x8BlkIdx ] |
|---|---|
| 0 | Intra_8x8_Vertical (prediction mode) |
| 1 | Intra_8x8_Horizontal (prediction mode) |
| 2 | Intra_8x8_DC (prediction mode) |
| 3 | Intra_8x8_Diagonal_Down_Left (prediction mode) |
| 4 | Intra_8x8_Diagonal_Down_Right (prediction mode) |
| 5 | Intra_8x8_Vertical_Right (prediction mode) |
| 6 | Intra_8x8_Horizontal_Down (prediction mode) |
| 7 | Intra_8x8_Vertical_Left (prediction mode) |
| 8 | Intra_8x8_Horizontal_Up (prediction mode) |

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Intra8x8PredMode[ luma8x8BlkIdx ] is derived as follows.

– The process specified in subclause 6.4.10.2 is invoked with luma8x8BlkIdx given as input and the output is assigned to mbAddrA, luma8x8BlkIdxA, mbAddrB, and luma8x8BlkIdxB.

– The variable dcPredModePredictedFlag is derived as follows.

  – If any of the following conditions are true, dcPredModePredictedFlag is set equal to 1

    – the macroblock with address mbAddrA is not available

    – the macroblock with address mbAddrB is not available

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  - the macroblock with address mbAddrA is available and coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1
  - the macroblock with address mbAddrB is available and coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1
- Otherwise, dcPredModePredictedFlag is set equal to 0.

– For N being either replaced by A or B, the variables intraMxMPredModeN are derived as follows.

- If dcPredModePredictedFlag is equal to 1 or (the macroblock with address mbAddrN is not coded in Intra_4x4 macroblock prediction mode and the macroblock with address mbAddrN is not coded in Intra_8x8 macroblock prediction mode), intraMxMPredModeN is set equal to 2 (Intra_8x8_DC prediction mode).
- Otherwise (dcPredModePredictedFlag is equal to 0 and (the macroblock with address mbAddrN is coded in Intra_4x4 macroblock prediction mode or the macroblock with address mbAddrN is coded in Intra_8x8 macroblock prediction mode)), the following applies.
  - If the macroblock with address mbAddrN is coded in Intra_8x8 macroblock mode, intraMxMPredModeN is set equal to Intra8x8PredMode[ luma8x8BlkIdxN ], where Intra8x8PredMode is the variable array assigned to the macroblock mbAddrN.
  - Otherwise (the macroblock with address mbAddrN is coded in Intra_4x4 macroblock mode), intraMxMPredModeN is derived by the following procedure, where Intra4x4PredMode is the variable array assigned to the macroblock mbAddrN.

$$intraMxMPredModeN = Intra4x4PredMode[ luma8x8BlkIdxN * 4 + n ] \quad (8\text{-}73)$$

    where the variable n is derived as follows

    - If N is equal to A, depending on the variable MbaffFrameFlag, the variable luma8x8BlkIdx, the current macroblock, and the macroblock mbAddrN, the following applies.
      - If MbaffFrameFlag is equal to 1, the current macroblock is a frame coded macroblock, the macroblock mbAddrN is a field coded macroblock, and luma8x8BlkIdx is equal to 2, n is set equal to 3.
      - Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a field coded macroblock or the macroblock mbAddrN is a frame coded macroblock or luma8x8BlkIdx is not equal to 2), n is set equal to 1.
    - Otherwise (N is equal to B), n is set equal to 2.

– Finally, given intraMxMPredModeA and intraMxMPredModeB, the variable Intra8x8PredMode[ luma8x8BlkIdx ] is derived by applying the following procedure.

```
predIntra8x8PredMode = Min( intraMxMPredModeA, intraMxMPredModeB )
if( prev_intra8x8_pred_mode_flag[ luma8x8BlkIdx ] )
    Intra8x8PredMode[ luma8x8BlkIdx ] = predIntra8x8PredMode
else                                                                    (8-74)
    if( rem_intra8x8_pred_mode[ luma8x8BlkIdx ] < predIntra8x8PredMode )
        Intra8x8PredMode[ luma8x8BlkIdx ] = rem_intra8x8_pred_mode[ luma8x8BlkIdx ]
    else
        Intra8x8PredMode[ luma8x8BlkIdx ] = rem_intra8x8_pred_mode[ luma8x8BlkIdx ] + 1
```

#### 8.3.2.2 Intra_8x8 sample prediction

This process is invoked for each 8x8 luma block of a macroblock with prediction mode equal to Intra_8x8 followed by the transform decoding process and picture construction process prior to deblocking for each 8x8 luma block.

Inputs to this process are

– the index of an 8x8 luma block luma8x8BlkIdx.

– an ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array $cS_L$ containing constructed luma samples prior to the deblocking filter process of neighbouring macroblocks.

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Output of this process are the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 for the 8x8 luma block with index luma8x8BlkIdx.

The position of the upper-left sample of an 8x8 luma block with index luma8x8BlkIdx inside the current macroblock is derived by invoking the inverse 8x8 luma block scanning process in subclause 6.4.5 with luma8x8BlkIdx as the input and the output being assigned to ( xO, yO ).

The 25 neighbouring samples p[ x, y ] that are constructed luma samples prior to the deblocking filter process, with x = -1, y = -1..7 and x = 0..15, y = -1, are derived as follows.

– The luma location ( xN, yN ) is specified by

$$xN = xO + x \tag{8-75}$$

$$yN = yO + y \tag{8-76}$$

– The derivation process for neighbouring locations in subclause 6.4.11 is invoked for luma locations with ( xN, yN ) as input and mbAddrN and ( xW, yW ) as output.

– Each sample p[ x, y ] with x = -1, y = -1..7 and x = 0..15, y = -1 is derived as follows.

  – If any of the following conditions is true, the sample p[ x, y ] is marked as "not available for Intra_8x8 prediction"

    – mbAddrN is not available,

    – the macroblock mbAddrN is coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1,

  – Otherwise, the sample p[ x, y ] is marked as "available for Intra_8x8 prediction" and the sample value p[ x, y ] is derived as follows.

    – The location of the upper-left luma sample of the macroblock mbAddrN is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with mbAddrN as the input and the output is assigned to ( xM, yM ).

    – Depending on the variable MbaffFrameFlag and the macroblock mbAddrN, the sample value p[ x, y ] is derived as follows.

      – If MbaffFrameFlag is equal to 1 and the macroblock mbAddrN is a field macroblock,

$$p[ x, y ] = cS_L[ xM + xW, yM + 2 * yW ] \tag{8-77}$$

      – Otherwise (MbaffFrameFlag is equal to 0 or the macroblock mbAddrN is a frame macroblock),

$$p[ x, y ] = cS_L[ xM + xW, yM + yW ] \tag{8-78}$$

When samples p[ x, -1 ], with x = 8..15 are marked as "not available for Intra_8x8 prediction," and the sample p[ 7, -1 ] is marked as "available for Intra_8x8 prediction," the sample value of p[ 7, -1 ] is substituted for sample values p[ x, -1 ], with x = 8..15 and samples p[ x, -1 ], with x = 8..15 are marked as "available for Intra_8x8 prediction".

NOTE – Each block is assumed to be constructed into a picture array prior to decoding of the next block.

The reference sample filtering process for Intra_8x8 sample prediction in subclause 8.3.2.2.1 is invoked with the samples p[ x, y ] with x = -1, y = -1..7 and x = 0..15, y = -1 (if available) as input and p'[ x, y ] with x = -1, y = -1..7 and x = 0..15, y = -1 as output.

Depending on Intra8x8PredMode[ luma8x8BlkIdx ], one of the Intra_8x8 prediction modes specified in subclauses 8.3.2.2.2 to 8.3.2.2.10 is invoked.

#### 8.3.2.2.1 Reference sample filtering process for Intra_8x8 sample prediction

Inputs to this process are the reference samples p[ x, y ] with x = -1, y = -1..7 and x = 0..15, y = -1 (if available) for Intra_8x8 sample prediction.

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Outputs of this process are the filtered reference samples p'[ x, y ] with x = -1, y = -1..7 and x = 0..15, y = -1 for Intra_8x8 sample prediction.

When all samples p[ x, -1 ] with x = 0..7 are marked as "available for Intra_8x8 prediction", the following applies.

– The value of p'[ 0, -1 ] is derived as follows.

– If p[ -1, -1 ] is marked as "available for Intra_8x8 prediction", p'[ 0, -1 ] is derived by

$$p'[ 0, -1 ] = ( p[ -1, -1 ] + 2 * p[ 0, -1 ] + p[ 1, -1 ] + 2 ) >> 2 \quad (8\text{-}79)$$

– Otherwise (p[ -1, -1 ] is marked as "not available for Intra_8x8 prediction"), p'[ 0, -1 ] is derived by

$$p'[ 0, -1 ] = ( 3 * p[ 0, -1 ] + p[ 1, -1 ] + 2 ) >> 2 \quad (8\text{-}80)$$

– The values of p'[ x, -1 ], with x = 1..7 are derived by

$$p'[ x, -1 ] = ( p[ x-1, -1 ] + 2 * p[ x, -1 ] + p[ x+1, -1 ] + 2 ) >> 2 \quad (8\text{-}81)$$

When all samples p[ x, -1 ] with x = 7..15 are marked as "available for Intra_8x8 prediction", the following applies.

– The values of p'[ x, -1 ], with x = 8..14 are derived by

$$p'[ x, -1 ] = ( p[ x-1, -1 ] + 2 * p[ x, -1 ] + p[ x+1, -1 ] + 2 ) >> 2 \quad (8\text{-}82)$$

– The value of p'[ 15, -1 ] is derived by

$$p'[ 15, -1 ] = ( p[ 14, -1 ] + 3 * p[ 15, -1 ] + 2 ) >> 2 \quad (8\text{-}83)$$

When the sample p[ -1, -1 ] is marked as "available for Intra_8x8 prediction", the value of p'[ -1, -1 ] is derived as follows.

– If the sample p[ 0, -1 ] is marked as "not available for Intra_8x8 prediction" or the sample p[ -1, 0 ] is marked as "not available for Intra_8x8 prediction", the following applies.

– If the sample p[ 0, -1 ] is marked as "available for Intra_8x8 prediction", p'[ -1, -1 ] is derived by

$$p'[ -1, -1 ] = ( 3 * p[ -1, -1 ] + p[ 0, -1 ] + 2 ) >> 2 \quad (8\text{-}84)$$

– Otherwise (the sample p[ 0, -1 ] is marked as "not available for Intra_8x8 prediction" and the sample p[ -1, 0 ] is marked as "available for Intra_8x8 prediction"), p'[ -1, -1 ] is derived by

$$p'[ -1, -1 ] = ( 3 * p[ -1, -1 ] + p[ -1, 0 ] + 2) >> 2 \quad (8\text{-}85)$$

– Otherwise (the sample p[ 0, -1 ] is marked as "available for Intra_8x8 prediction" and the sample p[ -1, 0 ] is marked as "available for Intra_8x8 prediction"), p'[ -1, -1 ] is derived by

$$p'[ -1, -1 ] = ( p[ 0, -1 ] + 2 * p[ -1, -1 ] + p[ -1, 0 ] + 2) >> 2 \quad (8\text{-}86)$$

When all samples p[ -1, y ] with y = 0..7 are marked as "available for Intra_8x8 prediction", the following applies.

– The value of p'[ -1, 0 ] is derived as follows.

– If p[ -1, -1 ] is marked as "available for Intra_8x8 prediction", p'[ -1, 0 ] is derived by

$$p'[ -1, 0 ] = ( p[ -1, -1 ] + 2 * p[ -1, 0 ] + p[ -1, 1 ] + 2 ) >> 2 \quad (8\text{-}87)$$

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– Otherwise (if p[ -1, -1 ] is marked as "not available for Intra_8x8 prediction"), p'[ -1, 0 ] is derived by

$$p'[ -1, 0 ] = ( 3 * p[ -1, 0 ] + p[ -1, 1 ] + 2 ) >> 2 \quad (8\text{-}88)$$

– The values of p'[ -1, y ], with y = 1..6 are derived by

$$p'[ -1, y ] = ( p[ -1, y-1 ] + 2 * p[ -1, y ] + p[ -1, y+1 ] + 2 ) >> 2 \quad (8\text{-}89)$$

– The value of p'[ -1, 7 ] is derived by

$$p'[ -1, 7 ] = ( p[ -1, 6 ] + 3 * p[ -1, 7 ] + 2 ) >> 2 \quad (8\text{-}90)$$

#### 8.3.2.2.2 Specification of Intra_8x8_Vertical prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[ luma8x8BlkIdx ] is equal to 0.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..7 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 are derived by

$$pred8x8_L[ x, y ] = p'[ x, -1 ], \text{ with } x, y = 0..7 \quad (8\text{-}91)$$

#### 8.3.2.2.3 Specification of Intra_8x8_Horizontal prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[ luma8x8BlkIdx ] is equal to 1.

This mode shall be used only when the samples p[ -1, y ], with y = 0..7 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 are derived by

$$pred8x8_L[ x, y ] = p'[ -1, y ], \text{ with } x, y = 0..7 \quad (8\text{-}92)$$

#### 8.3.2.2.4 Specification of Intra_8x8_DC prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[ luma8x8BlkIdx ] is equal to 2.

The values of the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 are derived as follows.

– If all samples p[ x, -1 ], with x = 0..7 and p[ -1, y ], with y = 0..7 are marked as "available for Intra_8x8 prediction," the values of the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 are derived by

$$pred8x8_L[ x, y ] = \left(\sum_{x'=0}^{7} p'[x', -1] + \sum_{y'=0}^{7} p'[-1, y'] + 8\right) >> 4 \quad (8\text{-}93)$$

– Otherwise, if any samples p[ x, -1 ], with x = 0..7 are marked as "not available for Intra_8x8 prediction" and all samples p[ -1, y ], with y = 0..7 are marked as "available for Intra_8x8 prediction", the values of the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 are derived by

$$pred8x8_L[ x, y ] = \left(\sum_{y'=0}^{7} p'[-1, y'] + 4\right) >> 3 \quad (8\text{-}94)$$

– Otherwise, if any samples p[ -1, y ], with y = 0..7 are marked as "not available for Intra_8x8 prediction" and all samples p[ x, -1 ], with x = 0..7 are marked as "available for Intra_8x8 prediction", the values of the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 are derived by

$$pred8x8_L[ x, y ] = \left(\sum_{x'=0}^{7} p'[x', -1] + 4\right) >> 3 \quad (8\text{-}95)$$

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– Otherwise (some samples p[ x, -1 ], with x = 0..7 and some samples p[ -1, y ], with y = 0..7 are marked as "not available for Intra_8x8 prediction"), the values of the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 are derived by

$$pred8x8_L[ x, y ] = ( 1 << ( BitDepth_Y - 1 ) ) \quad (8\text{-}96)$$

NOTE – An 8x8 luma block can always be predicted using this mode.

#### 8.3.2.2.5 Specification of Intra_8x8_Diagonal_Down_Left prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[ luma8x8BlkIdx ] is equal to 3.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..15 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 are derived as follows.

– If x is equal to 7 and y is equal to 7,

$$pred8x8_L[ x, y ] = ( p'[ 14, -1 ] + 3 * p'[15, -1 ] + 2 ) >> 2 \quad (8\text{-}97)$$

– Otherwise (x is not equal to 7 or y is not equal to 7),

$$pred8x8_L[ x, y ] = ( p'[ x + y, -1 ] + 2 * p'[ x + y + 1, -1 ] + p'[ x + y + 2, -1 ] + 2 ) >> 2 \quad (8\text{-}98)$$

#### 8.3.2.2.6 Specification of Intra_8x8_Diagonal_Down_Right prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[ luma8x8BlkIdx ] is equal to 4.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..7 and p[ -1, y ] with y = -1..7 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 are derived as follows.

– If x is greater than y,

$$pred8x8_L[ x, y ] = ( p'[ x - y - 2, -1] + 2 * p'[ x - y - 1, -1 ] + p'[ x - y, -1 ] + 2 ) >> 2 \quad (8\text{-}99)$$

– Otherwise if x is less than y,

$$pred8x8_L[ x, y ] = ( p'[ -1, y - x - 2 ] + 2 * p'[ -1, y - x - 1 ] + p'[ -1, y - x ] + 2 ) >> 2 \quad (8\text{-}100)$$

– Otherwise (x is equal to y),

$$pred8x8_L[ x, y ] = ( p'[ 0, -1 ] + 2 * p'[ -1, -1 ] + p'[ -1, 0 ] + 2 ) >> 2 \quad (8\text{-}101)$$

#### 8.3.2.2.7 Specification of Intra_8x8_Vertical_Right prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[ luma8x8BlkIdx ] is equal to 5.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..7 and p[ -1, y ] with y = -1..7 are marked as "available for Intra_8x8 prediction".

Let the variable zVR be set equal to 2 * x – y.

The values of the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 are derived as follows.

– If zVR is equal to 0, 2, 4, 6, 8, 10, 12, or 14

$$pred8x8_L[ x, y ] = ( p'[ x - ( y >> 1 ) - 1, -1 ] + p'[ x - ( y >> 1 ), -1 ] + 1 ) >> 1 \quad (8\text{-}102)$$

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– Otherwise, if zVR is equal to 1, 3, 5, 7, 9, 11, or 13

$$pred8x8_L[ x, y ] = ( p'[ x - ( y >> 1 ) - 2, -1] + 2 * p'[ x - ( y >> 1 ) - 1, -1 ] + p'[ x - ( y >> 1 ), -1 ] + 2 ) >> 2 \quad (8\text{-}103)$$

– Otherwise, if zVR is equal to -1,

$$pred8x8_L[ x, y ] = ( p'[ -1, 0 ] + 2 * p'[ -1, -1 ] + p'[ 0, -1 ] + 2 ) >> 2 \quad (8\text{-}104)$$

– Otherwise (zVR is equal to -2, -3, -4, -5, -6, or -7),

$$pred8x8_L[ x, y ] = ( p'[ -1, y - 2*x - 1 ] + 2 * p'[ -1, y - 2*x - 2 ] + p'[ -1, y - 2*x - 3 ] + 2 ) >> 2 \quad (8\text{-}105)$$

#### 8.3.2.2.8 Specification of Intra_8x8_Horizontal_Down prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[ luma8x8BlkIdx ] is equal to 6.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..7 and p[ -1, y ] with y = -1..7 are marked as "available for Intra_8x8 prediction".

Let the variable zHD be set equal to 2 * y – x.

The values of the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 are derived as follows.

– If zHD is equal to 0, 2, 4, 6, 8, 10, 12, or 14

$$pred8x8_L[ x, y ] = ( p'[ -1, y -( x >> 1 ) - 1 ] + p'[ -1, y - ( x >> 1 ) ] + 1 ) >> 1 \quad (8\text{-}106)$$

– Otherwise, if zHD is equal to 1, 3, 5, 7, 9, 11, or 13

$$pred8x8_L[ x, y ] = ( p'[ -1, y - ( x >> 1 ) - 2 ] + 2 * p'[ -1, y - ( x >> 1 ) - 1 ] + p'[ -1, y - ( x >> 1 ) ] + 2 ) >> 2 \quad (8\text{-}107)$$

– Otherwise, if zHD is equal to -1,

$$pred8x8_L[ x, y ] = ( p'[ -1, 0 ] + 2 * p'[ -1, -1 ] + p'[ 0, -1 ] + 2 ) >> 2 \quad (8\text{-}108)$$

– Otherwise (zHD is equal to –2, -3, -4, -5, -6, -7),

$$pred8x8_L[ x, y ] = ( p'[ x - 2*y - 1, -1 ] + 2 * p'[ x - 2*y - 2, -1 ] + p'[ x - 2*y - 3, -1 ] + 2 ) >> 2 \quad (8\text{-}109)$$

#### 8.3.2.2.9 Specification of Intra_8x8_Vertical_Left prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[ luma8x8BlkIdx ] is equal to 7.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..15 are marked as "available for Intra_8x8 prediction".

The values of the prediction samples $pred8x8_L[ x, y ]$, with x, y = 0..7 are derived as follows.

– If y is equal to 0, 2, 4 or 6

$$pred8x8_L[ x, y ] = ( p'[ x + ( y >> 1 ), -1 ] + p'[ x + ( y >> 1 ) + 1, -1 ] + 1) >> 1 \quad (8\text{-}110)$$

– Otherwise (y is equal to 1, 3, 5, 7),

$$pred8x8_L[ x, y ] = ( p'[ x + ( y >> 1 ), -1 ] + 2 * p'[ x + ( y >> 1 ) + 1, -1 ] + p'[ x + ( y >> 1 ) + 2, -1 ] + 2 ) >>2 \quad (8\text{-}111)$$

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#### 8.3.2.2.10 Specification of Intra_8x8_Horizontal_Up prediction mode

This Intra_8x8 prediction mode is invoked when Intra8x8PredMode[ luma8x8BlkIdx ] is equal to 8.

This mode shall be used only when the samples p[ -1, y ] with y = 0..7 are marked as "available for Intra_8x8 prediction".

Let the variable zHU be set equal to x + 2 * y.

The values of the prediction samples $pred8x8_L$[ x, y ], with x, y = 0..7 are derived as follows:

– If zHU is equal to 0, 2, 4, 6, 8, 10, or 12

$$pred8x8_L[ x, y ] = ( p'[ -1, y + ( x >> 1 ) ] + p'[ -1, y + ( x >> 1 ) + 1 ] + 1 ) >> 1 \quad (8\text{-}112)$$

– Otherwise, if zHU is equal to 1, 3, 5, 7, 9, or 11

$$pred8x8_L[ x, y ] = ( p'[ -1, y + ( x >> 1 ) ] + 2 * p'[ -1, y + ( x >> 1 ) + 1 ] + p'[ -1, y + ( x >> 1 ) + 2 ] + 2 ) >> 2 \quad (8\text{-}113)$$

– Otherwise, if zHU is equal to 13,

$$pred8x8_L[ x, y ] = ( p'[ -1, 6 ] + 3 * p'[ -1, 7 ] + 2 ) >> 2 \quad (8\text{-}114)$$

– Otherwise (zHU is greater than 13),

$$pred8x8_L[ x, y ] = p'[ -1, 7 ] \quad (8\text{-}115)$$

### 8.3.3 Intra_16x16 prediction process for luma samples

This process is invoked when the macroblock prediction mode is equal to Intra_16x16. It specifies how the Intra prediction luma samples for the current macroblock are derived.

Input to this process is a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array $cS_L$ containing constructed luma samples prior to the deblocking filter process of neighbouring macroblocks

Outputs of this process are Intra prediction luma samples for the current macroblock $pred_L$[ x, y ].

The 33 neighbouring samples p[ x, y ] that are constructed luma samples prior to the deblocking filter process, with x = -1, y = -1..15 and with x = 0..15, y = -1, are derived as follows.

– The derivation process for neighbouring locations in subclause 6.4.11 is invoked for luma locations with ( x, y ) assigned to ( xN, yN ) as input and mbAddrN and ( xW, yW ) as output.

– Each sample p[ x, y ] with x = -1, y = -1..15 and with x = 0..15, y = -1 is derived as follows.

  – If any of the following conditions is true, the sample p[ x, y ] is marked as "not available for Intra_16x16 prediction"

    – mbAddrN is not available,

    – the macroblock mbAddrN is coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1.

    – the macroblock mbAddrN has mb_type equal to SI and constrained_intra_pred_flag is equal to 1.

  – Otherwise, the sample p[ x, y ] is marked as "available for Intra_16x16 prediction" and the value of the sample p[ x, y ] is derived as follows.

    – The location of the upper-left luma sample of the macroblock mbAddrN is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with mbAddrN as the input and the output is assigned to ( xM, yM ).

    – Depending on the variable MbaffFrameFlag and the macroblock mbAddrN, the sample value p[ x, y ] is derived as follows.

      – If MbaffFrameFlag is equal to 1 and the macroblock mbAddrN is a field macroblock,

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$$p[ x, y ] = cS_L[ xM + xW, yM + 2 * yW ] \quad (8\text{-}116)$$

– Otherwise (MbaffFrameFlag is equal to 0 or the macroblock mbAddrN is a frame macroblock),

$$p[ x, y ] = cS_L[ xM + xW, yM + yW ] \quad (8\text{-}117)$$

Let $pred_L[ x, y ]$ with x, y = 0..15 denote the prediction samples for the 16x16 luma block samples.

Intra_16x16 prediction modes are specified in Table 8-4.

**Table 8-4 – Specification of Intra16x16PredMode and associated names**

| Intra16x16PredMode | Name of Intra16x16PredMode |
|---|---|
| 0 | Intra_16x16_Vertical (prediction mode) |
| 1 | Intra_16x16_Horizontal (prediction mode) |
| 2 | Intra_16x16_DC (prediction mode) |
| 3 | Intra_16x16_Plane (prediction mode) |

Depending on Intra16x16PredMode, one of the Intra_16x16 prediction modes specified in subclauses 8.3.3.1 to 8.3.3.4 is invoked.

#### 8.3.3.1 Specification of Intra_16x16_Vertical prediction mode

This Intra_16x16 prediction mode shall be used only when the samples p[ x, -1 ] with x = 0..15 are marked as "available for Intra_16x16 prediction".

$$pred_L[ x, y ] = p[ x, -1 ], \text{ with } x, y = 0..15 \quad (8\text{-}118)$$

#### 8.3.3.2 Specification of Intra_16x16_Horizontal prediction mode

This Intra_16x16 prediction mode shall be used only when the samples p[-1, y] with y = 0..15 are marked as "available for Intra_16x16 prediction".

$$pred_L[ x, y ] = p[ -1, y ], \text{ with } x, y = 0..15 \quad (8\text{-}119)$$

#### 8.3.3.3 Specification of Intra_16x16_DC prediction mode

This Intra_16x16 prediction mode operates, depending on whether the neighbouring samples are marked as "available for Intra_16x16 prediction", as follows.

– If all neighbouring samples p[ x, -1 ], with x = 0..15 and p[ -1, y ], with y = 0..15 are marked as "available for Intra_16x16 prediction", the prediction for all luma samples in the macroblock is given by:

$$pred_L[ x, y ] = \left(\sum_{x'=0}^{15} p[x', -1] + \sum_{y'=0}^{15} p[-1, y'] + 16\right) >> 5, \text{ with } x, y = 0..15 \quad (8\text{-}120)$$

– Otherwise, if any of the neighbouring samples p[ x, -1 ], with x = 0..15 are marked as "not available for Intra_16x16 prediction" and all of the neighbouring samples p[ -1, y ], with y = 0..15 are marked as "available for Intra_16x16 prediction", the prediction for all luma samples in the macroblock is given by:

$$pred_L[ x, y ] = \left(\sum_{y'=0}^{15} p[-1, y'] + 8\right) >> 4, \text{ with } x, y = 0..15 \quad (8\text{-}121)$$

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– Otherwise, if any of the neighbouring samples p[ -1, y ], with y = 0..15 are marked as "not available for Intra_16x16 prediction" and all of the neighbouring samples p[ x, -1 ], with x = 0..15 are marked as “available for Intra_16x16 prediction”, the prediction for all luma samples in the macroblock is given by:

$$pred_L[\,x, y\,] = \left(\sum_{x'=0}^{15} p[x', -1] + 8\right) >> 4 \text{ , with } x, y = 0..15 \tag{8-122}$$

– Otherwise (some of the neighbouring samples p[ x, -1 ], with x = 0..15 and some of the neighbouring samples p[ -1, y ], with y = 0..15 are marked as “not available for Intra_16x16 prediction”), the prediction for all luma samples in the macroblock is given by:

$$pred_L[\,x, y\,] = (\,1 << (\,BitDepth_Y - 1\,)\,), \text{ with } x, y = 0..15 \tag{8-123}$$

#### 8.3.3.4 Specification of Intra_16x16_Plane prediction mode

This Intra_16x16 prediction mode shall be used only when the samples p[ x, -1 ] with x = -1..15 and p[ -1, y ] with y = 0..15 are marked as “available for Intra_16x16 prediction”.

$$pred_L[\,x, y\,] = Clip1_Y(\,(\,a + b * (\,x - 7\,) + c * (\,y - 7\,) + 16\,) >> 5\,), \text{ with } x, y = 0..15; \tag{8-124}$$

where:

$$a = 16 * (\,p[\,-1, 15\,] + p[\,15, -1\,]\,) \tag{8-125}$$

$$b = (\,5 * H + 32\,) >> 6 \tag{8-126}$$

$$c = (\,5 * V + 32\,) >> 6 \tag{8-127}$$

and H and V are specified in Equations 8-128 and 8-129.

$$H = \sum_{x'=0}^{7} (\,x'+1\,) * (\,p[\,8 + x', -1\,] - p[\,6 - x', -1\,]\,) \tag{8-128}$$

$$V = \sum_{y'=0}^{7} (\,y'+1\,) * (\,p[\,-1, 8 + y'\,] - p[\,-1, 6 - y'\,]\,) \tag{8-129}$$

### 8.3.4 Intra prediction process for chroma samples

This process is invoked for I and SI macroblock types. It specifies how the Intra prediction chroma samples for the current macroblock are derived.

Inputs to this process are two (PicWidthInSamples$_C$)x(PicHeightInSamples$_C$) arrays $cS_{Cb}$ and $cS_{Cr}$ containing constructed chroma samples prior to the deblocking filter process of neighbouring macroblocks

Outputs of this process are Intra prediction chroma samples for the current macroblock $pred_{Cb}[\,x, y\,]$ and $pred_{Cr}[\,x, y\,]$.

Depending on the value of ChromaArrayType, the following applies.

– If ChromaArrayType is equal to 3, the Intra prediction chroma samples for the current macroblock $pred_{Cb}[\,x, y\,]$ and $pred_{Cr}[\,x, y\,]$ are derived using the Intra prediction process for chroma samples with ChromaArrayType equal to 3 as specified in subclause 8.3.4.5.

– Otherwise (ChromaArrayType is equal to 1 or 2), the following text specifies the Intra prediction chroma samples for the current macroblock $pred_{Cb}[\,x, y\,]$ and $pred_{Cr}[\,x, y\,]$.

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Both chroma blocks (Cb and Cr) of the macroblock use the same prediction mode. The prediction mode is applied to each of the chroma blocks separately. The process specified in this subclause is invoked for each chroma block. In the remainder of this subclause, chroma block refers to one of the two chroma blocks and the subscript C is used as a replacement of the subscript Cb or Cr.

The neighbouring samples p[ x, y ] that are constructed chroma samples prior to the deblocking filter process, with x = -1, y = -1..MbHeightC - 1 and with x = 0..MbWidthC - 1, y = -1, are derived as follows.

– The derivation process for neighbouring locations in subclause 6.4.11 is invoked for chroma locations with ( x, y ) assigned to ( xN, yN ) as input and mbAddrN and ( xW, yW ) as output.

– Each sample p[ x, y ] is derived as follows.

  – If any of the following conditions is true, the sample p[ x, y ] is marked as "not available for Intra chroma prediction"

    – mbAddrN is not available,

    – the macroblock mbAddrN is coded in Inter prediction mode and constrained_intra_pred_flag is equal to 1.

    – the macroblock mbAddrN has mb_type equal to SI and constrained_intra_pred_flag is equal to 1 and the current macroblock does not have mb_type equal to SI.

  – Otherwise, the sample p[ x, y ] is marked as "available for Intra chroma prediction" and the value of the sample p[ x, y ] is derived as follows.

    – The location of the upper-left luma sample of the macroblock mbAddrN is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with mbAddrN as the input and the output is assigned to ( xL, yL ).

    – The location ( xM, yM ) of the upper-left chroma sample of the macroblock mbAddr is derived by

$$xM = ( xL >> 4 ) * MbWidthC \quad (8\text{-}130)$$
$$yM = ( ( yL >> 4 ) * MbHeightC ) + ( yL \% 2 ) \quad (8\text{-}131)$$

    – Depending on the variable MbaffFrameFlag and the macroblock mbAddrN, the sample value p[ x, y ] is derived as follows.

      – If MbaffFrameFlag is equal to 1 and the macroblock mbAddrN is a field macroblock,

$$p[ x, y ] = cS_C[ xM + xW, yM + 2 * yW ] \quad (8\text{-}132)$$

      – Otherwise (MbaffFrameFlag is equal to 0 or the macroblock mbAddrN is a frame macroblock),

$$p[ x, y ] = cS_C[ xM + xW, yM + yW ] \quad (8\text{-}133)$$

Let $pred_C[ x, y ]$ with x = 0..MbWidthC - 1, y = 0..MbHeightC - 1 denote the prediction samples for the chroma block samples.

Intra chroma prediction modes are specified in Table 8-5.

**Table 8-5 – Specification of Intra chroma prediction modes and associated names**

| intra_chroma_pred_mode | Name of intra_chroma_pred_mode |
|---|---|
| 0 | Intra_Chroma_DC (prediction mode) |
| 1 | Intra_Chroma_Horizontal (prediction mode) |
| 2 | Intra_Chroma_Vertical (prediction mode) |
| 3 | Intra_Chroma_Plane (prediction mode) |

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Depending on intra_chroma_pred_mode, one of the Intra chroma prediction modes specified in subclauses 8.3.4.1 to 8.3.4.4 is invoked.

### 8.3.4.1 Specification of Intra_Chroma_DC prediction mode

This Intra chroma prediction mode is invoked when intra_chroma_pred_mode is equal to 0.

For each chroma block of 4x4 samples indexed by chroma4x4BlkIdx = 0..( 1 << ( ChromaArrayType + 1 ) ) – 1, the following applies.

– The position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx is derived as

xO = InverseRasterScan( chroma4x4BlkIdx, 4, 4, 8, 0 ) (8-134)

yO = InverseRasterScan( chroma4x4BlkIdx, 4, 4, 8, 1 ) (8-135)

– Depending on the values of xO and yO, the following applies.

– If ( xO, yO ) is equal to ( 0, 0 ) or xO and yO are greater than 0, the values of the prediction samples $pred_C[ x + xO, y + yO ]$ with x, y = 0..3 are derived as follows.

– If all samples p[ x + xO, -1 ], with x = 0..3 and p[ -1, y +yO ], with y = 0..3 are marked as “available for Intra chroma prediction”, the values of the prediction samples $pred_C[ x + xO, y + yO ]$, with x, y = 0..3 are derived as

$$pred_C[ x + xO, y + yO ] = \left( \sum_{x'=0}^{3} p[x'+xO,-1] + \sum_{y'=0}^{3} p[-1,y'+yO] + 4 \right) >> 3 \text{ , with x, y = 0..3.} \quad (8\text{-}136)$$

– Otherwise, if any samples p[ x + xO, -1 ], with x = 0..3 are marked as “not available for Intra chroma prediction” and all samples p[ -1, y +yO ], with y = 0..3 are marked as “available for Intra chroma prediction”, the values of the prediction samples $pred_C[ x + xO, y + yO ]$, with x, y = 0..3 are derived as

$$pred_C[ x + xO, y + yO ] = \left( \sum_{y'=0}^{3} p[-1,y'+yO] + 2 \right) >> 2 \text{ , with x, y = 0..3.} \quad (8\text{-}137)$$

– Otherwise, if any samples p[ -1, y +yO ], with y = 0..3 are marked as “not available for Intra chroma prediction” and all samples p[ x + xO, -1 ], with x = 0..3 are marked as “available for Intra chroma prediction”, the values of the prediction samples $pred_C[ x + xO, y + yO ]$, with x, y = 0..3 are derived as

$$pred_C[ x + xO, y + yO ] = \left( \sum_{x'=0}^{3} p[x'+xO,-1] + 2 \right) >> 2 \text{ , with x, y = 0..3.} \quad (8\text{-}138)$$

– Otherwise (some samples p[ x + xO, -1 ], with x = 0..3 and some samples p[ -1, y +yO ], with y = 0..3 are marked as “not available for Intra chroma prediction”), the values of the prediction samples $pred_C[ x + xO, y + yO ]$, with x, y = 0..3 are derived as

$pred_C[ x + xO, y + yO ] = ( 1 << ( BitDepth_C – 1 ) )$, with x, y = 0..3. (8-139)

– Otherwise, if xO is greater than 0 and yO is equal to 0, the values of the prediction samples $pred_C[ x + xO, y + yO ]$ with x, y = 0..3 are derived as follows.

– If all samples p[ x + xO, -1 ], with x = 0..3 are marked as “available for Intra chroma prediction”, the values of the prediction samples $pred_C[ x + xO, y + yO ]$, with x, y = 0..3 are derived as

$$pred_C[ x + xO, y + yO ] = \left( \sum_{x'=0}^{3} p[x'+xO,-1] + 2 \right) >> 2 \text{ , with x, y = 0..3.} \quad (8\text{-}140)$$

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– Otherwise, if all samples p[ -1, y +yO ], with y = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C$[ x + xO, y + yO ], with x, y = 0..3 are derived as

$$pred_C[\,x+xO, y+yO\,] = \left( \sum_{y'=0}^{3} p[-1, y'+yO] + 2 \right) >> 2 \text{ , with } x, y = 0..3. \quad (8\text{-}141)$$

– Otherwise (some samples p[ x + xO, -1 ], with x = 0..3 and some samples p[ -1, y +yO ], with y = 0..3 are marked as "not available for Intra chroma prediction"), the values of the prediction samples $pred_C$[ x + xO, y + yO ], with x, y = 0..3 are derived as

$$pred_C[\,x+xO, y+yO\,] = ( 1 << ( BitDepth_C - 1 ) ), \text{ with } x, y = 0..3. \quad (8\text{-}142)$$

– Otherwise (xO is equal to 0 and yO is greater than 0), the values of the prediction samples $pred_C$[ x + xO, y + yO ] with x, y = 0..3 are derived as follows.

– If all samples p[ -1, y +yO ], with y = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C$[ x + xO, y + yO ], with x, y = 0..3 are derived as

$$pred_C[\,x+xO, y+yO\,] = \left( \sum_{y'=0}^{3} p[-1, y'+yO] + 2 \right) >> 2 \text{ , with } x, y = 0..3. \quad (8\text{-}143)$$

– Otherwise, if all samples p[ x + xO, -1 ], with x = 0..3 are marked as "available for Intra chroma prediction", the values of the prediction samples $pred_C$[ x + xO, y + yO ], with x, y = 0..3 are derived as

$$pred_C[\,x+xO, y+yO\,] = \left( \sum_{x'=0}^{3} p[x'+xO, -1] + 2 \right) >> 2 \text{ , with } x, y = 0..3. \quad (8\text{-}144)$$

– Otherwise (some samples p[ x + xO, -1 ], with x = 0..3 and some samples p[ -1, y +yO ], with y = 0..3 are marked as "not available for Intra chroma prediction"), the values of the prediction samples $pred_C$[ x + xO, y + yO ], with x, y = 0..3 are derived as

$$pred_C[\,x+xO, y+yO\,] = ( 1 << ( BitDepth_C - 1 ) ), \text{ with } x, y = 0..3. \quad (8\text{-}145)$$

#### 8.3.4.2 Specification of Intra_Chroma_Horizontal prediction mode

This Intra chroma prediction mode is invoked when intra_chroma_pred_mode is equal to 1.

This mode shall be used only when the samples p[ -1, y ] with y = 0..MbHeightC - 1 are marked as "available for Intra chroma prediction"

The values of the prediction samples $pred_C$[ x, y ] are derived as follows.

$$pred_C[\,x, y\,] = p[\,-1, y\,], \text{ with } x = 0..MbWidthC - 1 \text{ and } y = 0..MbHeightC - 1 \quad (8\text{-}146)$$

#### 8.3.4.3 Specification of Intra_Chroma_Vertical prediction mode

This Intra chroma prediction mode is invoked when intra_chroma_pred_mode is equal to 2.

This mode shall be used only when the samples p[ x, -1 ] with x = 0..MbWidthC - 1 are marked as "available for Intra chroma prediction".

The values of the prediction samples $pred_C$[ x, y ] are derived as follows.

$$pred_C[\,x, y\,] = p[\,x, -1\,], \text{ with } x = 0..MbWidthC - 1 \text{ and } y = 0..MbHeightC - 1 \quad (8\text{-}147)$$

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#### 8.3.4.4 Specification of Intra_Chroma_Plane prediction mode

This Intra chroma prediction mode is invoked when intra_chroma_pred_mode is equal to 3.

This mode shall be used only when the samples p[ x, -1 ], with x = 0..MbWidthC - 1 and p[ -1, y ], with y = -1..MbHeightC - 1 are marked as "available for Intra chroma prediction".

The values of the prediction samples $pred_C[ x, y ]$ are derived as follows.

Let the variable xCF be set equal to 4 * ( ChromaArrayType == 3 ) and let the variable yCF be set equal to 4 * ( ChromaArrayType != 1 ).

$$pred_C[ x, y ] = Clip1_C( ( a + b * ( x - 3 - xCF ) + c * ( y - 3 - yCF ) + 16 ) >> 5 ),$$
$$\text{with } x = 0..MbWidthC - 1 \text{ and } y = 0..MbHeightC - 1 \quad (8\text{-}148)$$

where:

$$a = 16 * ( p[ -1, MbHeightC - 1 ] + p[ MbWidthC - 1, -1 ] ) \quad (8\text{-}149)$$

$$b = ( ( 34 - 29 * ( ChromaArrayType == 3 ) ) * H + 32 ) >> 6 \quad (8\text{-}150)$$

$$c = ( ( 34 - 29 * ( ChromaArrayType != 1 ) ) * V + 32 ) >> 6 \quad (8\text{-}151)$$

and H and V are specified as

$$H = \sum_{x'=0}^{3+xCF} (x'+1) * (p[4 + xCF + x', -1] - p[2 + xCF - x', -1]) \quad (8\text{-}152)$$

$$V = \sum_{y'=0}^{3+yCF} (y'+1) * (p[-1, 4 + yCF + y'] - p[-1, 2 + yCF - y']) \quad (8\text{-}153)$$

#### 8.3.4.5 Intra prediction for chroma samples with ChromaArrayType equal to 3

This process is invoked when ChromaArrayType is equal to 3. This process is invoked for I and SI macroblock types. It specifies how the Intra prediction chroma samples for the current macroblock are derived when ChromaArrayType is equal to 3.

Inputs to this process are constructed samples prior to the deblocking filter process from neighbouring Cb and Cr blocks and for Intra_NxN (where NxN is equal to 4x4 or 8x8) prediction mode, the associated values of IntraNxNPredMode from neighbouring macroblocks.

Outputs of this process are the Intra prediction samples of the Cb and Cr components of the macroblock or in case of the Intra_NxN prediction process, the outputs are NxN Cb sample arrays as part of the 16x16 Cb array of prediction samples of the macroblock, and NxN Cb sample arrays as part of the 16x16 Cb array of prediction samples of the macroblock.

Each Cb, Cr, and luma block with the same block index of the macroblock use the same prediction mode. The prediction mode is applied to each of the Cb and Cr blocks separately. The process specified in this subclause is invoked for each Cb and Cr block.

Depending on the macroblock prediction mode, the following applies.

– If the macroblock prediction mode is equal to Intra_4x4, the following applies.

  – The same process described in subclause 8.3.1 is also applied to Cb or Cr samples, substituting luma with Cb or Cr, substituting luma4x4BlkIdx with cb4x4BlkIdx or cr4x4BlkIdx, substituting $pred4x4_L$ with $pred4x4_{Cb}$ or $pred4x4_{Cr}$, and substituting $BitDepth_Y$ with $BitDepth_C$.

  – The output variable Intra4x4PredMode[luma4x4BlkIdx] from the process described in subclause 8.3.1.1 is also used for the 4x4 Cb or 4x4 Cr blocks with index luma4x4BlkIdx equal to index cb4x4BlkIdx or cr4x4BlkIdx.

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  - The process to derive prediction Cb or Cr samples is identical to the process described in subclause 8.3.1.2 and its subsequent subclauses when substituting luma with Cb or Cr, substituting $pred4x4_L$ with $pred4x4_{Cb}$ or $pred4x4_{Cr}$, and substituting $BitDepth_Y$ with $BitDepth_C$.

– Otherwise, if the macroblock prediction mode is equal to Intra_8x8, the following applies.

  - The same process described in subclause 8.3.2 is also applied to Cb or Cr samples, substituting luma with Cb or Cr, substituting luma8x8BlkIdx with cb8x8BlkIdx or cr8x8BlkIdx, substituting $pred8x8_L$ with $pred8x8_{Cb}$ or $pred8x8_{Cr}$, and substituting $BitDepth_Y$ with $BitDepth_C$.
  - The output variable Intra8x8PredMode[luma8x8BlkIdx] from the process described in subclause 8.3.2.1 is used for the 8x8 Cb or 8x8 Cr blocks with index luma8x8BlkIdx equal to index cb8x8BlkIdx or cr8x8BlkIdx.
  - The process to derive prediction Cb or Cr samples is identical to the process described in subclause 8.3.2.2 and its subsequent subclauses when substituting luma with Cb or Cr, substituting $pred8x8_L$ with $pred8x8_{Cb}$ or $pred8x8_{Cr}$, and substituting $BitDepth_Y$ with $BitDepth_C$.

– Otherwise, if the macroblock prediction mode is equal to Intra_16x16, the following applies.

  - The same process described in subclause 8.3.3 and in the subsequent subclause 8.3.3.1 to 8.3.3.4 is also applied to Cb or Cr samples, substituting luma with Cb or Cr, substituting $pred_L$ with $pred_{Cb}$ or $pred_{Cr}$, and substituting $BitDepth_Y$ with $BitDepth_C$.

### 8.3.5 Sample construction process for I_PCM macroblocks

This process is invoked when mb_type is equal to I_PCM.

The variable dy is derived as follows.

– If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock, dy is set equal to 2.

– Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock), dy is set equal to 1.

The position of the upper-left luma sample of the current macroblock is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with CurrMbAddr as input and the output being assigned to ( xP, yP ).

The constructed luma samples prior to the deblocking process are generated as specified by:

```
for( i = 0; i < 256; i++ )
  S'L[ xP + ( i % 16 ), yP + dy * ( i / 16 ) ) ] = pcm_sample_luma[ i ]          (8-154)
```

When ChromaArrayType is not equal to 0, the constructed chroma samples prior to the deblocking process are generated as specified by:

```
for( i = 0; i < MbWidthC * MbHeightC; i++ ) {
  S'Cb[ ( xP / SubWidthC ) + ( i % MbWidthC ),
        ( ( yP + SubHeightC – 1 ) / SubHeightC ) + dy * ( i / MbWidthC ) ] =
          pcm_sample_chroma[ i ]                                               (8-155)
  S'Cr[ ( xP / SubWidthC ) + ( i % MbWidthC ),
        ( ( yP + SubHeightC – 1 ) / SubHeightC ) + dy * ( i / MbWidthC ) ] =
          pcm_sample_chroma[ i + MbWidthC * MbHeightC ]
}
```

## 8.4 Inter prediction process

This process is invoked when decoding P and B macroblock types.

Outputs of this process are Inter prediction samples for the current macroblock that are a 16x16 array $pred_L$ of luma samples and when ChromaArrayType is not equal to 0 two (MbWidthC)x(MbHeightC) arrays $pred_{Cb}$ and $pred_{Cr}$ of chroma samples, one for each of the chroma components Cb and Cr.

The partitioning of a macroblock is specified by mb_type. Each macroblock partition is referred to by mbPartIdx. When the macroblock partitioning consists of partitions that are equal to sub-macroblocks, each sub-macroblock can be further

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partitioned into sub-macroblock partitions as specified by sub_mb_type. Each sub-macroblock partition is referred to by subMbPartIdx. When the macroblock partitioning does not consist of sub-macroblocks, subMbPartIdx is set equal to 0.

The following steps are specified for each macroblock partition or for each sub-macroblock partition.

The functions MbPartWidth( ), MbPartHeight( ), SubMbPartWidth( ), and SubMbPartHeight( ) describing the width and height of macroblock partitions and sub-macroblock partitions are specified in Table 7-13, 7-14, 7-17, and 7-18.

The range of the macroblock partition index mbPartIdx is derived as follows.

– If mb_type is equal to B_Skip or B_Direct_16x16, mbPartIdx proceeds over values 0..3.

– Otherwise (mb_type is not equal to B_Skip or B_Direct_16x16), mbPartIdx proceeds over values 0..NumMbPart( mb_type ) – 1.

For each value of mbPartIdx, the variables partWidth and partHeight for each macroblock partition or sub-macroblock partition in the macroblock are derived as follows.

– If mb_type is not equal to P_8x8, P_8x8ref0, B_Skip, B_Direct_16x16, or B_8x8, subMbPartIdx is set equal to 0, and partWidth and partHeight are derived as

$$partWidth = MbPartWidth( mb_type ) \quad (8\text{-}156)$$

$$partHeight = MbPartHeight( mb_type ) \quad (8\text{-}157)$$

– Otherwise, if mb_type is equal to P_8x8 or P_8x8ref0, or mb_type is equal to B_8x8 and sub_mb_type[ mbPartIdx ] is not equal to B_Direct_8x8, subMbPartIdx proceeds over values 0..NumSubMbPart( sub_mb_type ) – 1, and partWidth and partHeight are derived as

$$partWidth = SubMbPartWidth( sub_mb_type[ mbPartIdx ] ) \quad (8\text{-}158)$$

$$partHeight = SubMbPartHeight( sub_mb_type[ mbPartIdx ] ). \quad (8\text{-}159)$$

– Otherwise (mb_type is equal to B_Skip or B_Direct_16x16, or mb_type is equal to B_8x8 and sub_mb_type[ mbPartIdx ] is equal to B_Direct_8x8), subMbPartIdx proceeds over values 0..3, and partWidth and partHeight are derived as

$$partWidth = 4 \quad (8\text{-}160)$$

$$partHeight = 4 \quad (8\text{-}161)$$

When ChromaArrayType is not equal to 0, the variables partWidthC and partHeightC are derived as

$$partWidthC = partWidth / SubWidthC \quad (8\text{-}162)$$
$$partHeightC = partHeight / SubHeightC \quad (8\text{-}163)$$

Let the variable MvCnt be initially set equal to 0 before any invocation of subclause 8.4.1 for the macroblock.

The Inter prediction process for a macroblock partition mbPartIdx and a sub-macroblock partition subMbPartIdx consists of the following ordered steps

1. Derivation process for motion vector components and reference indices as specified in subclause 8.4.1.

   Inputs to this process are

   – a macroblock partition mbPartIdx,

   – a sub-macroblock partition subMbPartIdx.

   Outputs of this process are

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- luma motion vectors mvL0 and mvL1 and when ChromaArrayType is not equal to 0, the chroma motion vectors mvCL0 and mvCL1
- reference indices refIdxL0 and refIdxL1
- prediction list utilization flags predFlagL0 and predFlagL1
- the sub-macroblock partition motion vector count subMvCnt.

2. The variable MvCnt is incremented by subMvCnt.
3. Derivation process for prediction weights as specified in subclause 8.4.3.

   Inputs to this process are

   - reference indices refIdxL0 and refIdxL1
   - prediction list utilization flags predFlagL0 and predFlagL1

   Outputs of this process are

   - variables for weighted prediction $logWD_C$, $w_{0C}$, $w_{1C}$, $o_{0C}$, $o_{1C}$ with C being replaced by L and, when ChromaArrayType is not equal to 0, Cb and Cr.

4. Decoding process for Inter prediction samples as specified in subclause 8.4.2.

   Inputs to this process are

   - a macroblock partition mbPartIdx,
   - a sub-macroblock partition subMbPartIdx.
   - variables specifying partition width and height for luma and chroma (if available), partWidth, partHeight, partWidthC (if available), and partHeightC (if available)
   - luma motion vectors mvL0 and mvL1 and when ChromaArrayType is not equal to 0, the chroma motion vectors mvCL0 and mvCL1
   - reference indices refIdxL0 and refIdxL1
   - prediction list utilization flags predFlagL0 and predFlagL1
   - variables for weighted prediction $logWD_C$, $w_{0C}$, $w_{1C}$, $o_{0C}$, $o_{1C}$ with C being replaced by L and, when ChromaArrayType is not equal to 0, Cb and Cr

   Outputs of this process are

   - inter prediction samples (pred); which are a (partWidth)x(partHeight) array $predPart_L$ of prediction luma samples and when ChromaArrayType is not equal to 0 two (partWidthC)x(partHeightC) arrays $predPart_{Cr}$, and $predPart_{Cb}$ of prediction chroma samples, one for each of the chroma components Cb and Cr.

For use in derivation processes of variables invoked later in the decoding process, the following assignments are made:

MvL0[ mbPartIdx ][ subMbPartIdx ] = mvL0 (8-164)

MvL1[ mbPartIdx ][ subMbPartIdx ] = mvL1 (8-165)

RefIdxL0[ mbPartIdx ] = refIdxL0 (8-166)

RefIdxL1[ mbPartIdx ] = refIdxL1 (8-167)

PredFlagL0[ mbPartIdx ] = predFlagL0 (8-168)

PredFlagL1[ mbPartIdx ] = predFlagL1 (8-169)

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The location of the upper-left sample of the partition relative to the upper-left sample of the macroblock is derived by invoking the inverse macroblock partition scanning process as described in subclause 6.4.2.1 with mbPartIdx as the input and ( xP, yP ) as the output.

The location of the upper-left sample of the macroblock sub-partition relative to the upper-left sample of the macroblock partition is derived by invoking the inverse sub-macroblock partition scanning process as described in subclause 6.4.2.2 with subMbPartIdx as the input and ( xS, yS ) as the output.

The macroblock prediction is formed by placing the partition or sub-macroblock partition prediction samples in their correct relative positions in the macroblock, as follows.

The variable $pred_L[ xP + xS + x, yP + yS + y ]$ with x = 0 .. partWidth – 1, y = 0 .. partHeight – 1 is derived by

$$pred_L[ xP + xS + x, yP + yS + y ] = predPart_L[ x, y ] \quad (8\text{-}170)$$

When ChromaArrayType is not equal to 0, the variable $pred_C$ with x = 0..partWidthC – 1, y = 0..partHeightC – 1, and C in $pred_C$ and $predPart_C$ being replaced by Cb or Cr is derived by

$$pred_C[ xP / SubWidthC + xS / SubWidthC + x, yP / SubHeightC + yS / SubHeightC + y ] = predPart_C[ x, y ] \quad (8\text{-}171)$$

### 8.4.1 Derivation process for motion vector components and reference indices

Inputs to this process are

– a macroblock partition mbPartIdx,

– a sub-macroblock partition subMbPartIdx.

Outputs of this process are

– luma motion vectors mvL0 and mvL1 and when ChromaArrayType is not equal to 0, the chroma motion vectors mvCL0 and mvCL1

– reference indices refIdxL0 and refIdxL1

– prediction list utilization flags predFlagL0 and predFlagL1

– a sub-partition macroblock motion vector count variable subMvCnt

For the derivation of the variables mvL0 and mvL1 as well as refIdxL0 and refIdxL1, the following applies.

– If mb_type is equal to P_Skip, the derivation process for luma motion vectors for skipped macroblocks in P and SP slices in subclause 8.4.1.1 is invoked with the output being the luma motion vectors mvL0 and reference indices refIdxL0, and predFlagL0 is set equal to 1. mvL1 and refIdxL1 are marked as not available and predFlagL1 is set equal to 0. The sub-partition motion vector count variable subMvCnt is set equal to 1.

– Otherwise, if mb_type is equal to B_Skip or B_Direct_16x16 or sub_mb_type[ mbPartIdx ] is equal to B_Direct_8x8, the derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8 in B slices in subclause 8.4.1.2 is invoked with mbPartIdx and subMbPartIdx as the input and the output being the luma motion vectors mvL0, mvL1, the reference indices refIdxL0, refIdxL1, the sub-partition motion vector count subMvCnt, and the prediction utilization flags predFlagL0 and predFlagL1.

– Otherwise, for X being replaced by either 0 or 1 in the variables predFlagLX, mvLX, refIdxLX, and in Pred_LX and in the syntax elements ref_idx_lX and mvd_lX, the following applies.

1. The variables refIdxLX and predFlagLX are derived as follows.

   – If MbPartPredMode( mb_type, mbPartIdx ) or SubMbPredMode( sub_mb_type[ mbPartIdx ] ) is equal to Pred_LX or to BiPred,

$$refIdxLX = ref_idx_lX[ mbPartIdx ] \quad (8\text{-}172)$$

$$predFlagLX = 1 \quad (8\text{-}173)$$

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– Otherwise, the variables refIdxLX and predFlagLX are specified by

refIdxLX = -1 (8-174)

predFlagLX = 0 (8-175)

2. The variable subMvCnt for sub-partition motion vector count is set equal to predFlagL0 + predFlagL1.
3. The variable currSubMbType is derived as follows.
   – If the macroblock type is equal to B_8x8, currSubMbType is set equal to sub_mb_type[ mbPartIdx ].
   – Otherwise (the macroblock type is not equal to B_8x8), currSubMbType is set equal to "na".
4. When predFlagLX is equal to 1, the derivation process for luma motion vector prediction in subclause 8.4.1.3 is invoked with mbPartIdx subMbPartIdx, refIdxLX, and currSubMbType as the inputs and the output being mvpLX. The luma motion vectors are derived by

mvLX[ 0 ] = mvpLX[ 0 ] + mvd_lX[ mbPartIdx ][ subMbPartIdx ][ 0 ] (8-176)

mvLX[ 1 ] = mvpLX[ 1 ] + mvd_lX[ mbPartIdx ][ subMbPartIdx ][ 1 ] (8-177)

When ChromaArrayType is not equal to 0 and predFlagLX (with X being either 0 or 1) is equal to 1, the derivation process for chroma motion vectors in subclause 8.4.1.4 is invoked with mvLX and refIdxLX as input and the output being mvCLX.

#### 8.4.1.1 Derivation process for luma motion vectors for skipped macroblocks in P and SP slices

This process is invoked when mb_type is equal to P_Skip.

Outputs of this process are the motion vector mvL0 and the reference index refIdxL0.

The reference index refIdxL0 for a skipped macroblock is derived as follows.

refIdxL0 = 0. (8-178)

For the derivation of the motion vector mvL0 of a P_Skip macroblock type, the following applies.

– The process specified in subclause 8.4.1.3.2 is invoked with mbPartIdx set equal to 0, subMbPartIdx set equal to 0, currSubMbType set equal to "na", and listSuffixFlag set equal to 0 as input and the output is assigned to mbAddrA, mbAddrB, mvL0A, mvL0B, refIdxL0A, and refIdxL0B.
– The variable mvL0 is specified as follows.
  – If any of the following conditions are true, both components of the motion vector mvL0 are set equal to 0.
    – mbAddrA is not available
    – mbAddrB is not available
    – refIdxL0A is equal to 0 and both components of mvL0A are equal to 0
    – refIdxL0B is equal to 0 and both components of mvL0B are equal to 0
  – Otherwise, the derivation process for luma motion vector prediction as specified in subclause 8.4.1.3 is invoked with mbPartIdx = 0, subMbPartIdx = 0, refIdxL0, and currSubMbType = "na" as inputs and the output is assigned to mvL0.

NOTE – The output is directly assigned to mvL0, since the predictor is equal to the actual motion vector.

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#### 8.4.1.2 Derivation process for luma motion vectors for B_Skip, B_Direct_16x16, and B_Direct_8x8

This process is invoked when mb_type is equal to B_Skip or B_Direct_16x16, or sub_mb_type[ mbPartIdx ] is equal to B_Direct_8x8.

Inputs to this process are mbPartIdx and subMbPartIdx.

Outputs of this process are the reference indices refIdxL0, refIdxL1, the motion vectors mvL0 and mvL1, the sub-partition motion vector count subMvCnt, and the prediction list utilization flags, predFlagL0 and predFlagL1.

The derivation process depends on the value of direct_spatial_mv_pred_flag, which is present in the bitstream in the slice header syntax as specified in subclause 7.3.3, and is specified as follows.

– If direct_spatial_mv_pred_flag is equal to 1, the mode in which the outputs of this process are derived is referred to as spatial direct prediction mode.

– Otherwise (direct_spatial_mv_pred_flag is equal to 0), mode in which the outputs of this process are derived is referred to as temporal direct prediction mode.

Both spatial and temporal direct prediction mode use the co-located motion vectors and reference indices as specified in subclause 8.4.1.2.1.

The motion vectors and reference indices are derived as follows.

– If spatial direct prediction mode is used, the direct motion vector and reference index prediction mode specified in subclause 8.4.1.2.2 is used, with subMvCnt being an output.

– Otherwise (temporal direct prediction mode is used), the direct motion vector and reference index prediction mode specified in subclause 8.4.1.2.3 is used and the variable subMvCnt is derived as follows.

  – If subMbPartIdx is equal to 0, subMvCnt is set equal to 2.

  – Otherwise (subMbPartIdx is not equal to 0), subMvCnt is set equal to 0.

##### 8.4.1.2.1 Derivation process for the co-located 4x4 sub-macroblock partitions

Inputs to this process are mbPartIdx and subMbPartIdx.

Outputs of this process are the picture colPic, the co-located macroblock mbAddrCol, the motion vector mvCol, the reference index refIdxCol, and the variable vertMvScale (which can be One_To_One, Frm_To_Fld or Fld_To_Frm).

When RefPicList1[ 0 ] is a frame or a complementary field pair, let firstRefPicL1Top and firstRefPicL1Bottom be the top and bottom fields of RefPicList1[ 0 ], respectively, and let the following variables be specified as

topAbsDiffPOC = Abs( DiffPicOrderCnt( firstRefPicL1Top, CurrPic ) ) (8-179)

bottomAbsDiffPOC = Abs( DiffPicOrderCnt( firstRefPicL1Bottom, CurrPic ) ) (8-180)

The variable colPic specifies the picture that contains the co-located macroblock as specified in Table 8-6.

**Table 8-6 – Specification of the variable colPic**

| field_pic_flag | RefPicList1[ 0 ] is … | mb_field_decoding_flag | additional condition | colPic |
|---|---|---|---|---|
| 1 | a field of a decoded frame | | | the frame containing RefPicList1[ 0 ] |
| | a decoded field | | | RefPicList1[ 0 ] |
| 0 | a decoded frame | | | RefPicList1[ 0 ] |
| | a complementary field pair | 0 | topAbsDiffPOC < bottomAbsDiffPOC | firstRefPicL1Top |
| | | | topAbsDiffPOC >= bottomAbsDiffPOC | firstRefPicL1Bottom |
| | | 1 | ( CurrMbAddr & 1 ) == 0 | firstRefPicL1Top |
| | | | ( CurrMbAddr & 1 ) != 0 | firstRefPicL1Bottom |

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When direct_8x8_inference_flag is equal to 1, subMbPartIdx is set as follows.

subMbPartIdx = mbPartIdx (8-181)

Let PicCodingStruct( X ) be a function with the argument X being either CurrPic or colPic. It is specified in Table 8-7.

**Table 8-7 – Specification of PicCodingStruct( X )**

| X is coded with field_pic_flag equal to … | mb_adaptive_frame_field_flag | PicCodingStruct( X ) |
|---|---|---|
| 1 | | FLD |
| 0 | 0 | FRM |
| 0 | 1 | AFRM |

With luma4x4BlkIdx = mbPartIdx * 4 + subMbPartIdx, the inverse 4x4 luma block scanning process as specified in subclause 6.4.3 is invoked with luma4x4BlkIdx as the input and ( x, y ) assigned to ( xCol, yCol ) as the output.

Table 8-8 specifies the co-located macroblock address mbAddrCol, yM, and the variable vertMvScale in two steps:

1. Specification of a macroblock address mbAddrX depending on PicCodingStruct( CurrPic ), and PicCodingStruct( colPic ).

   NOTE – It is not possible for CurrPic and colPic picture coding types to be either (FRM, AFRM) or (AFRM, FRM) because these picture coding types must be separated by an IDR picture.

2. Specification of mbAddrCol, yM, and vertMvScale depending on mb_field_decoding_flag and the variable fieldDecodingFlagX, which is derived as follows.

   – If the macroblock mbAddrX in the picture colPic is a field macroblock, fieldDecodingFlagX is set equal to 1

   – Otherwise (the macroblock mbAddrX in the picture colPic is a frame macroblock), fieldDecodingFlagX is set equal to 0.

Unspecified values in Table 8-8 indicate that the value of the corresponding variable is not relevant for the current table row.

mbAddrCol is set equal to CurrMbAddr or to one of the following values.

mbAddrCol1 = 2 * PicWidthInMbs * ( CurrMbAddr / PicWidthInMbs ) +
( CurrMbAddr % PicWidthInMbs ) + PicWidthInMbs * ( yCol / 8 ) (8-182)

mbAddrCol2 = 2 * CurrMbAddr + ( yCol / 8 ) (8-183)

mbAddrCol3 = 2 * CurrMbAddr + bottom_field_flag (8-184)

mbAddrCol4 = PicWidthInMbs * ( CurrMbAddr / ( 2 * PicWidthInMbs ) ) +
( CurrMbAddr % PicWidthInMbs ) (8-185)

mbAddrCol5 = CurrMbAddr / 2 (8-186)

mbAddrCol6 = 2 * ( CurrMbAddr / 2 ) + ( ( topAbsDiffPOC < bottomAbsDiffPOC ) ? 0 : 1 ) (8-187)

mbAddrCol7 = 2 * ( CurrMbAddr / 2 ) + ( yCol / 8 ) (8-188)

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**Table 8-8 – Specification of mbAddrCol, yM, and vertMvScale**

| PicCodingStruct( CurrPic ) | PicCodingStruct( colPic ) | mbAddrX | mb_field_decoding_flag | fieldDecodingFlagX | mbAddrCol | yM | vertMvScale |
|---|---|---|---|---|---|---|---|
| FLD | FLD | | | | CurrMbAddr | yCol | One_To_One |
| | FRM | | | | mbAddrCol1 | ( 2 * yCol ) % 16 | Frm_To_Fld |
| | AFRM | 2*CurrMbAddr | | 0 | mbAddrCol2 | ( 2 * yCol ) % 16 | Frm_To_Fld |
| | | | | 1 | mbAddrCol3 | yCol | One_To_One |
| FRM | FLD | | | | mbAddrCol4 | 8 * ( (CurrMbAddr / PicWidthInMbs ) % 2) + 4 * ( yCol / 8 ) | Fld_To_Frm |
| | FRM | | | | CurrMbAddr | yCol | One_To_One |
| AFRM | FLD | | 0 | | mbAddrCol5 | 8 * ( CurrMbAddr % 2 ) +4 * ( yCol / 8 ) | Fld_To_Frm |
| | | | 1 | | mbAddrCol5 | yCol | One_To_One |
| | AFRM | CurrMbAddr | 0 | 0 | CurrMbAddr | yCol | One_To_One |
| | | | | 1 | mbAddrCol6 | 8 * ( CurrMbAddr % 2 ) + 4 * ( yCol / 8 ) | Fld_To_Frm |
| | | CurrMbAddr | 1 | 0 | mbAddrCol7 | ( 2 * yCol ) % 16 | Frm_To_Fld |
| | | | | 1 | CurrMbAddr | yCol | One_To_One |

Let mbPartIdxCol be the macroblock partition index of the co-located partition and subMbPartIdxCol the sub-macroblock partition index of the co-located sub-macroblock partition. The partition in the macroblock mbAddrCol inside the picture colPic covering the sample ( xCol, yM ) is assigned to mbPartIdxCol and the sub-macroblock partition inside the partition mbPartIdxCol covering the sample ( xCol, yM ) in the macroblock mbAddrCol inside the picture colPic is assigned to subMbPartIdxCol.

The prediction utilization flags predFlagL0Col and predFlagL1Col are set equal to PredFlagL0[ mbPartIdxCol ] and PredFlagL1[ mbPartIdxCol ], respectively, which are the prediction utilization flags that have been assigned to the macroblock partition mbAddrCol\mbPartIdxCol inside the picture colPic.

The motion vector mvCol and the reference index refIdxCol are derived as follows.

– If the macroblock mbAddrCol is coded in Intra macroblock prediction mode or both prediction utilization flags, predFlagL0Col and predFlagL1Col are equal to 0, both components of mvCol are set equal to 0 and refIdxCol is set equal to –1.

– Otherwise, the following applies.

  – If predFlagL0Col is equal to 1, the motion vector mvCol and the reference index refIdxCol are set equal to MvL0[ mbPartIdxCol ][ subMbPartIdxCol ] and RefIdxL0[ mbPartIdxCol ], respectively, which are the motion vector mvL0 and the reference index refIdxL0 that have been assigned to the (sub-)macroblock partition mbAddrCol\mbPartIdxCol\subMbPartIdxCol inside the picture colPic.

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– Otherwise (predFlagL0Col is equal to 0 and predFlagL1Col is equal to 1), the motion vector mvCol and the reference index refIdxCol are set equal to MvL1[ mbPartIdxCol ][ subMbPartIdxCol ] and RefIdxL1[ mbPartIdxCol ], respectively, which are the motion vector mvL1 and the reference index refIdxL1 that have been assigned to the (sub-)macroblock partition mbAddrCol\mbPartIdxCol\subMbPartIdxCol inside the picture colPic.

#### 8.4.1.2.2 Derivation process for spatial direct luma motion vector and reference index prediction mode

This process is invoked when direct_spatial_mv_pred_flag is equal to 1 and any of the following conditions is true.

– mb_type is equal to B_Skip

– mb_type is equal to B_Direct_16x16

– sub_mb_type[ mbPartIdx ] is equal to B_Direct_8x8.

Inputs to this process are mbPartIdx, subMbPartIdx.

Outputs of this process are the reference indices refIdxL0, refIdxL1, the motion vectors mvL0 and mvL1, the sub-partition motion vector count subMvCnt, and the prediction list utilization flags, predFlagL0 and predFlagL1.

The reference indices refIdxL0 and refIdxL1 and the variable directZeroPredictionFlag are derived by applying the following ordered steps.

1. Let the variable currSubMbType be set equal to sub_mb_type[ mbPartIdx ].

2. The process specified in subclause 8.4.1.3.2 is invoked with mbPartIdx = 0, subMbPartIdx = 0, currSubMbType, and listSuffixFlag = 0 as inputs and the output is assigned to the motion vectors mvL0N and the reference indices refIdxL0N with N being replaced by A, B, or C.

3. The process specified in subclause 8.4.1.3.2 is invoked with mbPartIdx = 0, subMbPartIdx = 0, currSubMbType, and listSuffixFlag = 1 as inputs and the output is assigned to the motion vectors mvL1N and the reference indices refIdxL1N with N being replaced by A, B, or C.

   NOTE 1 – The motion vectors mvL0N, mvL1N and the reference indices refIdxL0N, refIdxL1N are identical for all 4x4 sub-macroblock partitions of a macroblock.

4. The reference indices refIdxL0, refIdxL1, and directZeroPredictionFlag are derived by

$$refIdxL0 = MinPositive( refIdxL0A, MinPositive( refIdxL0B, refIdxL0C ) ) \quad (8\text{-}189)$$
$$refIdxL1 = MinPositive( refIdxL1A, MinPositive( refIdxL1B, refIdxL1C ) ) \quad (8\text{-}190)$$
$$directZeroPredictionFlag = 0 \quad (8\text{-}191)$$

   where

$$MinPositive( x, y ) = \begin{cases} Min( x, y ) & \text{if } x >= 0 \text{ and } y >= 0 \\ Max( x, y ) & \text{otherwise} \end{cases} \quad (8\text{-}192)$$

5. When both reference indices refIdxL0 and refIdxL1 are less than 0,

$$refIdxL0 = 0 \quad (8\text{-}193)$$
$$refIdxL1 = 0 \quad (8\text{-}194)$$
$$directZeroPredictionFlag = 1 \quad (8\text{-}195)$$

The process specified in subclause 8.4.1.2.1 is invoked with mbPartIdx, subMbPartIdx given as input and the output is assigned to refIdxCol and mvCol.

The variable colZeroFlag is derived as follows.

– If all of the following conditions are true, colZeroFlag is set equal to 1.

  – RefPicList1[ 0 ] is currently marked as "used for short-term reference".

  – refIdxCol is equal to 0

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– both motion vector components mvCol[ 0 ] and mvCol[ 1 ] lie in the range of -1 to 1 in units specified as follows.

  – If the co-located macroblock is a frame macroblock, the units of mvCol[ 0 ] and mvCol[ 1 ] are units of quarter luma frame samples.

  – Otherwise (the co-located macroblock is a field macroblock), the units of mvCol[ 0 ] and mvCol[ 1 ] are units of quarter luma field samples.

NOTE 2 – For purposes of determining the condition above, the value mvCol[ 1 ] is not scaled to use the units of a motion vector for the current macroblock in cases when the current macroblock is a frame macroblock and the co-located macroblock is a field macroblock or when the current macroblock is a field macroblock and the co-located macroblock is a frame macroblock. This aspect differs from the use of mvCol[ 1 ] in the temporal direct mode as specified in subclause 8.4.1.2.3, which applies scaling to the motion vector of the co-located macroblock to use the same units as the units of a motion vector for the current macroblock, using Equation 8-198 or Equation 8-199 in these cases.

– Otherwise, colZeroFlag is set equal to 0.

The motion vectors mvLX (with X being 0 or 1) are derived as follows.

– If any of the following conditions is true, both components of the motion vector mvLX are set equal to 0.

  – directZeroPredictionFlag is equal to 1

  – refIdxLX is less than 0

  – refIdxLX is equal to 0 and colZeroFlag is equal to 1

– Otherwise, the process specified in subclause 8.4.1.3 is invoked with mbPartIdx = 0, subMbPartIdx = 0, refIdxLX, and currSubMbType as inputs and the output is assigned to mvLX.

NOTE 3 – The motion vector mvLX returned from subclause 8.4.1.3 is identical for all 4x4 sub-macroblock partitions of a macroblock for which the process is invoked.

The prediction utilization flags predFlagL0 and predFlagL1 are derived as specified using Table 8-9.

**Table 8-9 – Assignment of prediction utilization flags**

| refIdxL0 | refIdxL1 | predFlagL0 | predFlagL1 |
|---|---|---|---|
| >= 0 | >= 0 | 1 | 1 |
| >= 0 | < 0 | 1 | 0 |
| < 0 | >= 0 | 0 | 1 |

The variable subMvCnt is derived as follows.

– If subMbPartIdx is not equal to 0, subMvCnt is set equal to 0.

– Otherwise (subMbPartIdx is equal to 0), subMvCnt is set equal to predFlagL0 + predFLagL1.

#### 8.4.1.2.3 Derivation process for temporal direct luma motion vector and reference index prediction mode

This process is invoked when direct_spatial_mv_pred_flag is equal to 0 and any of the following conditions is true.

– mb_type is equal to B_Skip

– mb_type is equal to B_Direct_16x16

– sub_mb_type[ mbPartIdx ] is equal to B_Direct_8x8.

Inputs to this process are mbPartIdx and subMbPartIdx.

Outputs of this process are the motion vectors mvL0 and mvL1, the reference indices refIdxL0 and refIdxL1, and the prediction list utilization flags, predFlagL0 and predFlagL1.

The process specified in subclause 8.4.1.2.1 is invoked with mbPartIdx, subMbPartIdx given as input and the output is assigned to colPic, mbAddrCol, mvCol, refIdxCol, and vertMvScale.

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The reference indices refIdxL0 and refIdxL1 are derived as follows.

$$refIdxL0 = ( ( refIdxCol < 0 ) ? 0 : MapColToList0( refIdxCol ) ) \quad (8\text{-}196)$$

$$refIdxL1 = 0 \quad (8\text{-}197)$$

NOTE 1 – If the current macroblock is a field macroblock, refIdxL0 and refIdxL1 index a list of fields; otherwise (the current macroblock is a frame macroblock), refIdxL0 and refIdxL1 index a list of frames or complementary reference field pairs.

Let refPicCol be a frame, a field, or a complementary field pair that was referred by the reference index refIdxCol when decoding the co-located macroblock mbAddrCol inside the picture colPic. The function MapColToList0( refIdxCol ) is specified as follows.

- If vertMvScale is equal to One_To_One, the following applies.
  - If field_pic_flag is equal to 0 and the current macroblock is a field macroblock, the following applies.
    - Let refIdxL0Frm be the lowest valued reference index in the current reference picture list RefPicList0 that references the frame or complementary field pair that contains the field refPicCol. RefPicList0 shall contain a frame or complementary field pair that contains the field refPicCol. The return value of MapColToList0( ) is specified as follows.
      - If the field referred to by refIdxCol has the same parity as the current macroblock, MapColToList0( refIdxCol ) returns the reference index ( refIdxL0Frm << 1 ).
      - Otherwise (the field referred by refIdxCol has the opposite parity of the current macroblock), MapColToList0( refIdxCol) returns the reference index ( ( refIdxL0Frm << 1 ) + 1 ).
  - Otherwise (field_pic_flag is equal to 1 or the current macroblock is a frame macroblock), MapColToList0( refIdxCol ) returns the lowest valued reference index refIdxL0 in the current reference picture list RefPicList0 that references refPicCol. RefPicList0 shall contain refPicCol.
- Otherwise, if vertMvScale is equal to Frm_To_Fld, the following applies.
  - If field_pic_flag is equal to 0, let refIdxL0Frm be the lowest valued reference index in the current reference picture list RefPicList0 that references refPicCol. MapColToList0( refIdxCol ) returns the reference index ( refIdxL0Frm << 1 ). RefPicList0 shall contain refPicCol.
  - Otherwise (field_pic_flag is equal to 1), MapColToList0( refIdxCol ) returns the lowest valued reference index refIdxL0 in the current reference picture list RefPicList0 that references the field of refPicCol with the same parity as the current picture CurrPic. RefPicList0 shall contain the field of refPicCol with the same parity as the current picture CurrPic.
- Otherwise (vertMvScale is equal to Fld_To_Frm), MapColToList0( refIdxCol ) returns the lowest valued reference index refIdxL0 in the current reference picture list RefPicList0 that references the frame or complementary field pair that contains refPicCol. RefPicList0 shall contain a frame or complementary field pair that contains the field refPicCol.

NOTE 2 – A decoded reference picture that was marked as "used for short-term reference" when it was referenced in the decoding process of the picture containing the co-located macroblock may have been modified to be marked as "used for long-term reference" before being used for reference for inter prediction using the direct prediction mode for the current macroblock.

Depending on the value of vertMvScale the vertical component of mvCol is modified as follows.

- If vertMvScale is equal to Frm_To_Fld

$$mvCol[ 1 ] = mvCol[ 1 ] / 2 \quad (8\text{-}198)$$

- Otherwise, if vertMvScale is equal to Fld_To_Frm

$$mvCol[ 1 ] = mvCol[ 1 ] * 2 \quad (8\text{-}199)$$

- Otherwise (vertMvScale is equal to One_To_One), mvCol[ 1 ] remains unchanged.

The variables currPicOrField, pic0, and pic1, are derived as follows.

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– If field_pic_flag is equal to 0 and the current macroblock is a field macroblock, the following applies.
  – currPicOrField is the field of the current picture CurrPic that has the same parity as the current macroblock.
  – pic1 is the field of RefPicList1[ 0 ] that has the same parity as the current macroblock.
  – The variable pic0 is derived as follows.
    – If refIdxL0 % 2 is equal to 0, pic0 is the field of RefPicList0[ refIdxL0 / 2 ] that has the same parity as the current macroblock.
    – Otherwise (refIdxL0 % 2 is not equal to 0), pic0 is the field of RefPicList0[ refIdxL0 / 2 ] that has the opposite parity of the current macroblock.
– Otherwise (field_pic_flag is equal to 1 or the current macroblock is a frame macroblock), currPicOrField is the current picture CurrPic, pic1 is the decoded reference picture RefPicList1[ 0 ], and pic0 is the decoded reference picture RefPicList0[ refIdxL0 ].

The two motion vectors mvL0 and mvL1 for each 4x4 sub-macroblock partition of the current macroblock are derived as follows:

NOTE 3 – It is often the case that many of the 4x4 sub-macroblock partitions share the same motion vectors and reference pictures. In these cases, temporal direct mode motion compensation can calculate the inter prediction sample values in larger units than 4x4 luma sample blocks. For example, when direct_8x8_inference_flag is equal to 1, at least each 8x8 luma sample quadrant of the macroblock shares the same motion vectors and reference pictures.

– If the reference index refIdxL0 refers to a long-term reference picture, or DiffPicOrderCnt( pic1, pic0 ) is equal to 0, the motion vectors mvL0, mvL1 for the direct mode partition are derived by

$$mvL0 = mvCol \tag{8-200}$$

$$mvL1 = 0 \tag{8-201}$$

– Otherwise, the motion vectors mvL0, mvL1 are derived as scaled versions of the motion vector mvCol of the co-located sub-macroblock partition as specified below (see Figure 8-2)

$$tx = ( 16\,384 + Abs( td / 2 ) ) / td \tag{8-202}$$

$$DistScaleFactor = Clip3( -1024, 1023, ( tb * tx + 32 ) >> 6 ) \tag{8-203}$$

$$mvL0 = ( DistScaleFactor * mvCol + 128 ) >> 8 \tag{8-204}$$

$$mvL1 = mvL0 - mvCol \tag{8-205}$$

where tb and td are derived as follows.

$$tb = Clip3( -128, 127, DiffPicOrderCnt( currPicOrField, pic0 ) ) \tag{8-206}$$

$$td = Clip3( -128, 127, DiffPicOrderCnt( pic1, pic0 ) ) \tag{8-207}$$

NOTE 4 – mvL0 and mvL1 cannot exceed the ranges specified in Annex A.

The prediction utilization flags predFlagL0 and predFlagL1 are both set equal to 1.

Figure 8-2 illustrates the temporal direct-mode motion vector inference when the current picture is temporally between the reference picture from reference picture list 0 and the reference picture from reference picture list 1.

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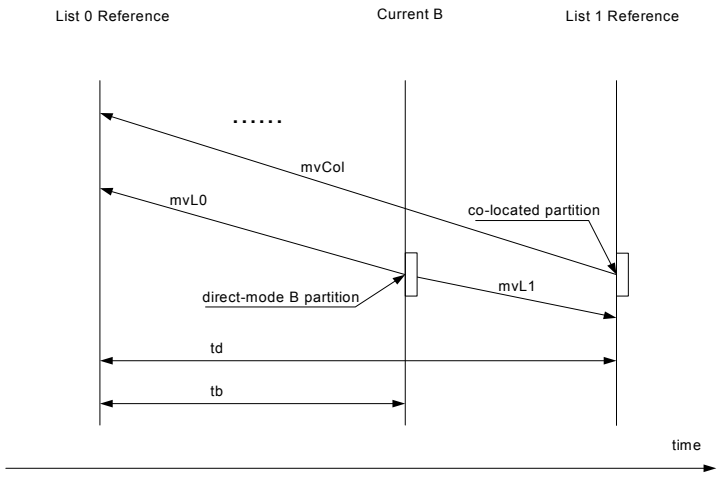


**Figure 8-2 – Example for temporal direct-mode motion vector inference (informative)**

### 8.4.1.3 Derivation process for luma motion vector prediction

Inputs to this process are

– the macroblock partition index mbPartIdx,

– the sub-macroblock partition index subMbPartIdx,

– the reference index of the current partition refIdxLX (with X being 0 or 1),

– the variable currSubMbType.

Output of this process is the prediction mvpLX of the motion vector mvLX (with X being 0 or 1).

The derivation process for the neighbouring blocks for motion data in subclause 8.4.1.3.2 is invoked with mbPartIdx, subMbPartIdx, currSubMbType, and listSuffixFlag = X (with X being 0 or 1 for refIdxLX being refIdxL0 or refIdxL1, respectively) as the input and with mbAddrN\mbPartIdxN\subMbPartIdxN, reference indices refIdxLXN and the motion vectors mvLXN with N being replaced by A, B, or C as the output.

The derivation process for median luma motion vector prediction in subclause 8.4.1.3.1 is invoked with mbAddrN\mbPartIdxN\subMbPartIdxN, mvLXN, refIdxLXN with N being replaced by A, B, or C and refIdxLX as the input and mvpLX as the output, unless one of the following is true.

– MbPartWidth( mb_type ) is equal to 16, MbPartHeight( mb_type ) is equal to 8, mbPartIdx is equal to 0, and refIdxLXB is equal to refIdxLX,

$$mvpLX = mvLXB \tag{8-208}$$

– MbPartWidth( mb_type ) is equal to 16, MbPartHeight( mb_type ) is equal to 8, mbPartIdx is equal to 1, and refIdxLXA is equal to refIdxLX,

$$mvpLX = mvLXA \tag{8-209}$$

– MbPartWidth( mb_type ) is equal to 8, MbPartHeight( mb_type ) is equal to 16, mbPartIdx is equal to 0, and refIdxLXA is equal to refIdxLX,

$$mvpLX = mvLXA \tag{8-210}$$

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– MbPartWidth( mb_type ) is equal to 8, MbPartHeight( mb_type ) is equal to 16, mbPartIdx is equal to 1, and refIdxLXC is equal to refIdxLX,

$$mvpLX = mvLXC \tag{8-211}$$

Figure 8-3 illustrates the non-median prediction as described above.

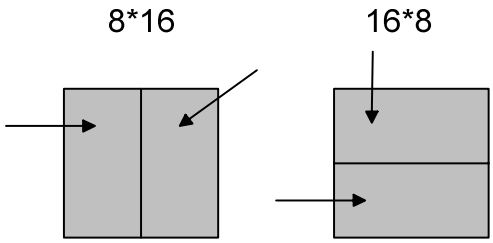


**Figure 8-3 – Directional segmentation prediction (informative)**

#### 8.4.1.3.1 Derivation process for median luma motion vector prediction

Inputs to this process are

– the neighbouring partitions mbAddrN\mbPartIdxN\subMbPartIdxN (with N being replaced by A, B, or C),

– the motion vectors mvLXN (with N being replaced by A, B, or C) of the neighbouring partitions,

– the reference indices refIdxLXN (with N being replaced by A, B, or C) of the neighbouring partitions, and

– the reference index refIdxLX of the current partition.

Output of this process is the motion vector prediction mvpLX.

The variable mvpLX is derived as follows:

– When both partitions mbAddrB\mbPartIdxB\subMbPartIdxB and mbAddrC\mbPartIdxC\subMbPartIdxC are not available and mbAddrA\mbPartIdxA\subMbPartIdxA is available,

$$mvLXB = mvLXA \tag{8-212}$$

$$mvLXC = mvLXA \tag{8-213}$$

$$refIdxLXB = refIdxLXA \tag{8-214}$$

$$refIdxLXC = refIdxLXA \tag{8-215}$$

– Depending on reference indices refIdxLXA, refIdxLXB, or refIdxLXC, the following applies.

  – If one and only one of the reference indices refIdxLXA, refIdxLXB, or refIdxLXC is equal to the reference index refIdxLX of the current partition, the following applies. Let refIdxLXN be the reference index that is equal to refIdxLX, the motion vector mvLXN is assigned to the motion vector prediction mvpLX:

$$mvpLX = mvLXN \tag{8-216}$$

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– Otherwise, each component of the motion vector prediction mvpLX is given by the median of the corresponding vector components of the motion vector mvLXA, mvLXB, and mvLXC:

mvpLX[ 0 ] = Median( mvLXA[ 0 ], mvLXB[ 0 ], mvLXC[ 0 ] ) (8-217)

mvpLX[ 1 ] = Median( mvLXA[ 1 ], mvLXB[ 1 ], mvLXC[ 1 ] ) (8-218)

#### 8.4.1.3.2 Derivation process for motion data of neighbouring partitions

Inputs to this process are

– the macroblock partition index mbPartIdx,

– the sub-macroblock partition index subMbPartIdx,

– the current sub-macroblock type currSubMbType,

– the list suffix flag listSuffixFlag

Outputs of this process are (with N being replaced by A, B, or C)

– mbAddrN\mbPartIdxN\subMbPartIdxN specifying neighbouring partitions,

– the motion vectors mvLXN of the neighbouring partitions, and

– the reference indices refIdxLXN of the neighbouring partitions.

Variable names that include the string "LX" are interpreted with the X being equal to listSuffixFlag.

The partitions mbAddrN\mbPartIdxN\subMbPartIdxN with N being either A, B, or C are derived in the following ordered steps.

1. Let mbAddrD\mbPartIdxD\subMbPartIdxD be variables specifying an additional neighbouring partition.

– The process in subclause 6.4.10.7 is invoked with mbPartIdx, currSubMbType, and subMbPartIdx as input and the output is assigned to mbAddrN\mbPartIdxN\subMbPartIdxN with N being replaced by A, B, C, or D.

2. When the partition mbAddrC\mbPartIdxC\subMbPartIdxC is not available, the following applies

mbAddrC = mbAddrD (8-219)

mbPartIdxC = mbPartIdxD (8-220)

subMbPartIdxC = subMbPartIdxD (8-221)

The motion vectors mvLXN and reference indices refIdxLXN (with N being A, B, or C) are derived as follows.

– If the macroblock partition or sub-macroblock partition mbAddrN\mbPartIdxN\subMbPartIdxN is not available or mbAddrN is coded in Intra prediction mode or predFlagLX of mbAddrN\mbPartIdxN\subMbPartIdxN is equal to 0, both components of mvLXN are set equal to 0 and refIdxLXN is set equal to –1.

– Otherwise, the following applies.

  – The motion vector mvLXN and reference index refIdxLXN are set equal to MvLX[ mbPartIdxN ][ subMbPartIdxN ] and RefIdxLX[ mbPartIdxN ], respectively, which are the motion vector mvLX and reference index refIdxLX that have been assigned to the (sub-)macroblock partition mbAddrN\mbPartIdxN\subMbPartIdxN.

  – The variables mvLXN[ 1 ] and refIdxLXN are further processed as follows.

    – If the current macroblock is a field macroblock and the macroblock mbAddrN is a frame macroblock

mvLXN[ 1 ] = mvLXN[ 1 ] / 2 (8-222)

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refIdxLXN = refIdxLXN * 2 (8-223)

– Otherwise, if the current macroblock is a frame macroblock and the macroblock mbAddrN is a field macroblock

mvLXN[ 1 ] = mvLXN[ 1 ] * 2 (8-224)

refIdxLXN = refIdxLXN / 2 (8-225)

– Otherwise, the vertical motion vector component mvLXN[ 1 ] and the reference index refIdxLXN remain unchanged.

#### 8.4.1.4 Derivation process for chroma motion vectors

This process is only invoked when ChromaArrayType is not equal to 0.

Inputs to this process are a luma motion vector mvLX and a reference index refIdxLX.

Output of this process is a chroma motion vector mvCLX.

A chroma motion vector is derived from the corresponding luma motion vector.

The precision of the chroma motion vector components is 1 ÷ ( 4 * SubWidthC ) horizontally and 1 ÷ ( 4 * SubHeightC ) vertically.

NOTE – For example, when using the 4:2:0 chroma format, since the units of luma motion vectors are one-quarter luma sample units and chroma has half horizontal and vertical resolution compared to luma, the units of chroma motion vectors are one-eighth chroma sample units, i.e., a value of 1 for the chroma motion vector refers to a one-eighth chroma sample displacement. For example, when the luma vector applies to 8x16 luma samples, the corresponding chroma vector in 4:2:0 chroma format applies to 4x8 chroma samples and when the luma vector applies to 4x4 luma samples, the corresponding chroma vector in 4:2:0 chroma format applies to 2x2 chroma samples.

For the derivation of the motion vector mvCLX, the following applies.

– If ChromaArrayType is not equal to 1 or the current macroblock is a frame macroblock, the horizontal and vertical components of the chroma motion vector mvCLX are derived as

mvCLX[ 0 ] = mvLX[ 0 ] (8-226)
mvCLX[ 1 ] = mvLX[ 1 ] (8-227)

– Otherwise (ChromaArrayType is equal to 1 and the current macroblock is a field macroblock), only the horizontal component of the chroma motion vector mvCLX[ 0 ] is derived using Equation 8-226. The vertical component of the chroma motion vector mvCLX[ 1 ] is dependent on the parity of the current field or the current macroblock and the reference picture, which is referred by the reference index refIdxLX. mvCLX[ 1 ] is derived from mvLX[ 1 ] according to Table 8-10.

**Table 8-10 – Derivation of the vertical component of the chroma vector in field coding mode**

| **Parity conditions** | | **mvCLX[ 1 ]** |
|---|---|---|
| Reference picture (refIdxLX) | Current field (picture/macroblock) | |
| Top field | Bottom field | mvLX[ 1 ] + 2 |
| Bottom field | Top field | mvLX[ 1 ] – 2 |
| Otherwise | | mvLX[ 1 ] |

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### 8.4.2 Decoding process for Inter prediction samples

Inputs to this process are

– a macroblock partition mbPartIdx,

– a sub-macroblock partition subMbPartIdx.

– variables specifying partition width and height for luma and chroma (if available), partWidth, partHeight, partWidthC (if available) and partHeightC (if available)

– luma motion vectors mvL0 and mvL1 and when ChromaArrayType is not equal to 0 chroma motion vectors mvCL0 and mvCL1

– reference indices refIdxL0 and refIdxL1

– prediction list utilization flags, predFlagL0 and predFlagL1

– variables for weighted prediction $\text{logWD}_C$, $w_{0C}$, $w_{1C}$, $o_{0C}$, $o_{1C}$ with C being replaced by L and, when ChromaArrayType is not equal to 0, Cb and Cr

Outputs of this process are

– the Inter prediction samples predPart, which are a (partWidth)x(partHeight) array $\text{predPart}_L$ of prediction luma samples, and when ChromaArrayType is not equal to 0 two (partWidthC)x(partHeightC) arrays $\text{predPart}_{Cb}$, $\text{predPart}_{Cr}$ of prediction chroma samples, one for each of the chroma components Cb and Cr.

Let $\text{predPartL0}_L$ and $\text{predPartL1}_L$ be (partWidth)x(partHeight) arrays of predicted luma sample values and when ChromaArrayType is not equal to 0 $\text{predPartL0}_{Cb}$, $\text{predPartL1}_{Cb}$, $\text{predPartL0}_{Cr}$, and $\text{predPartL1}_{Cr}$ be (partWidthC)x(partHeightC) arrays of predicted chroma sample values.

For LX being replaced by either L0 or L1 in the variables predFlagLX, RefPicListX, refIdxLX, refPicLX, predPartLX, the following is specified.

When predFlagLX is equal to 1, the following applies.

– The reference picture consisting of an ordered two-dimensional array $\text{refPicLX}_L$ of luma samples and when ChromaArrayType is not equal to 0 two ordered two-dimensional arrays $\text{refPicLX}_{Cb}$ and $\text{refPicLX}_{Cr}$ of chroma samples is derived by invoking the process specified in subclause 8.4.2.1 with refIdxLX and RefPicListX given as input.

– The array $\text{predPartLX}_L$ and when ChromaArrayType is not equal to 0 the arrays $\text{predPartLX}_{Cb}$ and $\text{predPartLX}_{Cr}$ are derived by invoking the process specified in subclause 8.4.2.2 with the current partition specified by mbPartIdx\subMbPartIdx, the motion vectors mvLX, mvCLX (if available), and the reference arrays with $\text{refPicLX}_L$, $\text{refPicLX}_{Cb}$ (if available), and $\text{refPicLX}_{Cr}$ (if available) given as input.

For C being replaced by L, Cb (if available), or Cr (if available), the array $\text{predPart}_C$ of the prediction samples of component C is derived by invoking the process specified in subclause 8.4.2.3 with the current partition specified by mbPartIdx and subMbPartIdx, the prediction utilization flags predFlagL0 and predFlagL1, the arrays $\text{predPartL0}_C$ and $\text{predPartL1}_C$, and the variables for weighted prediction $\text{logWD}_C$, $w_{0C}$, $w_{1C}$, $o_{0C}$, $o_{1C}$ given as input.

#### 8.4.2.1 Reference picture selection process

Input to this process is a reference index refIdxLX.

Output of this process is a reference picture consisting of a two-dimensional array of luma samples $\text{refPicLX}_L$ and, when ChromaArrayType is not equal to 0, two two-dimensional arrays of chroma samples $\text{refPicLX}_{Cb}$ and $\text{refPicLX}_{Cr}$.

Depending on field_pic_flag, the reference picture list RefPicListX (which has been derived as specified in subclause 8.2.4) consists of the following.

– If field_pic_flag is equal to 1, each entry of RefPicListX is a reference field or a field of a reference frame.

– Otherwise (field_pic_flag is equal to 0), each entry of RefPicListX is a reference frame or a complementary reference field pair.

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For the derivation of the reference picture, the following applies.

– If field_pic_flag is equal to 1, the reference field or field of a reference frame RefPicListX[ refIdxLX ] is the output. The output reference field or field of a reference frame consists of a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array of luma samples $refPicLX_L$ and, when ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays of chroma samples $refPicLX_{Cb}$ and $refPicLX_{Cr}$.

– Otherwise (field_pic_flag is equal to 0), the following applies.

  – If the current macroblock is a frame macroblock, the reference frame or complementary reference field pair RefPicListX[ refIdxLX ] is the output. The output reference frame or complementary reference field pair consists of a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$) array of luma samples $refPicLX_L$ and, when ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$) arrays of chroma samples $refPicLX_{Cb}$ and $refPicLX_{Cr}$.

  – Otherwise (the current macroblock is a field macroblock), the following applies.

    – Let refFrame be the reference frame or complementary reference field pair RefPicListX[ refIdxLX / 2 ].

    – The field of refFrame is selected as follows.

      – If refIdxLX % 2 is equal to 0, the field of refFrame that has the same parity as the current macroblock is the output.

      – Otherwise (refIdxLX % 2 is equal to 1), the field of refFrame that has the opposite parity as the current macroblock is the output.

    – The output reference field or field of a reference frame consists of a ($PicWidthInSamples_L$)x($PicHeightInSamples_L$ / 2) array of luma samples $refPicLX_L$ and, when ChromaArrayType is not equal to 0, two ($PicWidthInSamples_C$)x($PicHeightInSamples_C$ / 2) arrays of chroma samples $refPicLX_{Cb}$ and $refPicLX_{Cr}$.

Depending on separate_colour_plane_flag, the following applies.

– If separate_colour_plane_flag is equal to 0, the reference picture sample arrays $refPicLX_L$, $refPicLX_{Cb}$ (if available), and $refPicLX_{Cr}$ (if available) correspond to decoded sample arrays $S_L$, $S_{Cb}$ (if available), $S_{Cr}$ (if available) derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.

– Otherwise (separate_colour_plane_flag is equal to 1), the following applies.

  – If colour_plane_id is equal to 0, the reference picture sample array $refPicLX_L$ corresponds to the decoded sample array $S_L$ derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.

  – Otherwise, if colour_plane_id is equal to 1, the reference picture sample array $refPicLX_L$ corresponds to the decoded sample array $S_{Cb}$ derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.

  – Otherwise (colour_plane_id is equal to 2), the reference picture sample array $refPicLX_L$ corresponds to the decoded sample array $S_{Cr}$ derived in subclause 8.7 for a previously-decoded reference field or reference frame or complementary reference field pair or field of a reference frame.

#### 8.4.2.2 Fractional sample interpolation process

Inputs to this process are

– the current partition given by its partition index mbPartIdx and its sub-macroblock partition index subMbPartIdx,

– the width and height partWidth, partHeight of this partition in luma-sample units,

– a luma motion vector mvLX given in quarter-luma-sample units,

– when ChromaArrayType is not equal to 0, a chroma motion vector mvCLX with a precision of one-(4*SubWidthC)-th chroma-sample units horizontally and one-(4*SubHeightC)-th chroma-sample units vertically, and

– the selected reference picture sample arrays $refPicLX_L$, and when ChromaArrayType is not equal to 0, $refPicLX_{Cb}$, and $refPicLX_{Cr}$

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Outputs of this process are

– a (partWidth)x(partHeight) array predPartLX$_L$ of prediction luma sample values and

– when ChromaArrayType is not equal to 0, two (partWidthC)x(partHeightC) arrays predPartLX$_{Cb}$, and predPartLX$_{Cr}$ of prediction chroma sample values.

Let ( xA$_L$, yA$_L$ ) be the location given in full-sample units of the upper-left luma sample of the current partition given by mbPartIdx\subMbPartIdx relative to the upper-left luma sample location of the given two-dimensional array of luma samples.

Let ( xInt$_L$, yInt$_L$ ) be a luma location given in full-sample units and ( xFrac$_L$, yFrac$_L$ ) be an offset given in quarter-sample units. These variables are used only inside this subclause for specifying general fractional-sample locations inside the reference sample arrays refPicLX$_L$, refPicLX$_{Cb}$ (if available), and refPicLX$_{Cr}$ (if available).

For each luma sample location ( 0 <= x$_L$ < partWidth, 0 <= y$_L$ < partHeight ) inside the prediction luma sample array predPartLX$_L$, the corresponding prediction luma sample value predPartLX$_L$[ x$_L$, y$_L$ ] is derived as follows:

– The variables xInt$_L$, yInt$_L$, xFrac$_L$, and yFrac$_L$ are derived by

$$xInt_L = xA_L + ( mvLX[ 0 ] >> 2 ) + x_L \quad (8\text{-}228)$$
$$yInt_L = yA_L + ( mvLX[ 1 ] >> 2 ) + y_L \quad (8\text{-}229)$$

$$xFrac_L = mvLX[ 0 ] \& 3 \quad (8\text{-}230)$$
$$yFrac_L = mvLX[ 1 ] \& 3 \quad (8\text{-}231)$$

– The prediction luma sample value predPartLX$_L$[ x$_L$, y$_L$ ] is derived by invoking the process specified in subclause 8.4.2.2.1 with ( xInt$_L$, yInt$_L$ ), ( xFrac$_L$, yFrac$_L$ ) and refPicLX$_L$ given as input.

When ChromaArrayType is not equal to 0, the following applies.

Let ( xInt$_C$, yInt$_C$ ) be a chroma location given in full-sample units and ( xFrac$_C$, yFrac$_C$ ) be an offset given in one-(4*SubWidthC)-th chroma-sample units horizontally and one-(4*SubHeightC)-th chroma-sample units vertically. These variables are used only inside this subclause for specifying general fractional-sample locations inside the reference sample arrays refPicLX$_{Cb}$, and refPicLX$_{Cr}$.

For each chroma sample location ( 0 <= x$_C$ < partWidthC, 0 <= y$_C$ < partHeightC ) inside the prediction chroma sample arrays predPartLX$_{Cb}$ and predPartLX$_{Cr}$, the corresponding prediction chroma sample values predPartLX$_{Cb}$[ x$_C$, y$_C$ ] and predPartLX$_{Cr}$[ x$_C$, y$_C$ ] are derived as follows:

– Depending on ChromaArrayType, the variables xInt$_C$, yInt$_C$, xFrac$_C$, and yFrac$_C$ are derived as follows.

  – If ChromaArrayType is equal to 1,

$$xInt_C = ( xA_L / SubWidthC ) + ( mvCLX[ 0 ] >> 3 ) + x_C \quad (8\text{-}232)$$
$$yInt_C = ( yA_L / SubHeightC ) + ( mvCLX[ 1 ] >> 3 ) + y_C \quad (8\text{-}233)$$

$$xFrac_C = mvCLX[ 0 ] \& 7 \quad (8\text{-}234)$$
$$yFrac_C = mvCLX[ 1 ] \& 7 \quad (8\text{-}235)$$

  – Otherwise, if ChromaArrayType is equal to 2,

$$xInt_C = ( xA_L / SubWidthC ) + ( mvCLX[ 0 ] >> 3 ) + x_C \quad (8\text{-}236)$$
$$yInt_C = ( yA_L / SubHeightC ) + ( mvCLX[ 1 ] >> 2 ) + y_C \quad (8\text{-}237)$$

$$xFrac_C = mvCLX[ 0 ] \& 7 \quad (8\text{-}238)$$
$$yFrac_C = ( mvCLX[ 1 ] \& 3 ) << 1 \quad (8\text{-}239)$$

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– Otherwise (ChromaArrayType is equal to 3),

$$xInt_C = xA_L + ( mvLX[ 0 ] >> 2 ) + x_C \quad (8\text{-}240)$$
$$yInt_C = yA_L + ( mvLX[ 1 ] >> 2 ) + y_C \quad (8\text{-}241)$$

$$xFrac_C = ( mvCX[ 0 ] \& 3 ) \quad (8\text{-}242)$$
$$yFrac_C = ( mvCX[ 1 ] \& 3 ) \quad (8\text{-}243)$$

– Depending on ChromaArrayType, the following applies.

  – If ChromaArrayType is not equal to 3, the following applies.

    – The prediction sample value $predPartLX_{Cb}[ x_C, y_C ]$ is derived by invoking the process specified in subclause 8.4.2.2.2 with ( $xInt_C$, $yInt_C$ ), ( $xFrac_C$, $yFrac_C$ ) and $refPicLX_{Cb}$ given as input.

    – The prediction sample value $predPartLX_{Cr}[ x_C, y_C ]$ is derived by invoking the process specified in subclause 8.4.2.2.2 with ( $xInt_C$, $yInt_C$ ), ( $xFrac_C$, $yFrac_C$ ) and $refPicLX_{Cr}$ given as input.

  – Otherwise (ChromaArrayType is equal to 3), the following applies.

    – The prediction sample value $predPartLX_{Cb}[ x_C, y_C ]$ is derived by invoking the process specified in subclause 8.4.2.2.1 with ( $xInt_C$, $yInt_C$ ), ( $xFrac_C$, $yFrac_C$ ) and $refPicLX_{Cb}$ given as input.

    – The prediction sample value $predPartLX_{Cr}[ x_C, y_C ]$ is derived by invoking the process specified in subclause 8.4.2.2.1 with ( $xInt_C$, $yInt_C$ ), ( $xFrac_C$, $yFrac_C$ ) and $refPicLX_{Cr}$ given as input.

#### 8.4.2.2.1 Luma sample interpolation process

Inputs to this process are

– a luma location in full-sample units ( $xInt_L$, $yInt_L$ ),

– a luma location offset in fractional-sample units ( $xFrac_L$, $yFrac_L$ ), and

– the luma sample array of the selected reference picture $refPicLX_L$

Output of this process is a predicted luma sample value $predPartLX_L[ x_L, y_L ]$.

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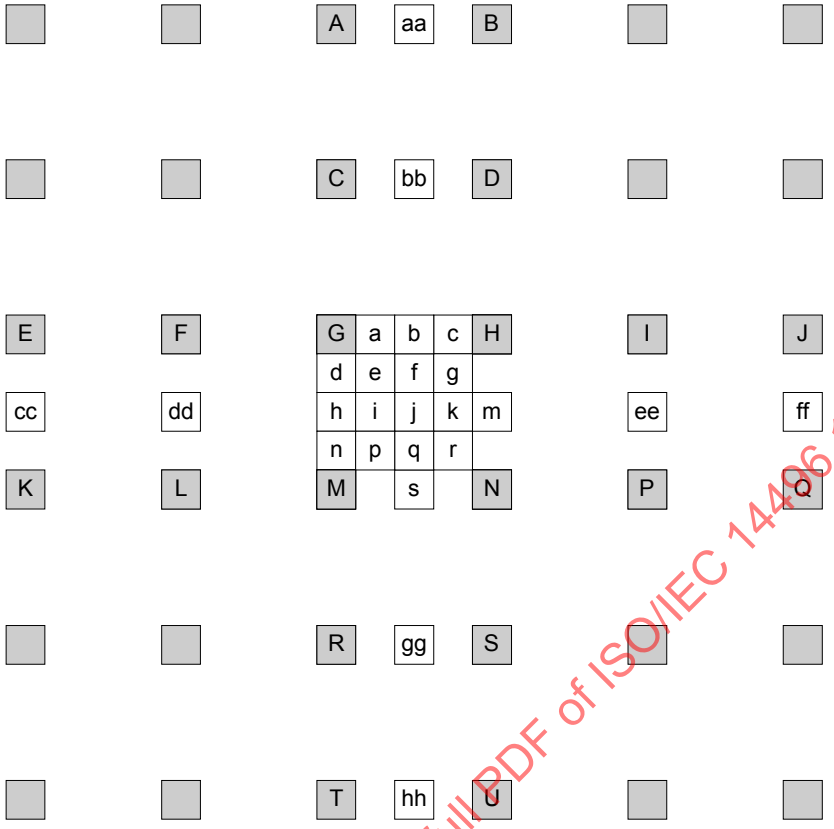


**Figure 8-4 – Integer samples (shaded blocks with upper-case letters) and fractional sample positions (un-shaded blocks with lower-case letters) for quarter sample luma interpolation**

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The variable $refPicHeightEffective_L$, which is the height of the effective reference picture luma array, is derived as follows.

– If MbaffFrameFlag is equal to 0 or mb_field_decoding_flag is equal to 0, $refPicHeightEffective_L$ is set equal to $PicHeightInSamples_L$.

– Otherwise (MbaffFrameFlag is equal to 1 and mb_field_decoding_flag is equal to 1), $refPicHeightEffective_L$ is set equal to $PicHeightInSamples_L$ / 2.

In Figure 8-4, the positions labelled with upper-case letters within shaded blocks represent luma samples at full-sample locations inside the given two-dimensional array $refPicLX_L$ of luma samples. These samples may be used for generating the predicted luma sample value $predPartLX_L[ x_L, y_L ]$. The locations ( $xZ_L$, $yZ_L$ ) for each of the corresponding luma samples Z, where Z may be A, B, C, D, E, F, G, H, I, J, K, L, M, N, P, Q, R, S, T, or U, inside the given array $refPicLX_L$ of luma samples are derived as follows:

$$xZ_L = Clip3( 0, PicWidthInSamples_L - 1, xInt_L + xDZ_L )$$
$$yZ_L = Clip3( 0, refPicHeightEffective_L - 1, yInt_L + yDZ_L ) \quad (8\text{-}244)$$

Table 8-11 specifies ( $xDZ_L$, $yDZ_L$ ) for different replacements of Z.

**Table 8-11 – Differential full-sample luma locations**

| Z | A | B | C | D | E | F | G | H | I | J | K | L | M | N | P | Q | R | S | T | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $xDZ_L$ | 0 | 1 | 0 | 1 | -2 | -1 | 0 | 1 | 2 | 3 | -2 | -1 | 0 | 1 | 2 | 3 | 0 | 1 | 0 | 1 |
| $yDZ_L$ | -2 | -2 | -1 | -1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 |

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Given the luma samples ‘A’ to ‘U’ at full-sample locations ( $xA_L$, $yA_L$ ) to ( $xU_L$, $yU_L$ ), the luma samples ‘a’ to ‘s’ at fractional sample positions are derived by the following rules. The luma prediction values at half sample positions are derived by applying a 6-tap filter with tap values ( 1, -5, 20, 20, -5, 1 ). The luma prediction values at quarter sample positions are derived by averaging samples at full and half sample positions. The process for each fractional position is described below.

– The samples at half sample positions labelled b are derived by first calculating intermediate values denoted as $b_1$ by applying the 6-tap filter to the nearest integer position samples in the horizontal direction. The samples at half sample positions labelled h are derived by first calculating intermediate values denoted as $h_1$ by applying the 6-tap filter to the nearest integer position samples in the vertical direction:

$$b_1 = ( E - 5 * F + 20 * G + 20 * H - 5 * I + J ) \quad (8\text{-}245)$$
$$h_1 = ( A - 5 * C + 20 * G + 20 * M - 5 * R + T ) \quad (8\text{-}246)$$

The final prediction values b and h are derived using:

$$b = Clip1_Y( ( b_1 + 16 ) >> 5 ) \quad (8\text{-}247)$$
$$h = Clip1_Y( ( h_1 + 16 ) >> 5 ) \quad (8\text{-}248)$$

– The samples at half sample position labelled as j are derived by first calculating intermediate value denoted as $j_1$ by applying the 6-tap filter to the intermediate values of the closest half sample positions in either the horizontal or vertical direction because these yield an equal result.

$$j_1 = cc - 5 * dd + 20 * h_1 + 20 * m_1 - 5 * ee + ff, \text{ or} \quad (8\text{-}249)$$
$$j_1 = aa - 5 * bb + 20 * b_1 + 20 * s_1 - 5 * gg + hh \quad (8\text{-}250)$$

where intermediate values denoted as aa, bb, gg, $s_1$ and hh are derived by applying the 6-tap filter horizontally in the same manner as the derivation of $b_1$ and intermediate values denoted as cc, dd, ee, $m_1$ and ff are derived by applying the 6-tap filter vertically in the same manner as the derivation of $h_1$. The final prediction value j are derived using:

$$j = Clip1_Y( ( j_1 + 512 ) >> 10 ) \quad (8\text{-}251)$$

– The final prediction values s and m are derived from $s_1$ and $m_1$ in the same manner as the derivation of b and h, as given by:

$$s = Clip1_Y( ( s_1 + 16 ) >> 5 ) \quad (8\text{-}252)$$
$$m = Clip1_Y( ( m_1 + 16 ) >> 5 ) \quad (8\text{-}253)$$

– The samples at quarter sample positions labelled as a, c, d, n, f, i, k, and q are derived by averaging with upward rounding of the two nearest samples at integer and half sample positions using:

$$a = ( G + b + 1 ) >> 1 \quad (8\text{-}254)$$
$$c = ( H + b + 1 ) >> 1 \quad (8\text{-}255)$$
$$d = ( G + h + 1 ) >> 1 \quad (8\text{-}256)$$
$$n = ( M + h + 1 ) >> 1 \quad (8\text{-}257)$$
$$f = ( b + j + 1 ) >> 1 \quad (8\text{-}258)$$
$$i = ( h + j + 1 ) >> 1 \quad (8\text{-}259)$$
$$k = ( j + m + 1 ) >> 1 \quad (8\text{-}260)$$
$$q = ( j + s + 1 ) >> 1. \quad (8\text{-}261)$$

– The samples at quarter sample positions labelled as e, g, p, and r are derived by averaging with upward rounding of the two nearest samples at half sample positions in the diagonal direction using

$$e = ( b + h + 1 ) >> 1 \quad (8\text{-}262)$$
$$g = ( b + m + 1 ) >> 1 \quad (8\text{-}263)$$
$$p = ( h + s + 1 ) >> 1 \quad (8\text{-}264)$$
$$r = ( m + s + 1 ) >> 1. \quad (8\text{-}265)$$

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The luma location offset in fractional-sample units ( $xFrac_L$, $yFrac_L$ ) specifies which of the generated luma samples at full-sample and fractional-sample locations is assigned to the predicted luma sample value $predPartLX_L[ x_L, y_L ]$. This assignment is done according to Table 8-12. The value of $predPartLX_L[ x_L, y_L ]$ is the output.

**Table 8-12 – Assignment of the luma prediction sample $predPartLX_L[ x_L, y_L ]$**

| $xFrac_L$ | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $yFrac_L$ | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 | 0 | 1 | 2 | 3 |
| $predPartLX_L[ x_L, y_L ]$ | G | d | h | n | a | e | i | p | b | f | j | q | c | g | k | r |

#### 8.4.2.2.2 Chroma sample interpolation process

This process is only invoked when ChromaArrayType is equal to 1 or 2.

Inputs to this process are

– a chroma location in full-sample units ( $xInt_C$, $yInt_C$ ),

– a chroma location offset in fractional-sample units ( $xFrac_C$, $yFrac_C$ ), and

– chroma component samples from the selected reference picture $refPicLX_C$.

Output of this process is a predicted chroma sample value $predPartLX_C[ x_C, y_C ]$.

In Figure 8-5, the positions labelled with A, B, C, and D represent chroma samples at full-sample locations inside the given two-dimensional array $refPicLX_C$ of chroma samples.

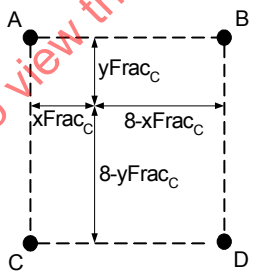


**Figure 8-5 – Fractional sample position dependent variables in chroma interpolation and surrounding integer position samples A, B, C, and D**

The variable $refPicHeightEffective_C$, which is the height of the effective reference picture chroma array, is derived as follows.

– If MbaffFrameFlag is equal to 0 or mb_field_decoding_flag is equal to 0, $refPicHeightEffective_C$ is set equal to $PicHeightInSamples_C$.

– Otherwise (MbaffFrameFlag is equal to 1 and mb_field_decoding_flag is equal to 1), $refPicHeightEffective_C$ is set equal to $PicHeightInSamples_C$ / 2.

The sample coordinates specified in Equations 8-266 through 8-273 are used for generating the predicted chroma sample value $predPartLX_C[ x_C, y_C ]$.

$$xA_C = Clip3( 0, PicWidthInSamples_C - 1, xInt_C ) \quad (8\text{-}266)$$
$$xB_C = Clip3( 0, PicWidthInSamples_C - 1, xInt_C + 1 ) \quad (8\text{-}267)$$
$$xC_C = Clip3( 0, PicWidthInSamples_C - 1, xInt_C ) \quad (8\text{-}268)$$
$$xD_C = Clip3( 0, PicWidthInSamples_C - 1, xInt_C + 1 ) \quad (8\text{-}269)$$

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$$yA_C = Clip3( 0, refPicHeightEffective_C - 1, yInt_C ) \quad (8\text{-}270)$$
$$yB_C = Clip3( 0, refPicHeightEffective_C - 1, yInt_C ) \quad (8\text{-}271)$$
$$yC_C = Clip3( 0, refPicHeightEffective_C - 1, yInt_C + 1 ) \quad (8\text{-}272)$$
$$yD_C = Clip3( 0, refPicHeightEffective_C - 1, yInt_C + 1 ) \quad (8\text{-}273)$$

Given the chroma samples A, B, C, and D at full-sample locations specified in Equations 8-266 through 8-273, the predicted chroma sample value $predPartLX_C[ x_C, y_C ]$ is derived as follows:

$$predPartLX_C[ x_C, y_C ] = ( ( 8 - xFrac_C ) * ( 8 - yFrac_C ) * A + xFrac_C * ( 8 - yFrac_C ) * B + ( 8 - xFrac_C ) * yFrac_C * C + xFrac_C * yFrac_C * D + 32 ) >> 6 \quad (8\text{-}274)$$

### 8.4.2.3 Weighted sample prediction process

Inputs to this process are

- mbPartIdx: the current partition given by the partition index
- subMbPartIdx: the sub-macroblock partition index
- predFlagL0 and predFlagL1: prediction list utilization flags
- $predPartLX_L$: a (partWidth)x(partHeight) array of prediction luma samples (with LX being replaced by L0 or L1 depending on predFlagL0 and predFlagL1)
- when ChromaArrayType is not equal to 0, $predPartLX_{Cb}$ and $predPartLX_{Cr}$: (partWidthC)x(partHeightC) arrays of prediction chroma samples, one for each of the chroma components Cb and Cr (with LX being replaced by L0 or L1 depending on predFlagL0 and predFlagL1)
- variables for weighted prediction $logWD_C$, $w_{0C}$, $w_{1C}$, $o_{0C}$, $o_{1C}$ with C being replaced by L and, when ChromaArrayType is not equal to 0, Cb and Cr

Outputs of this process are

- $predPart_L$: a (partWidth)x(partHeight) array of prediction luma samples and
- when ChromaArrayType is not equal to 0, $predPart_{Cb}$, and $predPart_{Cr}$: (partWidthC)x(partHeightC) arrays of prediction chroma samples, one for each of the chroma components Cb and Cr.

For macroblocks or partitions with predFlagL0 equal to 1 in P and SP slices, the following applies.

- If weighted_pred_flag is equal to 0, the default weighted sample prediction process as described in subclause 8.4.2.3.1 is invoked with the same inputs and outputs as the process described in this subclause.
- Otherwise (weighted_pred_flag is equal to 1), the explicit weighted prediction process as described in subclause 8.4.2.3.2 is invoked with the same inputs and outputs as the process described in this subclause.

For macroblocks or partitions with predFlagL0 or predFlagL1 equal to 1 in B slices, the following applies.

- If weighted_bipred_idc is equal to 0, the default weighted sample prediction process as described in subclause 8.4.2.3.1 is invoked with the same inputs and outputs as the process described in this subclause.
- Otherwise, if weighted_bipred_idc is equal to 1, the explicit weighted sample prediction process as described in subclause 8.4.2.3.2, for macroblocks or partitions with predFlagL0 or predFlagL1 equal to 1 with the same inputs and outputs as the process described in this subclause.
- Otherwise (weighted_bipred_idc is equal to 2), the following applies.
  - If predFlagL0 is equal to 1 and predFlagL1 is equal to 1, the implicit weighted sample prediction as described in subclause 8.4.2.3.2 is invoked with the same inputs and outputs as the process described in this subclause.
  - Otherwise (predFlagL0 or predFlagL1 are equal to 1 but not both), the default weighted sample prediction process as described in subclause 8.4.2.3.1 is invoked with the same inputs and outputs as the process described in this subclause.

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#### 8.4.2.3.1 Default weighted sample prediction process

Input to this process are the same as specified in subclause 8.4.2.3.

Output of this process are the same as specified in subclause 8.4.2.3.

Depending on the available component for which the prediction block is derived, the following applies.

– If the luma sample prediction values $predPart_L[ x, y ]$ are derived, the following applies with C set equal to L, x set equal to 0 .. partWidth - 1, and y set equal to 0 .. partHeight - 1.

– Otherwise, if the chroma Cb component sample prediction values $predPart_{Cb}[ x, y ]$ are derived, the following applies with C set equal to Cb, x set equal to 0 .. partWidthC - 1, and y set equal to 0 .. partHeightC - 1.

– Otherwise (the chroma Cr component sample prediction values $predPart_{Cr}[ x, y ]$ are derived), the following applies with C set equal to Cr, x set equal to 0 .. partWidthC - 1, and y set equal to 0 .. partHeightC - 1.

The prediction sample values are derived as follows.

– If predFlagL0 is equal to 1 and predFlagL1 is equal to 0

$$predPart_C[ x, y ] = predPartL0_C[ x, y ] \quad (8\text{-}275)$$

– Otherwise, if predFlagL0 is equal to 0 and predFlagL1 is equal to 1

$$predPart_C[ x, y ] = predPartL1_C[ x, y ] \quad (8\text{-}276)$$

– Otherwise (predFlagL0 and predFlagL1 are equal to 1),

$$predPart_C[ x, y ] = ( predPartL0_C[ x, y ] + predPartL1_C[ x, y ] + 1 ) >> 1. \quad (8\text{-}277)$$

#### 8.4.2.3.2 Weighted sample prediction process

Input to this process are the same as specified in subclause 8.4.2.3.

Output of this process are the same as specified in subclause 8.4.2.3.

Depending on the available component for which the prediction block is derived, the following applies.

– If the luma sample prediction values $predPart_L[ x, y ]$ are derived, the following applies with C set equal to L, x set equal to 0 .. partWidth - 1, and y set equal to 0 .. partHeight - 1.

– Otherwise, if the chroma Cb component sample prediction values $predPart_{Cb}[ x, y ]$ are derived, the following applies with C set equal to Cb, x set equal to 0 .. partWidthC - 1, and y set equal to 0 .. partHeightC - 1.

– Otherwise (the chroma Cr component sample prediction values $predPart_{Cr}[ x, y ]$ are derived), the following applies with C set equal to Cr, x set equal to 0 .. partWidthC - 1, and y set equal to 0 .. partHeightC - 1.

The prediction sample values are derived as follows

– If the predFlagL0 is equal to 1 and predFlagL1 is equal to 0, the final predicted sample values $predPart_C[ x, y ]$ are derived by

$$\begin{aligned} &\text{if}( logWD_C >= 1 ) \\ &\quad predPart_C[ x, y ] = Clip1_C( ( ( predPartL0_C[ x, y ] * w_{0C} + 2^{logWD_C - 1} ) >> logWD_C ) + o_{0C} ) \\ &\text{else} \\ &\quad predPart_C[ x, y ] = Clip1_C( predPartL0_C[ x, y ] * w_{0C} + o_{0C} ) \end{aligned} \quad (8\text{-}278)$$

– Otherwise, if the predFlagL0 is equal to 0 and predFlagL1 is equal to 1, the final predicted sample values $predPart_C[ x, y ]$ are derived by

$$\begin{aligned} &\text{if}( logWD_C >= 1 ) \\ &\quad predPart_C[ x, y ] = Clip1_C( ( ( predPartL1_C[ x, y ] * w_{1C} + 2^{logWD_C - 1} ) >> logWD_C ) + o_{1C} ) \end{aligned}$$

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else (8-279)

$predPart_C[ x, y ] = Clip1_C( predPartL1_C[ x, y ] * w_{1C} + o_{1C} )$

– Otherwise (both predFlagL0 and predFlagL1 are equal to 1), the final predicted sample values $predPart_C[ x, y ]$ are derived by

$$predPart_C[ x, y ] = Clip1_C( ( ( predPartL0_C[ x, y ] * w_{0C} + predPartL1_C[ x, y ] * w_{1C} + 2^{logWD_C} ) >> ( logWD_C + 1 ) ) + ( ( o_{0C} + o_{1C} + 1 ) >> 1 ) ) \quad (8\text{-}280)$$

### 8.4.3 Derivation process for prediction weights

Inputs to this process are

– the reference indices refIdxL0 and refIdxL1

– the prediction utilization flags predFlagL0 and predFlagL1

Outputs of this process are

– variables for weighted prediction $logWD_C$, $w_{0C}$, $w_{1C}$, $o_{0C}$, $o_{1C}$ with C being replaced by L and, when ChromaArrayType is not equal to 0, Cb and Cr

For C being replaced by L and, when ChromaArrayType is not equal to 0, Cb and Cr, the variables $logWD_C$, $w_{0C}$, $w_{1C}$, $o_{0C}$, $o_{1C}$ are derived as follows.

– If weighted_bipred_idc is equal to 2 and the (slice_type % 5) is equal to 1, implicit mode weighted prediction is used as follows.

$logWD_C = 5$ (8-281)

$o_{0C} = 0$ (8-282)

$o_{1C} = 0$ (8-283)

and $w_{0C}$ and $w_{1C}$ are derived as follows.

– The variables currPicOrField, pic0, and pic1 are derived as follows:

  – If field_pic_flag is equal to 0 and the current macroblock is a field macroblock, the following applies.

    – currPicOrField is the field of the current picture CurrPic that has the same parity as the current macroblock.

    – The variable pic0 is derived as follows.

      If refIdxL0 % 2 is equal to 0, pic0 is the field of RefPicList0[ refIdxL0 / 2 ] that has the same parity as the current macroblock.

      – Otherwise (refIdxL0 % 2 is not equal to 0), pic0 is the field of RefPicList0[ refIdxL0 / 2 ] that has the opposite parity of the current macroblock.

    – The variable pic1 is derived as follows.

      – If refIdxL1 % 2 is equal to 0, pic1 is the field of RefPicList1[ refIdxL1 / 2 ] that has the same parity as the current macroblock.

      – Otherwise (refIdxL1 % 2 is not equal to 0), pic1 is the field of RefPicList1[ refIdxL1 / 2 ] that has the opposite parity of the current macroblock.

  – Otherwise (field_pic_flag is equal to 1 or the current macroblock is a frame macroblock), currPicOrField is the current picture CurrPic, pic1 is RefPicList1[ refIdxL1 ], and pic0 is RefPicList0[ refIdxL0 ].

– The variables tb, td, tx, and DistScaleFactor are derived from the values of currPicOrField, pic0, pic1 using Equations 8-206, 8-207, 8-202, and 8-203, respectively.

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– If DiffPicOrderCnt( pic1, pic0 ) is equal to 0 or one or both of pic1 and pic0 is marked as "used for long-term reference" or ( DistScaleFactor >> 2 ) < -64 or ( DistScaleFactor >> 2 ) > 128, $w_{0C}$ and $w_{1C}$ are derived as

$$w_{0C} = 32 \quad (8\text{-}284)$$

$$w_{1C} = 32 \quad (8\text{-}285)$$

- Otherwise,

$$w_{0C} = 64 - (\text{DistScaleFactor} >> 2) \quad (8\text{-}286)$$

$$w_{1C} = \text{DistScaleFactor} >> 2 \quad (8\text{-}287)$$

– Otherwise (weighted_pred_flag is equal to 1 in slices with (slice_type % 5) equal to 0 or 3 or weighted_bipred_idc equal to 1 in slices with (slice_type % 5) equal to 1), explicit mode weighted prediction is used as follows.

– The variables refIdxL0WP and refIdxL1WP are derived as follows.

– If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock

$$\text{refIdxL0WP} = \text{refIdxL0} >> 1 \quad (8\text{-}288)$$

$$\text{refIdxL1WP} = \text{refIdxL1} >> 1 \quad (8\text{-}289)$$

– Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock),

$$\text{refIdxL0WP} = \text{refIdxL0} \quad (8\text{-}290)$$

$$\text{refIdxL1WP} = \text{refIdxL1} \quad (8\text{-}291)$$

– The variables $\text{logWD}_C$, $w_{0C}$, $w_{1C}$, $o_{0C}$, and $o_{1C}$ are derived as follows.

– If C is equal to L for luma samples

$$\text{logWD}_C = \text{luma_log2_weight_denom} \quad (8\text{-}292)$$

$$w_{0C} = \text{luma_weight_l0[ refIdxL0WP ]} \quad (8\text{-}293)$$

$$w_{1C} = \text{luma_weight_l1[ refIdxL1WP ]} \quad (8\text{-}294)$$

$$o_{0C} = \text{luma_offset_l0[ refIdxL0WP ]} * ( 1 << ( \text{BitDepth}_Y - 8 ) ) \quad (8\text{-}295)$$

$$o_{1C} = \text{luma_offset_l1[ refIdxL1WP ]} * ( 1 << ( \text{BitDepth}_Y - 8 ) ) \quad (8\text{-}296)$$

– Otherwise (C is equal to Cb or Cr for chroma samples, with iCbCr = 0 for Cb, iCbCr = 1 for Cr),

$$\text{logWD}_C = \text{chroma_log2_weight_denom} \quad (8\text{-}297)$$

$$w_{0C} = \text{chroma_weight_l0[ refIdxL0WP ][ iCbCr ]} \quad (8\text{-}298)$$

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$$w_{1C} = \text{chroma_weight_l1[ refIdxL1WP ][ iCbCr ]} \quad (8\text{-}299)$$

$$o_{0C} = \text{chroma_offset_l0[ refIdxL0WP ][ iCbCr ]} * ( 1 << ( \text{BitDepth}_C - 8 ) ) \quad (8\text{-}300)$$

$$o_{1C} = \text{chroma_offset_l1[ refIdxL1WP ][ iCbCr ]} * ( 1 << ( \text{BitDepth}_C - 8 ) ) \quad (8\text{-}301)$$

When explicit mode weighted prediction is used and predFlagL0 and predFlagL1 are equal to 1, the following constraint shall be obeyed for C equal to L and, when ChromaArrayType is not equal to 0, Cb and Cr

$$-128 <= w_{0C} + w_{1C} <= ( ( \text{logWD}_C == 7 ) ? 127 : 128 ) \quad (8\text{-}302)$$

NOTE – For implicit mode weighted prediction, weights $w_{0C}$ and $w_{1C}$ are each guaranteed to be in the range of -64..128 and the constraint expressed in Equation 8-302, although not explicitly imposed, will always be met. For explicit mode weighted prediction with $\text{logWD}_C$ equal to 7, when one of the two weights $w_{0C}$ or $w_{1C}$ is inferred to be equal to 128 (as a consequence of luma_weight_l0_flag, luma_weight_l1_flag, chroma_weight_l0_flag, or chroma_weight_l1_flag equal to 0), the other weight ($w_{1C}$ or $w_{0C}$) must have a negative value in order for the constraint expressed in Equation 8-302 to hold (and therefore the other flag luma_weight_l0_flag, luma_weight_l1_flag, chroma_weight_l0_flag, or chroma_weight_l1_flag must be equal to 1).

## 8.5 Transform coefficient decoding process and picture construction process prior to deblocking filter process

Inputs to this process are Intra16x16DCLevel (if available), Intra16x16ACLevel (if available), CbIntra16x16DCLevel (if available), CbIntra16x16ACLevel (if available), CrIntra16x16DCLevel (if available), CrIntra16x16ACLevel (if available), LumaLevel (if available), LumaLevel8x8 (if available), ChromaDCLevel (if available), ChromaACLevel (if available), CbLevel (if available), CrLevel (if available), CbLevel8x8 (if available), CrLevel8x8 (if available), and available Inter or Intra prediction sample arrays for the current macroblock for the applicable components $\text{pred}_L$, $\text{pred}_{Cb}$, or $\text{pred}_{Cr}$.

NOTE 1 – When decoding a macroblock in Intra_4x4 (or Intra_8x8) prediction mode, the luma component of the macroblock prediction array may not be complete, since for each 4x4 (or 8x8) luma block, the Intra_4x4 (or Intra_8x8) prediction process for luma samples as specified in subclause 8.3.1 (or 8.3.2) and the process specified in this subclause are iterated. When ChromaArrayType is equal to 3, the Cb and Cr component of the macroblock prediction array may not be complete for the same reason.

Outputs of this process are the constructed sample arrays prior to the deblocking filter process for the applicable components $S'_L$, $S'_{Cb}$, or $S'_{Cr}$.

NOTE 2 – When decoding a macroblock in Intra_4x4 (or Intra_8x8) prediction mode, the luma component of the macroblock constructed sample arrays prior to the deblocking filter process may not be complete, since for each 4x4 (or 8x8) luma block, the Intra_4x4 (or Intra_8x8) prediction process for luma samples as specified in subclause 8.3.1 (or 8.3.2) and the process specified in this subclause are iterated. When ChromaArrayType is equal to 3, the Cb and Cr component of the macroblock constructed sample arrays prior to the deblocking filter process may not be complete for the same reason.

This subclause specifies transform coefficient decoding and picture construction prior to the deblocking filter process.

When the current macroblock is coded as P_Skip or B_Skip, all values of LumaLevel, LumaLevel8x8, CbLevel, CbLevel8x8, CrLevel, CrLevel8x8, ChromaDCLevel, ChromaACLevel are set equal to 0 for the current macroblock.

### 8.5.1 Specification of transform decoding process for 4x4 luma residual blocks

This specification applies when transform_size_8x8_flag is equal to 0.

When the current macroblock prediction mode is not equal to Intra_16x16, the variable LumaLevel contains the levels for the luma transform coefficients. For a 4x4 luma block indexed by luma4x4BlkIdx = 0..15, the following ordered steps are specified.

1. The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with LumaLevel[ luma4x4BlkIdx ] as the input and the two-dimensional array c as the output.
2. The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c as the input and r as the output.

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3. When qpprime_y_zero_transform_bypass_flag is equal to 1, $QP'_Y$ is equal to 0, the macroblock prediction mode is equal to Intra_4x4, and Intra4x4PredMode[ luma4x4BlkIdx ] is equal to 0 or 1, the intra residual transform-bypass decoding process as specified in subclause 8.5.14 is invoked with nW set equal to 4, nH set equal to 4, horPredFlag set equal to Intra4x4PredMode[ luma4x4BlkIdx ], and the 4x4 array r as the inputs, and the output is a modified version of the 4x4 array r.
4. The position of the upper-left sample of a 4x4 luma block with index luma4x4BlkIdx inside the macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to ( xO, yO ).
5. The 4x4 array u with elements $u_{ij}$ for i, j = 0..3 is derived as

$$u_{ij} = Clip1_Y( pred_L[ xO + j, yO + i ] + r_{ij} ) \quad (8\text{-}303)$$

When qpprime_y_zero_transform_bypass_flag is equal to 1 and $QP'_Y$ is equal to 0, the bitstream shall not contain data that result in a value of $u_{ij}$ as computed by Equation 8-303 that is not equal to $pred_L[ xO + j, yO + i ] + r_{ij}$.

6. The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with u and luma4x4BlkIdx as the inputs.

### 8.5.2 Specification of transform decoding process for luma samples of Intra_16x16 macroblock prediction mode

When the current macroblock prediction mode is equal to Intra_16x16, the variables Intra16x16DCLevel and Intra16x16ACLevel contain the levels for the luma transform coefficients. The transform coefficient decoding proceeds in the following ordered steps:

1. The 4x4 luma DC transform coefficients of all 4x4 luma blocks of the macroblock are decoded.
   a. The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with Intra16x16DCLevel as the input and the two-dimensional array c as the output.
   b. The scaling and transformation process for luma DC transform coefficients for Intra_16x16 macroblock type as specified in subclause 8.5.9 is invoked with $BitDepth_Y$, $QP'_Y$, and c as the input and dcY as the output.
2. The 16x16 array rMb is derived by processing the 4x4 luma blocks indexed by luma4x4BlkIdx = 0..15, and for each 4x4 luma block, the following ordered steps are specified.
   a. The variable lumaList, which is a list of 16 entries, is derived. The first entry of lumaList is the corresponding value from the array dcY. Figure 8-6 shows the assignment of the indices of the array dcY to the luma4x4BlkIdx. The two numbers in the small squares refer to indices i and j in $dcY_{ij}$, and the numbers in large squares refer to luma4x4BlkIdx.

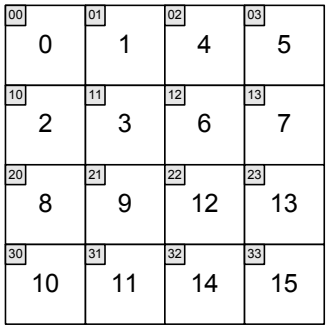


**Figure 8-6 – Assignment of the indices of dcY to luma4x4BlkIdx**

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The elements in lumaList with index k = 1..15 are specified as

lumaList[ k ] = Intra16x16ACLevel[ luma4x4BlkIdx ][ k - 1 ] (8-304)

b. The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with lumaList as the input and the two-dimensional array c as the output.

c. The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c as the input and r as the output.

d. The position of the upper-left sample of a 4x4 luma block with index luma4x4BlkIdx inside the macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to ( xO, yO ).

e. The elements rMb[ x, y ] of the 16x16 array rMb with x = xO..xO + 3 and y = yO..yO + 3 are derived by

rMb[ xO + j, yO + i ] = $r_{ij}$ (8-305)

3. When qpprime_y_zero_transform_bypass_flag is equal to 1, $QP'_Y$ is equal to 0, and Intra16x16PredMode is equal to 0 or 1, the intra residual transform-bypass decoding process as specified in subclause 8.5.14 is invoked with nW set equal to 16, nH set equal to 16, horPredFlag set equal to Intra16x16PredMode, and the 16x16 array rMb as the inputs, and the output is a modified version of the 16x16 array rMb.

4. The 16x16 array u with elements $u_{ij}$ for i, j = 0..15 is derived as

$u_{ij} = Clip1_Y( pred_L[ j, i ] + rMb[ j, i ] )$ (8-306)

When qpprime_y_zero_transform_bypass_flag is equal to 1 and $QP'_Y$ is equal to 0, the bitstream shall not contain data that result in a value of $u_{ij}$ as computed by Equation 8-306 that is not equal to $pred_L[ j, i ] + rMb[ j, i ]$.

5. The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with u as the input.

### 8.5.3 Specification of transform decoding process for 8x8 luma residual blocks

This specification applies when transform_size_8x8_flag is equal to 1.

The variable LumaLevel8x8[ luma8x8BlkIdx ] with luma8x8BlkIdx = 0..3 contains the levels for the luma transform coefficients for the luma 8x8 block with index luma8x8BlkIdx.

For an 8x8 luma block indexed by luma8x8BlkIdx = 0..3, the following ordered steps are specified.

1. The inverse scanning process for 8x8 luma transform coefficients as described in subclause 8.5.7 is invoked with LumaLevel8x8[ luma8x8BlkIdx ] as the input and the two-dimensional array c as the output.

2. The scaling and transformation process for residual 8x8 blocks as specified in subclause 8.5.12 is invoked with c as the input and r as the output.

3. When qpprime_y_zero_transform_bypass_flag is equal to 1, $QP'_Y$ is equal to 0, the macroblock prediction mode is equal to Intra_8x8, and Intra8x8PredMode[ luma8x8BlkIdx ] is equal to 0 or 1, the intra residual transform-bypass decoding process as specified in subclause 8.5.14 is invoked with nW set equal to 8, nH set equal to 8, horPredFlag set equal to Intra8x8PredMode[ luma8x8BlkIdx ], and the 8x8 array r as the inputs, and the output is a modified version of the 8x8 array r.

4. The position of the upper-left sample of an 8x8 luma block with index luma8x8BlkIdx inside the macroblock is derived by invoking the inverse 8x8 luma block scanning process in subclause 6.4.5 with luma8x8BlkIdx as the input and the output being assigned to ( xO, yO ).

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5. The 8x8 array u with elements $u_{ij}$ for i, j = 0..7 is derived as

$$u_{ij} = Clip1_Y( pred_L[ xO + j, yO + i ] + r_{ij} ) \quad (8\text{-}307)$$

When qpprime_y_zero_transform_bypass_flag is equal to 1 and $QP'_Y$ is equal to 0, the bitstream shall not contain data that result in a value of $u_{ij}$ as computed by Equation 8-307 that is not equal to $pred_L[ xO + j, yO + i ] + r_{ij}$.

6. The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with u and luma8x8BlkIdx as the inputs.

### 8.5.4 Specification of transform decoding process for chroma samples

This process is invoked for each chroma component Cb and Cr separately when ChromaArrayType is not equal to 0.

Depending on ChromaArrayType, the following applies.

– If ChromaArrayType is equal to 3, the transform decoding process for chroma samples with ChromaArrayType equal to 3 as specified in subclause 8.5.5 is invoked.

– Otherwise (ChromaArrayType is not equal to 3), the following text specifies the transform decoding process for chroma samples.

For each chroma component, the variables ChromaDCLevel[ iCbCr ] and ChromaACLevel[ iCbCr ], with iCbCr set equal to 0 for Cb and iCbCr set equal to 1 for Cr, contain the levels for both components of the chroma transform coefficients.

Let the variable numChroma4x4Blks be set equal to (MbWidthC / 4) * (MbHeightC / 4).

For each chroma component, the transform decoding proceeds separately in the following ordered steps:

1. The numChroma4x4Blks chroma DC transform coefficients of the 4x4 chroma blocks of the component indexed by iCbCr of the macroblock are decoded.

   a. Depending on the variable ChromaArrayType, the following applies.

   – If ChromaArrayType is equal to 1, the 2x2 array c is derived using the inverse raster scanning process applied to ChromaDCLevel as follows

$$c = \begin{bmatrix} ChromaDCLevel[ iCbCr ][ 0 ] & ChromaDCLevel[ iCbCr ][ 1 ] \\ ChromaDCLevel[ iCbCr ][ 2 ] & ChromaDCLevel[ iCbCr ][ 3 ] \end{bmatrix} \quad (8\text{-}308)$$

   – Otherwise (ChromaArrayType is equal to 2), the 2x4 array c is derived using the inverse raster scanning process applied to ChromaDCLevel as follows

$$c = \begin{bmatrix} ChromaDCLevel[iCbCr][0] & ChromaDCLevel[iCbCr][2] \\ ChromaDCLevel[iCbCr][1] & ChromaDCLevel[iCbCr][5] \\ ChromaDCLevel[iCbCr][3] & ChromaDCLevel[iCbCr][6] \\ ChromaDCLevel[iCbCr][4] & ChromaDCLevel[iCbCr][7] \end{bmatrix} \quad (8\text{-}309)$$

   b. The scaling and transformation process for chroma DC transform coefficients as specified in subclause 8.5.10 is invoked with c as the input and dcC as the output.

2. The (MbWidthC)x(MbHeightC) array rMb is derived by processing the 4x4 chroma blocks indexed by chroma4x4BlkIdx = 0..numChroma4x4Blks – 1 of the component indexed by iCbCr, and for each 4x4 chroma block, the following ordered steps are specified.

   a. The variable chromaList, which is a list of 16 entries, is derived. The first entry of chromaList is the corresponding value from the array dcC. Figure 8-7 shows the assignment of the indices of the array dcC to the chroma4x4BlkIdx. The two numbers in the small squares refer to indices i and j in $dcC_{ij}$, and the numbers in large squares refer to chroma4x4BlkIdx.

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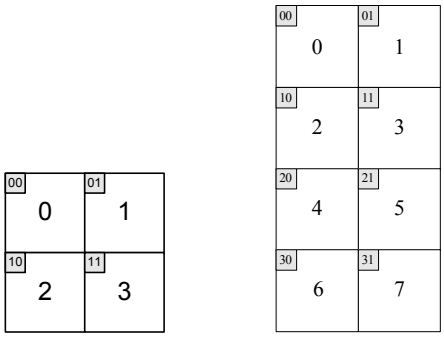


**Figure 8-7 – Assignment of the indices of dcC to chroma4x4BlkIdx: (a) ChromaArrayType equal to 1, (b) ChromaArrayType equal to 2**

The elements in chromaList with index k = 1..15 are specified as

$$chromaList[ k ] = ChromaACLevel[ chroma4x4BlkIdx ][ k - 1 ] \quad (8\text{-}310)$$

b. The inverse scanning process for transform coefficients as specified in subclause 8.5.10 is invoked with chromaList as the input and the two-dimensional array c as the output.

c. The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c as the input and r as the output.

d. The position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx inside the macroblock is derived by

$$xO = InverseRasterScan( chroma4x4BlkIdx, 4, 4, 8, 0 ) \quad (8\text{-}311)$$

$$yO = InverseRasterScan( chroma4x4BlkIdx, 4, 4, 8, 1 ) \quad (8\text{-}312)$$

e. The elements rMb[ x, y ] of the (MbWidthC)x(MbHeightC) array rMb with x = xO..xO + 3 and y = yO..yO + 3 are derived by

$$rMb[ xO + j, yO + i ] = r_{ij} \quad (8\text{-}313)$$

3. When qpprime_y_zero_transform_bypass_flag is equal to 1, $QP'_Y$ is equal to 0, the macroblock prediction mode is equal to Intra_4x4, Intra_8x8, or Intra_16x16, and intra_chroma_pred_mode is equal to 1 or 2, the intra residual transform-bypass decoding process as specified in subclause 8.5.14 is invoked with nW set equal to MbWidthC, nH set equal to MbHeightC, horPredFlag set equal to (intra_chroma_pred_mode – 1), and the (MbWidthC)x(MbHeightC) array rMb as the inputs, and the output is a modified version of the (MbWidthC)x(MbHeightC) array rMb.

4. The (MbWidthC)x(MbHeightC) array u with elements $u_{ij}$ for i = 0..MbHeight – 1 and j = 0..MbWidth – 1 is derived as

$$u_{ij} = Clip1_C( pred_C[ j, i ] + rMb[ j, i ] ) \quad (8\text{-}314)$$

When qpprime_y_zero_transform_bypass_flag is equal to 1 and $QP'_Y$ is equal to 0, the bitstream shall not contain data that result in a value of $u_{ij}$ as computed by Equation 8-314 that is not equal to $pred_C[ j, i ] + rMb[ j, i ]$.

5. The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with u as the input.

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### 8.5.5 Specification of transform decoding process for chroma samples with ChromaArrayType equal to 3

This process is invoked for each chroma component Cb and Cr separately when ChromaArrayType is equal to 3.

Depending on the macroblock prediction mode and transform_size_8x8_flag, the following applies.

– If the macroblock prediction mode is equal to Intra_16x16, the transform decoding process for Cb or Cr residual blocks shall be identical to the process described in subclause 8.5.2 when substituting luma with Cb or Cr, substituting Intra16x16DCLevel with CbIntra16x16DCLevel or CrIntra16x16DCLevel, substituting Intra16x16ACLevel with CbIntra16x16ACLevel or CrIntra16x16ACLevel, and substituting $pred_L$ with $pred_{Cb}$ or $pred_{Cr}$, substituting luma4x4BlkIdx with cb4x4BlkIdx or cr4x4BlkIdx, substituting lumaList with CbList or CrList, substituting $BitDepth_Y$ with $BitDepth_C$, substituting $QP'_Y$ with $QP'_C$, and substituting $Clip1_Y$ with $Clip1_C$.

– Otherwise, if transform_size_8x8_flag is equal to 1, the transform decoding process for 8x8 Cb or 8x8 Cr residual blocks shall be identical to the process described in subclause 8.5.3 when substituting luma with Cb or Cr, substituting LumaLevel8x8 with CbLevel8x8 or CrLevel8x8, substituting $pred_L$ with $pred_{Cb}$ or $pred_{Cr}$, substituting luma8x8BlkIdx with cb8x8BlkIdx or cr8x8BlkIdx, and substituting $Clip1_Y$ with $Clip1_C$.

– Otherwise (the macroblock prediction mode is not equal to Intra_16x16 and transform_size_8x8_flag is equal to 0), the transform decoding process for 4x4 Cb or 4x4 Cr residual blocks shall be identical to the process described in subclause 8.5.1 when substituting luma with Cb or Cr, substituting LumaLevel with CbLevel or CrLevel, substituting $pred_L$ with $pred_{Cb}$ or $pred_{Cr}$, substituting luma4x4BlkIdx with cb4x4BlkIdx or cr4x4BlkIdx, and substituting $Clip1_Y$ with $Clip1_C$. During the scaling of 4x4 block transform coefficient levels that is specified within subclause 8.5.11, which is invoked as part of the process specified in subclause 8.5.1, the input 4x4 array c is treated as not relating to a luma residual block coded using Intra_16x16 prediction mode and not relating to a chroma residual block.

### 8.5.6 Inverse scanning process for transform coefficients

Input to this process is a list of 16 values.

Output of this process is a variable c containing a two-dimensional array of 4x4 values. In the case of transform coefficients, these 4x4 values represent levels assigned to locations in the transform block. In the case of applying the inverse scanning process to a scaling list, the output variable c contains a two-dimensional array representing a 4x4 scaling matrix.

The inverse scanning process for transform coefficients maps the sequence of transform coefficient levels to the transform coefficient level positions. Table 8-13 specifies the two mappings: inverse zig-zag scan and inverse field scan. The inverse zig-zag scan is used for transform coefficients in frame macroblocks and the inverse field scan is used for transform coefficients in field macroblocks.

The inverse scanning process for scaling lists maps the sequence of scaling list entries to the positions in the corresponding scaling matrix. For this mapping, the inverse zig-zag scan is used.

Figure 8-8 illustrates the scans.

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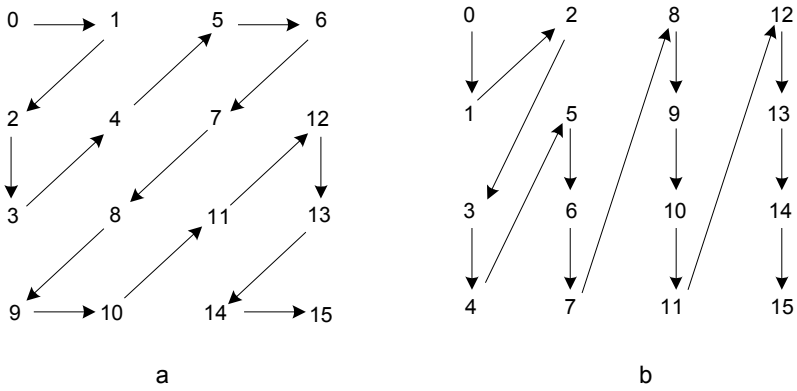


**Figure 8-8 – 4x4 block scans. (a) Zig-zag scan. (b) Field scan (informative)**

Table 8-13 provides the mapping from the index idx of input list of 16 elements to indices i and j of the two-dimensional array c.

**Table 8-13 – Specification of mapping of idx to $c_{ij}$ for zig-zag and field scan**

| idx | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| zig-zag | $c_{00}$ | $c_{01}$ | $c_{10}$ | $c_{20}$ | $c_{11}$ | $c_{02}$ | $c_{03}$ | $c_{12}$ | $c_{21}$ | $c_{30}$ | $c_{31}$ | $c_{22}$ | $c_{13}$ | $c_{23}$ | $c_{32}$ | $c_{33}$ |
| field | $c_{00}$ | $c_{10}$ | $c_{01}$ | $c_{20}$ | $c_{30}$ | $c_{11}$ | $c_{21}$ | $c_{31}$ | $c_{02}$ | $c_{12}$ | $c_{22}$ | $c_{32}$ | $c_{03}$ | $c_{13}$ | $c_{23}$ | $c_{33}$ |

### 8.5.7 Inverse scanning process for 8x8 transform coefficients

Input to this process is a list of 64 values.

Output of this process is a variable c containing a two-dimensional array of 8x8 values. In the case of transform coefficients, these 8x8 values represent levels assigned to locations in the transform block. In the case of applying the inverse scanning process to a scaling list, the output variable c contains a two-dimensional array representing an 8x8 scaling matrix.

The inverse scanning process for transform coefficients maps the sequence of transform coefficient levels to the transform coefficient level positions. Table 8-14 specifies the two mappings: inverse 8x8 zig-zag scan and inverse 8x8 field scan. The inverse 8x8 zig-zag scan is used for transform coefficients in frame macroblocks and the inverse 8x8 field scan is used for transform coefficients in field macroblocks.

The inverse scanning process for scaling lists maps the sequence of scaling list entries to the positions in the corresponding scaling matrix. For this mapping, the inverse zig-zag scan is used.

Figure 8-9 illustrates the scans.

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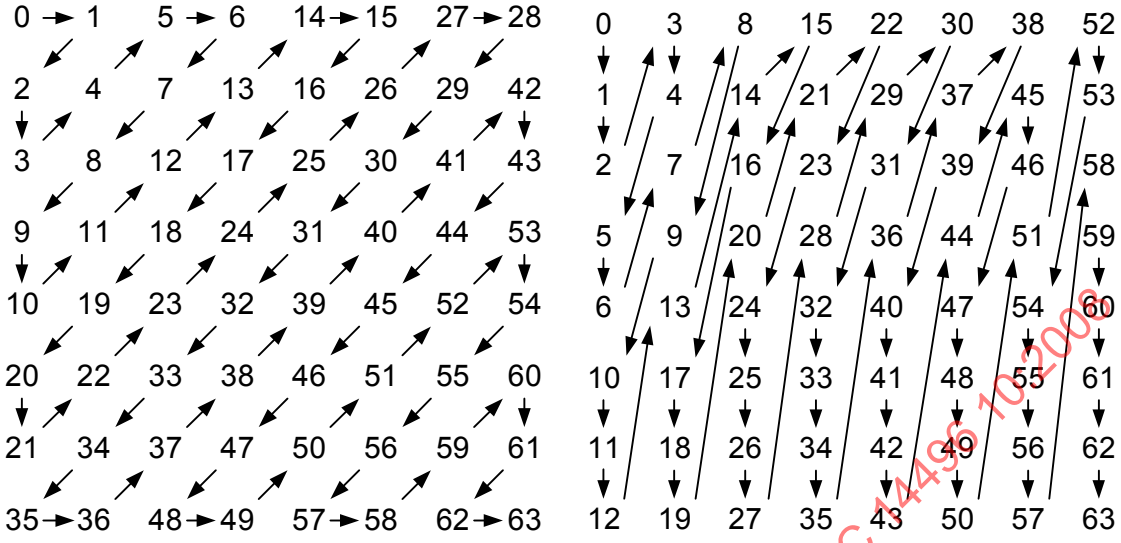


a b

**Figure 8-9 – 8x8 block scans. (a) 8x8 zig-zag scan. (b) 8x8 field scan (informative)**

Table 8-14 provides the mapping from the index idx of the input list of 64 elements to indices i and j of the two-dimensional array c.

**Table 8-14 – Specification of mapping of idx to $c_{ij}$ for 8x8 zig-zag and 8x8 field scan**

| idx | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| zig-zag | $c_{00}$ | $c_{01}$ | $c_{10}$ | $c_{20}$ | $c_{11}$ | $c_{02}$ | $c_{03}$ | $c_{12}$ | $c_{21}$ | $c_{30}$ | $c_{40}$ | $c_{31}$ | $c_{22}$ | $c_{13}$ | $c_{04}$ | $c_{05}$ |
| field | $c_{00}$ | $c_{10}$ | $c_{20}$ | $c_{01}$ | $c_{11}$ | $c_{30}$ | $c_{40}$ | $c_{21}$ | $c_{02}$ | $c_{31}$ | $c_{50}$ | $c_{60}$ | $c_{70}$ | $c_{41}$ | $c_{12}$ | $c_{03}$ |

**Table 8-14 (continued) – Specification of mapping of idx to cij for 8x8 zig-zag and 8x8 field scan**

| idx | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| zig-zag | $c_{14}$ | $c_{23}$ | $c_{32}$ | $c_{41}$ | $c_{50}$ | $c_{60}$ | $c_{51}$ | $c_{42}$ | $c_{33}$ | $c_{24}$ | $c_{15}$ | $c_{06}$ | $c_{07}$ | $c_{16}$ | $c_{25}$ | $c_{34}$ |
| field | $c_{22}$ | $c_{51}$ | $c_{61}$ | $c_{71}$ | $c_{32}$ | $c_{13}$ | $c_{04}$ | $c_{23}$ | $c_{42}$ | $c_{52}$ | $c_{62}$ | $c_{72}$ | $c_{33}$ | $c_{14}$ | $c_{05}$ | $c_{24}$ |

**Table 8-14 (continued) – Specification of mapping of idx to cij for 8x8 zig-zag and 8x8 field scan**

| idx | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| zig-zag | $c_{43}$ | $c_{52}$ | $c_{61}$ | $c_{70}$ | $c_{71}$ | $c_{62}$ | $c_{53}$ | $c_{44}$ | $c_{35}$ | $c_{26}$ | $c_{17}$ | $c_{27}$ | $c_{36}$ | $c_{45}$ | $c_{54}$ | $c_{63}$ |
| field | $c_{43}$ | $c_{53}$ | $c_{63}$ | $c_{73}$ | $c_{34}$ | $c_{15}$ | $c_{06}$ | $c_{25}$ | $c_{44}$ | $c_{54}$ | $c_{64}$ | $c_{74}$ | $c_{35}$ | $c_{16}$ | $c_{26}$ | $c_{45}$ |

**Table 8-14 (concluded) – Specification of mapping of idx to cij for 8x8 zig-zag and 8x8 field scan**

| idx | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| zig-zag | $c_{72}$ | $c_{73}$ | $c_{64}$ | $c_{55}$ | $c_{46}$ | $c_{37}$ | $c_{47}$ | $c_{56}$ | $c_{65}$ | $c_{74}$ | $c_{75}$ | $c_{66}$ | $c_{57}$ | $c_{67}$ | $c_{76}$ | $c_{77}$ |
| field | $c_{55}$ | $c_{65}$ | $c_{75}$ | $c_{36}$ | $c_{07}$ | $c_{17}$ | $c_{46}$ | $c_{56}$ | $c_{66}$ | $c_{76}$ | $c_{27}$ | $c_{37}$ | $c_{47}$ | $c_{57}$ | $c_{67}$ | $c_{77}$ |

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### 8.5.8 Derivation process for the chroma quantisation parameters and scaling function

Outputs of this process are:

– $QP_C$: the chroma quantisation parameter for each chroma component Cb and Cr

– $QS_C$: the additional chroma quantisation parameter for each chroma component Cb and Cr required for decoding SP and SI slices (if applicable)

NOTE 1 – QP quantisation parameter values $QP_Y$ and $QS_Y$ are always in the range of $-QpBdOffset_Y$ to 51, inclusive. QP quantisation parameter values $QP_C$ and $QS_C$ are always in the range of $-QpBdOffset_C$ to 51, inclusive.

The value of $QP_C$ for a chroma component is determined from the current value of $QP_Y$ and the value of chroma_qp_index_offset (for Cb) or second_chroma_qp_index_offset (for Cr).

NOTE 2 – The scaling equations are specified such that the equivalent transform coefficient level scaling factor doubles for every increment of 6 in $QP_Y$. Thus, there is an increase in the factor used for scaling of approximately 12 % for each increase of 1 in the value of $QP_Y$.

The value of $QP_C$ for each chroma component is determined as specified in Table 8-15 based on the index denoted as $qP_I$.

The variable $qP_{Offset}$ for each chroma component is derived as follows.

– If the chroma component is the Cb component, $qP_{Offset}$ is specified as

$$qP_{Offset} = \text{chroma_qp_index_offset} \tag{8-315}$$

– Otherwise (the chroma component is the Cr component), $qP_{Offset}$ is specified as

$$qP_{Offset} = \text{second_chroma_qp_index_offset} \tag{8-316}$$

The value of $qP_I$ for each chroma component is derived as

$$qP_I = \text{Clip3}( -QpBdOffset_C, 51, QP_Y + qP_{Offset} ) \tag{8-317}$$

The value of $QP'_C$ for the chroma components is derived as

$$QP'_C = QP_C + QpBdOffset_C \tag{8-318}$$

**Table 8-15 – Specification of $QP_C$ as a function of $qP_I$**

| $qP_I$ | <30 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $QP_C$ | $=qP_I$ | 29 | 30 | 31 | 32 | 32 | 33 | 34 | 34 | 35 | 35 | 36 | 36 | 37 | 37 | 37 | 38 | 38 | 38 | 39 | 39 | 39 | 39 |

When the current slice is an SP or SI slice, $QS_C$ is derived using the above process, substituting $QP_Y$ with $QS_Y$ and $QP_C$ with $QS_C$.

The 4x4 matrix weightScale( i, j ) is specified as follows.

– The variable mbIsInterFlag is derived as follows.

  – If the current macroblock is coded using Inter macroblock prediction modes, mbIsInterFlag is set equal to 1.

  – Otherwise (the current macroblock is coded using Intra macroblock prediction modes), mbIsInterFlag is set equal to 0.

– The variable iYCbCr derived as follows.

  – If separate_colour_plane_flag is equal to 1, iYCbCr is set equal to colour_plane_id.

  – Otherwise (separate_colour_plane_flag is equal to 0), the following applies.

    – If the input array c relates to a luma residual block, iYCbCr is set equal to 0.

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  - Otherwise, if the input array c relates to a chroma residual block and the chroma component is equal to Cb, iYCbCr is set equal to 1.
  - Otherwise (the input array c relates to a chroma residual block and the chroma component is equal to Cr), iYCbCr is set equal to 2.
- The inverse scanning process for transform coefficients as specified in subclause 8.5.6 is invoked with ScalingList4x4[ iYCbCr + ( (mbIsInterFlag == 1 ) ? 3 : 0 )] as the input and the output is assigned to the 4x4 matrix weightScale.

LevelScale( m, i, j ) is specified by

$$\text{LevelScale}( m, i, j ) = \text{weightScale}( i, j ) * \text{normAdjust}( m, i, j ) \tag{8-319}$$

where

$$\text{normAdjust}(m,i,j) = \begin{cases} v_{m0} & \text{for } ( i \% 2, j \% 2 ) \text{ equal to } (0,0), \\ v_{m1} & \text{for } ( i \% 2, j \% 2 ) \text{ equal to } (1,1), \\ v_{m2} & \text{otherwise;} \end{cases} \tag{8-320}$$

where the first and second subscripts of v are row and column indices, respectively, of the matrix specified as:

$$v = \begin{bmatrix} 10 & 16 & 13 \\ 11 & 18 & 14 \\ 13 & 20 & 16 \\ 14 & 23 & 18 \\ 16 & 25 & 20 \\ 18 & 29 & 23 \end{bmatrix}. \tag{8-321}$$

The 8x8 matrix weightScale8x8( i, j ) is specified as follows.

- The variable mbIsInterFlag is derived as follows.
  - If the current macroblock is coded using Inter macroblock prediction modes, mbIsInterFlag is set equal to 1.
  - Otherwise (the current macroblock is coded using Intra macroblock prediction modes), mbIsInterFlag is set equal to 0.
- The variable iYCbCr derived as follows.
  - If separate_colour_plane_flag is equal to 1, iYCbCr is set equal to colour_plane_id.
  - Otherwise (separate_colour_plane_flag is equal to 0), the following applies.
    - If the input array c relates to a luma residual block, iYCbCr is set equal to 0.
    - Otherwise, if the input array c relates to a chroma residual block and the chroma component is equal to Cb, iYCbCr is set equal to 1.
    - Otherwise (the input array c relates to a chroma residual block and the chroma component is equal to Cr), iYCbCr is set equal to 2.
- The inverse scanning process for 8x8 transform coefficients as specified in subclause 8.5.7 is invoked with ScalingList8x8[ mbIsInterFlag ] as the input and the output is assigned to the 8x8 matrix weightScale8x8.

LevelScale( m, i, j ) is specified by

$$\text{LevelScale8x8}( m, i, j ) = \text{weightScale8x8}( i, j ) * \text{normAdjust8x8}( m, i, j ) \tag{8-322}$$

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where

$$\text{normAdjust8x8}(m,i,j) = \begin{cases} v_{m0} & \text{for } (i\,\%\,4, j\,\%\,4) \text{ equal to } (0,0), \\ v_{m1} & \text{for } (i\,\%\,2, j\,\%\,2) \text{ equal to } (1,1), \\ v_{m2} & \text{for } (i\,\%\,4, j\,\%\,4) \text{ equal to } (2,2), \\ v_{m3} & \text{for } (i\,\%\,4, j\,\%\,2) \text{ equal to } (0,1) \text{ or } (i\,\%\,2, j\,\%\,4) \text{ equal to } (1,0), \\ v_{m4} & \text{for } (i\,\%\,4, j\,\%\,4) \text{ equal to } (0,2) \text{ or } (i\,\%\,4, j\,\%\,4) \text{ equal to } (2,0), \\ v_{m5} & \text{otherwise;} \end{cases} \tag{8-323}$$

where the first and second subscripts of v are row and column indices, respectively, of the matrix specified as:

$$v = \begin{bmatrix} 20 & 18 & 32 & 19 & 25 & 24 \\ 22 & 19 & 35 & 21 & 28 & 26 \\ 26 & 23 & 42 & 24 & 33 & 31 \\ 28 & 25 & 45 & 26 & 35 & 33 \\ 32 & 28 & 51 & 30 & 40 & 38 \\ 36 & 32 & 58 & 34 & 46 & 43 \end{bmatrix}. \tag{8-324}$$

### 8.5.9 Scaling and transformation process for DC transform coefficients for Intra_16x16 macroblock type

Inputs to this process are

– the variables bitDepth and qP,

– transform coefficient level values for DC transform coefficients of Intra_16x16 macroblocks as a 4x4 array c with elements $c_{ij}$, where i and j form a two-dimensional frequency index.

Outputs of this process are 16 scaled DC values for 4x4 blocks of Intra_16x16 macroblocks as a 4x4 array dcY with elements $dcY_{ij}$.

Depending on the values of qpprime_y_zero_transform_bypass_flag and $QP'_Y$, the following applies.

– If qpprime_y_zero_transform_bypass_flag is equal to 1 and $QP'_Y$ is equal to 0, the output dcY is derived as

$$dcY_{ij} = c_{ij} \quad \text{with} \quad i, j = 0..3 \tag{8-325}$$

– Otherwise (qpprime_y_zero_transform_bypass_flag is equal to 0 or $QP'_Y$ is not equal to 0), the following text of this process specifies the output.

The inverse transform for the 4x4 luma DC transform coefficients is specified by:

$$f = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} & c_{02} & c_{03} \\ c_{10} & c_{11} & c_{12} & c_{13} \\ c_{20} & c_{21} & c_{22} & c_{23} \\ c_{30} & c_{31} & c_{32} & c_{33} \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix}. \tag{8-326}$$

The bitstream shall not contain data that results in any element $f_{ij}$ of f with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})}-1$, inclusive.

After the inverse transform, the scaling is performed as follows.

– If qP is greater than or equal to 36, the scaled result is derived as

$$dcY_{ij} = ( f_{ij} * \text{LevelScale}( qP \,\%\, 6, 0, 0 ) ) << ( qP / 6 - 6 ), \quad \text{with} \quad i, j = 0...3 \tag{8-327}$$

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– Otherwise (qP is less than 36), the scaled result is derived as

$$dcY_{ij} = ( f_{ij} * LevelScale( qP \% 6, 0, 0 ) + ( 1 << ( 5 - qP / 6) ) ) >> ( 6 - qP / 6 ), \quad \text{with } i, j = 0...3 \tag{8-328}$$

The bitstream shall not contain data that results in any element $dcY_{ij}$ of dcY with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

NOTE 1 – When entropy_coding_mode_flag is equal to 0 and qP is less than 10 and profile_idc is equal to 66, 77, or 88, the range of values that can be represented for the elements $c_{ij}$ of c is not sufficient to represent the full range of values of the elements $dcY_{ij}$ of dcY that could be necessary to form a close approximation of the content of any possible source picture by use of the Intra_16x16 macroblock type.

NOTE 2 – Since the range limit imposed on the elements $dcY_{ij}$ of dcY is imposed after the right shift in Equation 8-328, a larger range of values must be supported in the decoder prior to the right shift.

### 8.5.10 Scaling and transformation process for chroma DC transform coefficients

This process is only invoked when ChromaArrayType is equal to 1 or 2.

Inputs to this process are transform coefficient level values for chroma DC transform coefficients of one chroma component of the macroblock as an (MbWidthC / 4)x(MbHeightC / 4) array c with elements $c_{ij}$, where i and j form a two-dimensional frequency index.

Outputs of this process are the scaled DC values as an (MbWidthC / 4)x(MbHeightC / 4) array dcC with elements $dcC_{ij}$.

The variables bitDepth and qP are set equal to $BitDepth_C$ and $QP'_C$, respectively.

Depending on the values of qpprime_y_zero_transform_bypass_flag and $QP'_Y$, the following applies.

– If qpprime_y_zero_transform_bypass_flag is equal to 1 and $QP'_Y$ is equal to 0, the output dcC is derived as

$$dcC_{ij} = c_{ij} \quad \text{with } i = 0..( MbWidthC / 4 ) - 1 \text{ and } j = 0..( MbHeightC / 4 ) - 1. \tag{8-329}$$

– Otherwise (qpprime_y_zero_transform_bypass_flag is equal to 0 or $QP'_Y$ is not equal to 0), the following applies.

  – The transformation process for chroma DC transform coefficients as specified in subclause 8.5.10.1 is invoked with bitDepth and c as the inputs and the output is assigned to the (MbWidthC / 4)x(MbHeightC / 4) array f of chroma DC values with elements $f_{ij}$.

  – The scaling process for chroma DC transform coefficients as specified in subclause 8.5.10.2 is invoked with bitDepth, qP, and f as the inputs and the output is assigned to the (MbWidthC / 4)x(MbHeightC / 4) array dcY of scaled chroma DC values with elements $dcY_{ij}$.

#### 8.5.10.1 Transformation process for chroma DC transform coefficients

Inputs of this process are transform coefficient level values for chroma DC transform coefficients of one chroma component of the macroblock as an (MbWidthC / 4)x(MbHeightC / 4) array c with elements $c_{ij}$, where i and j form a two-dimensional frequency index.

Outputs of this process are the DC values as an (MbWidthC / 4)x(MbHeightC / 4) array f with elements $f_{ij}$.

Depending on the variable ChromaArrayType, the inverse transform is specified as follows.

– If ChromaArrayType is equal to 1, the inverse transform for the 2x2 chroma DC transform coefficients is specified as

$$f = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} \\ c_{10} & c_{11} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \tag{8-330}$$

– Otherwise, (ChromaArrayType is equal to 2), the inverse transform for the 2x4 chroma DC transform coefficients is specified as

$$f = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \\ 1 & -1 & 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00} & c_{01} \\ c_{10} & c_{11} \\ c_{20} & c_{21} \\ c_{30} & c_{31} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \tag{8-331}$$

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#### 8.5.10.2 Scaling process for chroma DC transform coefficients

Inputs of this process are

– the variables bitDepth and qP

– DC values as an (MbWidthC / 4)x(MbHeightC / 4) array f with elements $f_{ij}$

Outputs of this process are scaled DC values as an (MbWidthC / 4)x(MbHeightC / 4) array dcC with elements $dcC_{ij}$.

The bitstream shall not contain data that results in any element $f_{ij}$ of f with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

Scaling is performed depending on the variable ChromaArrayType as follows.

– If ChromaArrayType is equal to 1, the scaled result is derived as

$$dcC_{ij} = ( ( f_{ij} * LevelScale( qP \% 6, 0, 0 ) ) << ( qP/ 6 ) ) >> 5, \quad with \quad i, j = 0, 1 \tag{8-332}$$

– Otherwise (ChromaArrayType is equal to 2), the following applies.

– The variable $qP_{DC}$ is derived as

$$qP_{DC} = qP + 3 \tag{8-333}$$

– Depending on the value of $qP_{DC}$, the following applies.

– If $qP_{DC}$ is greater than or equal to 36, the scaled result is derived as

$$dcC_{ij} = ( f_{ij} * LevelScale( qP_{DC} \% 6, 0, 0 ) ) << ( qP_{DC} / 6 - 6 ), \quad \text{with } i = 0..3, j = 0, 1 \tag{8-334}$$

– Otherwise ($qP_{DC}$ is less than 36), the scaled result is derived as

$$dcC_{ij} = ( f_{ij} * LevelScale( qP_{DC} \% 6, 0, 0 ) + 2^{5 - qP_{DC}/6} ) >> ( 6 - qP_{DC} / 6 ), \quad \text{with } i = 0..3, j = 0, 1 \tag{8-335}$$

The bitstream shall not contain data that results in any element $dcC_{ij}$ of dcC with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

NOTE 1 – When entropy_coding_mode_flag is equal to 0 and qP is less than 4 and profile_idc is equal to 66, 77, or 88, the range of values that can be represented for the elements $c_{ij}$ of c in subclause 8.5.10.1 may not be sufficient to represent the full range of values of the elements $dcC_{ij}$ of dcC that could be necessary to form a close approximation of the content of any possible source picture.

NOTE 2 – Since the range limit imposed on the elements $dcC_{ij}$ of dcC is imposed after the right shift in Equation 8-332 or 8-335, a larger range of values must be supported in the decoder prior to the right shift.

#### 8.5.11 Scaling and transformation process for residual 4x4 blocks

Input to this process is a 4x4 array c with elements $c_{ij}$ which is either an array relating to a residual block of the luma component or an array relating to a residual block of a chroma component.

Outputs of this process are residual sample values as 4x4 array r with elements $r_{ij}$.

The variable bitDepth is derived as follows.

– If the input array c relates to a luma residual block, bitDepth is set equal to $BitDepth_Y$.

– Otherwise (the input array c relates to a chroma residual block), bitDepth is set equal to $BitDepth_C$.

The variable sMbFlag is derived as follows.

- If mb_type is equal to SI or the macroblock prediction mode is equal to Inter in an SP slice, sMbFlag is set equal to 1,

- Otherwise (mb_type not equal to SI and the macroblock prediction mode is not equal to Inter in an SP slice), sMbFlag is set equal to 0.

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The variable qP is derived as follows.

– If the input array c relates to a luma residual block and sMbFlag is equal to 0

$$qP = QP'_Y \quad (8\text{-}336)$$

– Otherwise, if the input array c relates to a luma residual block and sMbFlag is equal to 1

$$qP = QS_Y \quad (8\text{-}337)$$

– Otherwise, if the input array c relates to a chroma residual block and sMbFlag is equal to 0

$$qP = QP'_C \quad (8\text{-}338)$$

– Otherwise (the input array c relates to a chroma residual block and sMbFlag is equal to 1),

$$qP = QS_C \quad (8\text{-}339)$$

Depending on the values of qpprime_y_zero_transform_bypass_flag and $QP'_Y$, the following applies.

– If qpprime_y_zero_transform_bypass_flag is equal to 1 and $QP'_Y$ is equal to 0, the output r is derived as

$$r_{ij} = c_{ij} \text{ with } i, j = 0..3 \quad (8\text{-}340)$$

– Otherwise (qpprime_y_zero_transform_bypass_flag is equal to 0 or $QP'_Y$ is not equal to 0), the following applies.

  – The scaling process for residual 4x4 blocks as specified in subclause 8.5.11.1 is invoked with bitDepth, qP, and c as the inputs and the output is assigned to the 4x4 array d of scaled transform coefficients with elements $d_{ij}$.

  – The transformation process for residual 4x4 blocks as specified in subclause 8.5.11.2 is invoked with bitDepth and d as the inputs and the outputs is assigned to the 4x4 array r of residual sample values with elements $r_{ij}$.

### 8.5.11.1 Scaling process for residual 4x4 blocks

Inputs of this process are

– the variables bitDepth and qP

– a 4x4 array c with elements $c_{ij}$ which is either an array relating to a residual block of luma component or an array relating to a residual block of a chroma component

Output of this process is a 4x4 array of scaled transform coefficients d with elements $d_{ij}$.

The bitstream shall not contain data that results in any element $c_{ij}$ of c with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

Scaling of 4x4 block transform coefficient levels $c_{ij}$ proceeds as follows.

– If all of the following conditions are true

  – i is equal to 0

  – j is equal to 0

  – c relates to a luma residual block coded using Intra_16x16 prediction mode or c relates to a chroma residual block

  the variable $d_{00}$ is derived by

$$d_{00} = c_{00} \quad (8\text{-}341)$$

  – Otherwise, the following applies.

  – If qP is greater than or equal to 24, the scaled result is derived as follows

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$$d_{ij} = ( c_{ij} * \text{LevelScale}( qP \% 6, i, j) ) << ( qP / 6 - 4), \text{ with } i,j = 0..3 \text{ except as noted above} \quad (8\text{-}342)$$

– Otherwise (qP is less than 24), the scaled result is derived as follows

$$d_{ij} = ( c_{ij} * \text{LevelScale}( qP \% 6, i, j ) + 2^{3-qP/6} ) >> ( 4 - qP / 6 ), \text{ with } i, j = 0..3 \text{ except as noted above} \quad (8\text{-}343)$$

The bitstream shall not contain data that results in any element $d_{ij}$ of d with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 1$, inclusive.

#### 8.5.11.2 Transformation process for residual 4x4 blocks

Inputs of this process are

– the variable bitDepth

– a 4x4 array of scaled transform coefficients d with elements $d_{ij}$

Outputs of this process are residual sample values as 4x4 array r with elements $r_{ij}$.

The bitstream shall not contain data that results in any element $d_{ij}$ of d with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 1$, inclusive.

The transform process shall convert the block of scaled transform coefficients to a block of output samples in a manner mathematically equivalent to the following.

First, each (horizontal) row of scaled transform coefficients is transformed using a one-dimensional inverse transform as follows.

A set of intermediate values is computed as follows.

$$e_{i0} = d_{i0} + d_{i2}, \quad \text{with} \quad i = 0..3 \quad (8\text{-}344)$$

$$e_{i1} = d_{i0} - d_{i2}, \quad \text{with} \quad i = 0..3 \quad (8\text{-}345)$$

$$e_{i2} = ( d_{i1} >> 1 ) - d_{i3}, \quad \text{with} \quad i = 0..3 \quad (8\text{-}346)$$

$$e_{i3} = d_{i1} + ( d_{i3} >> 1 ), \quad \text{with} \quad i = 0..3 \quad (8\text{-}347)$$

The bitstream shall not contain data that results in any element $e_{ij}$ of e with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 1$, inclusive.

Then, the transformed result is computed from these intermediate values as follows.

$$f_{i0} = e_{i0} + e_{i3}, \quad \text{with} \quad i = 0..3 \quad (8\text{-}348)$$

$$f_{i1} = e_{i1} + e_{i2}, \quad \text{with} \quad i = 0..3 \quad (8\text{-}349)$$

$$f_{i2} = e_{i1} - e_{i2}, \quad \text{with} \quad i = 0..3 \quad (8\text{-}350)$$

$$f_{i3} = e_{i0} - e_{i3}, \quad \text{with} \quad i = 0..3 \quad (8\text{-}351)$$

The bitstream shall not contain data that results in any element $f_{ij}$ of f with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 1$, inclusive.

Then, each (vertical) column of the resulting matrix is transformed using the same one-dimensional inverse transform as follows.

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A set of intermediate values is computed as follows.

$$g_{0j} = f_{0j} + f_{2j}, \quad \text{with} \quad j = 0..3 \tag{8-352}$$

$$g_{1j} = f_{0j} - f_{2j}, \quad \text{with} \quad j = 0..3 \tag{8-353}$$

$$g_{2j} = ( f_{1j} >> 1 ) - f_{3j}, \quad \text{with} \quad j = 0..3 \tag{8-354}$$

$$g_{3j} = f_{1j} + ( f_{3j} >> 1 ), \quad \text{with} \quad j = 0..3 \tag{8-355}$$

The bitstream shall not contain data that results in any element $g_{ij}$ of g with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 1$, inclusive.

Then, the transformed result is computed from these intermediate values as follows.

$$h_{0j} = g_{0j} + g_{3j}, \quad \text{with} \quad j = 0..3 \tag{8-356}$$

$$h_{1j} = g_{1j} + g_{2j}, \quad \text{with} \quad j = 0..3 \tag{8-357}$$

$$h_{2j} = g_{1j} - g_{2j}, \quad \text{with} \quad j = 0..3 \tag{8-358}$$

$$h_{3j} = g_{0j} - g_{3j}, \quad \text{with} \quad j = 0..3 \tag{8-359}$$

The bitstream shall not contain data that results in any element $h_{ij}$ of h with i, j = 0..3 that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 33$, inclusive.

After performing both the one-dimensional horizontal and the one-dimensional vertical inverse transforms to produce an array of transformed samples, the final constructed residual sample values is derived as

$$r_{ij} = ( h_{ij} + 2^5 ) >> 6 \quad \text{with} \quad i, j = 0..3 \tag{8-360}$$

### 8.5.12 Scaling and transformation process for residual 8x8 blocks

Input to this process is an 8x8 array c with elements $c_{ij}$ which is either an array relating to an 8x8 residual block of the luma component or, when ChromaArrayType is equal to 3, an array relating to an 8x8 residual block of a chroma component.

NOTE 1 – When separate_colour_plane_flag is equal to 1, all residual blocks are considered to be associated with the luma component for purposes of the decoding process of each coded picture (prior to the final assignment of the decoded picture to a particular luma or chroma picture array according to the value of colour_plane_id).

Outputs of this process are residual sample values as 8x8 array r with elements $r_{ij}$.

The variables bitDepth and qP are derived as follows.

- If the input array c relates to a luma residual block, bitDepth is set equal to $\text{BitDepth}_Y$ and QP is set equal to $\text{QP}'_Y$.
- Otherwise (the input array c relates to a chroma residual block), bitDepth is set equal to $\text{BitDepth}_C$ and QP is set equal to $\text{QP}'_C$.

NOTE 2 – When separate_colour_plane_flag is equal to 1, all residual blocks are considered to be associated with the luma component for purposes of the decoding process of each colour component of a picture.

Depending on the values of qpprime_y_zero_transform_bypass_flag and $\text{QP}'_Y$, the following applies.

- If qpprime_y_zero_transform_bypass_flag is equal to 1 and $\text{QP}'_Y$ is equal to 0, the output r is derived as

$$r_{ij} = c_{ij} \quad \text{with} \quad i, j = 0..7 \tag{8-361}$$

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– Otherwise (qpprime_y_zero_transform_bypass_flag is equal to 0 or QP'Y is not equal to 0), the following applies.

  – The scaling process for residual 8x8 blocks as specified in subclause 8.5.12.1 is invoked with bitDepth, qP, and c as the inputs and the output is assigned to the 8x8 array d of scaled transform coefficients with elements $d_{ij}$.

  – The transformation process for residual 8x8 blocks as specified in subclause 8.5.12.2 is invoked with bitDepth and d as the inputs and the outputs is assigned to the 8x8 array r of residual sample values with elements $r_{ij}$.

#### 8.5.12.1 Scaling process for residual 8x8 blocks

Inputs of this process are

– the variables bitDepth and qP

– an 8x8 array c with elements $c_{ij}$ which is either an array relating to a residual block of luma component or an array relating to a residual block of a chroma component

Output of this process is an 8x8 array of scaled transform coefficients d with elements $d_{ij}$.

The bitstream shall not contain data that results in any element $c_{ij}$ of c with i, j = 0..7 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

The scaling process for 8x8 block transform coefficient levels $c_{ij}$ proceeds as follows.

  – If qP is greater than or equal to 36, the scaled result is derived as

$$d_{ij} = (c_{ij} * LevelScale8x8( qP \% 6, i, j) ) << ( qP / 6 – 6), \text{ with } i,j = 0..7 \quad (8\text{-}362)$$

  – Otherwise (qP is less than 36), the scaled result is derived as

$$d_{ij} = (c_{ij} * LevelScale8x8( qP \% 6, i, j) ) + 2^{5-QP'_Y/6}) >> ( 6 – qP_Y/6), \text{ with } i,j = 0..7 \quad (8\text{-}363)$$

The bitstream shall not contain data that results in any element $d_{ij}$ of d with i, j = 0..7 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)}-1$, inclusive.

#### 8.5.12.2 Transformation process for residual 8x8 blocks

Inputs of this process are

– the variable bitDepth

– an 8x8 array of scaled transform coefficients d with elements $d_{ij}$

Outputs of this process are residual sample values as 8x8 array r with elements $r_{ij}$.

The bitstream shall not contain data that results in any element $d_{ij}$ of d with i, j = 0..7 that exceeds the range of integer values from $-2^{(7 + bitDepth)}$ to $2^{(7 + bitDepth)} – 1$, inclusive.

The transform process shall convert the block of scaled transform coefficients to a block of output samples in a manner mathematically equivalent to the following.

First, each (horizontal) row of scaled transform coefficients is transformed using a one-dimensional inverse transform as follows.

– A set of intermediate values $e_{ij}$ is derived by

$$e_{i0} = d_{i0} + d_{i4}, \text{ with } i = 0..7 \quad (8\text{-}364)$$

$$e_{i1} = – d_{i3} + d_{i5} – d_{i7} – (d_{i7} >> 1), \text{ with } i = 0..7 \quad (8\text{-}365)$$

$$e_{i2} = d_{i0} – d_{i4}, \text{ with } i = 0..7 \quad (8\text{-}366)$$

$$e_{i3} = d_{i1} + d_{i7} – d_{i3} – (d_{i3} >> 1), \text{ with } i = 0..7 \quad (8\text{-}367)$$

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$$e_{i4} = ( d_{i2} >> 1 ) - d_{i6}, \text{ with } i = 0..7 \quad (8\text{-}368)$$

$$e_{i5} = - d_{i1} + d_{i7} + d_{i5} + (d_{i5} >> 1), \text{ with } i = 0..7 \quad (8\text{-}369)$$

$$e_{i6} = d_{i2} + ( d_{i6} >> 1 ), \text{ with } i = 0..7 \quad (8\text{-}370)$$

$$e_{i7} = d_{i3} + d_{i5} + d_{i1} + (d_{i1} >> 1), \text{ with } i = 0..7 \quad (8\text{-}371)$$

– A second set of intermediate results $f_{ij}$ is computed from the intermediate values $e_{ij}$ as

$$f_{i0} = e_{i0} + e_{i6}, \text{ with } i = 0..7 \quad (8\text{-}372)$$

$$f_{i1} = e_{i1} + (e_{i7} >> 2), \text{ with } i = 0..7 \quad (8\text{-}373)$$

$$f_{i2} = e_{i2} + e_{i4}, \text{ with } i = 0..7 \quad (8\text{-}374)$$

$$f_{i3} = e_{i3} + (e_{i5} >> 2), \text{ with } i = 0..7 \quad (8\text{-}375)$$

$$f_{i4} = e_{i2} - e_{i4}, \text{ with } i = 0..7 \quad (8\text{-}376)$$

$$f_{i5} = (e_{i3} >> 2) - e_{i5}, \text{ with } i = 0..7 \quad (8\text{-}377)$$

$$f_{i6} = e_{i0} - e_{i6}, \text{ with } i = 0..7 \quad (8\text{-}378)$$

$$f_{i7} = e_{i7} - (e_{i1} >> 2), \text{ with } i = 0..7 \quad (8\text{-}379)$$

– Then, the transformed result $g_{ij}$ is computed from these intermediate values $f_{ij}$ as

$$g_{i0} = f_{i0} + f_{i7}, \text{ with } i = 0..7 \quad (8\text{-}380)$$

$$g_{i1} = f_{i2} + f_{i5}, \text{ with } i = 0..7 \quad (8\text{-}381)$$

$$g_{i2} = f_{i4} + f_{i3}, \text{ with } i = 0..7 \quad (8\text{-}382)$$

$$g_{i3} = f_{i6} + f_{i1}, \text{ with } i = 0..7 \quad (8\text{-}383)$$

$$g_{i4} = f_{i6} - f_{i1}, \text{ with } i = 0..7 \quad (8\text{-}384)$$

$$g_{i5} = f_{i4} - f_{i3}, \text{ with } i = 0..7 \quad (8\text{-}385)$$

$$g_{i6} = f_{i2} - f_{i5}, \text{ with } i = 0..7 \quad (8\text{-}386)$$

$$g_{i7} = f_{i0} - f_{i7}, \text{ with } i = 0..7 \quad (8\text{-}387)$$

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Then, each (vertical) column of the resulting matrix is transformed using the same one-dimensional inverse transform as follows.

– A set of intermediate values $h_{ij}$ is computed from the horizontally transformed value $g_{ij}$ as

$$h_{0j} = g_{0j} + g_{4j}, \text{ with } j = 0..7 \quad (8\text{-}388)$$

$$h_{1j} = -g_{3j} + g_{5j} - g_{7j} - (g_{7j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}389)$$

$$h_{2j} = g_{0j} - g_{4j}, \text{ with } j = 0..7 \quad (8\text{-}390)$$

$$h_{3j} = g_{1j} + g_{7j} - g_{3j} - (g_{3j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}391)$$

$$h_{4j} = ( g_{2j} >> 1 ) - g_{6j}, \text{ with } j = 0..7 \quad (8\text{-}392)$$

$$h_{5j} = -g_{1j} + g_{7j} + g_{5j} + (g_{5j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}393)$$

$$h_{6j} = g_{2j} + ( g_{6j} >> 1 ), \text{ with } j = 0..7 \quad (8\text{-}394)$$

$$h_{7j} = g_{3j} + g_{5j} + g_{1j} + (g_{1j} >> 1), \text{ with } j = 0..7 \quad (8\text{-}395)$$

– A second set of intermediate results $k_{ij}$ is computed from the intermediate values $h_{ij}$ as

$$k_{0j} = h_{0j} + h_{6j}, \text{ with } j = 0..7 \quad (8\text{-}396)$$

$$k_{1j} = h_{1j} + (h_{7j} >> 2), \text{ with } j = 0..7 \quad (8\text{-}397)$$

$$k_{2j} = h_{2j} + h_{4j}, \text{ with } j = 0..7 \quad (8\text{-}398)$$

$$k_{3j} = h_{3j} + (h_{5j} >> 2), \text{ with } j = 0..7 \quad (8\text{-}399)$$

$$k_{4j} = h_{2j} - h_{4j}, \text{ with } j = 0..7 \quad (8\text{-}400)$$

$$k_{5j} = (h_{3j} >> 2) - h_{5j}, \text{ with } j = 0..7 \quad (8\text{-}401)$$

$$k_{6j} = h_{0j} - h_{6j}, \text{ with } j = 0..7 \quad (8\text{-}402)$$

$$k_{7j} = h_{7j} - (h_{1j} >> 2), \text{ with } j = 0..7 \quad (8\text{-}403)$$

– Then, the transformed result $m_{ij}$ is computed from these intermediate values $k_{ij}$ as

$$m_{0j} = k_{0j} + k_{7j}, \text{ with } j = 0..7 \quad (8\text{-}404)$$

$$m_{1j} = k_{2j} + k_{5j}, \text{ with } j = 0..7 \quad (8\text{-}405)$$

$$m_{2j} = k_{4j} + k_{3j}, \text{ with } j = 0..7 \quad (8\text{-}406)$$

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$$m_{3j} = k_{6j} + k_{1j}, \text{ with } j = 0..7 \quad (8\text{-}407)$$

$$m_{4j} = k_{6j} - k_{1j}, \text{ with } j = 0..7 \quad (8\text{-}408)$$

$$m_{5j} = k_{4j} - k_{3j}, \text{ with } j = 0..7 \quad (8\text{-}409)$$

$$m_{6j} = k_{2j} - k_{5j}, \text{ with } j = 0..7 \quad (8\text{-}410)$$

$$m_{7j} = k_{0j} - k_{7j}, \text{ with } j = 0..7 \quad (8\text{-}411)$$

The bitstream shall not contain data that results in any element $e_{ij}$, $f_{ij}$, $g_{ij}$, $h_{ij}$, or $k_{ij}$ for i and j in the range of 0..7, inclusive, that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 1$, inclusive.

The bitstream shall not contain data that results in any element $m_{ij}$ for i and j in the range of 0..7, inclusive, that exceeds the range of integer values from $-2^{(7 + \text{bitDepth})}$ to $2^{(7 + \text{bitDepth})} - 33$, inclusive.

After performing both the one-dimensional horizontal and the one-dimensional vertical inverse transforms to produce an array of transformed samples, the final constructed residual sample values are derived as

$$r_{ij} = ( m_{ij} + 2^5 ) >> 6 \text{ with } i, j = 0..7 \quad (8\text{-}412)$$

### 8.5.13 Picture construction process prior to deblocking filter process

Inputs to this process are

- a sample array u with elements $u_{ij}$ which is a 16x16 luma block or an (MbWidthC)x(MbHeightC) chroma block or a 4x4 luma block or a 4x4 chroma block or an 8x8 luma block or, when ChromaArrayType is equal to 3, an 8x8 chroma block
- when u is not a 16x16 luma block or an (MbWidthC)x(MbHeightC) chroma block, a block index luma4x4BlkIdx or chroma4x4BlkIdx or luma8x8BlkIdx or cb4x4BlkIdx or cr4x4BlkIdx or cb8x8BlkIdx or cr8x8BlkIdx

The position of the upper-left luma sample of the current macroblock is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with CurrMbAddr as input and the output being assigned to ( xP, yP ).

When u is a luma block, for each sample $u_{ij}$ of the luma block, the following applies.

- Depending on the size of the block u, the following applies.
  - If u is a 16x16 luma block, the position ( xO, yO ) of the upper-left sample of the 16x16 luma block inside the macroblock is set equal to ( 0, 0 ) and the variable nE is set equal to 16.
  - Otherwise, if u is an 4x4 luma block, the position of the upper-left sample of the 4x4 luma block with index luma4x4BlkIdx inside the macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to ( xO, yO ), and the variable nE is set equal to 4.
  - Otherwise (u is an 8x8 luma block), the position of the upper-left sample of the 8x8 luma block with index luma8x8BlkIdx inside the macroblock is derived by invoking the inverse 8x8 luma block scanning process in subclause 6.4.5 with luma8x8BlkIdx as the input and the output being assigned to ( xO, yO ), and the variable nE is set equal to 8.
- Depending on the variable MbaffFrameFlag and the current macroblock, the following applies.
  - If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock

    $$S'_L[ xP + xO + j, yP + 2 * ( yO + i ) ] = u_{ij} \quad \text{with } i, j = 0..nE - 1 \quad (8\text{-}413)$$

  - Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock),

    $$S'_L[ xP + xO + j, yP + yO + i ] = u_{ij} \quad \text{with } i, j = 0..nE - 1 \quad (8\text{-}414)$$

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When u is a chroma block, for each sample $u_{ij}$ of the chroma block, the following applies.

– The subscript C in the variable $S'_C$ is replaced with Cb for the Cb chroma component and with Cr for the Cr chroma component.

– Depending on the size of the block u, the following applies.

  – If u is an (MbWidthC)x(MbHeightC) Cb or Cr block, the variable nW is set equal to MbWidthC, the variable nH is set equal to MbHeightC, and the position ( xO, yO ) of the upper-left sample of the (nW)x(nH) Cb or Cr block inside the macroblock is set equal to ( 0, 0 ).

  – Otherwise, if u is a 4x4 Cb or Cr block, the variables nW and nH are set equal to 4 and, depending on the variable ChromaArrayType, the position of the upper-left sample of a 4x4 Cb or Cr block with index chroma4x4BlkIdx inside the macroblock is derived as follows.

    – If ChromaArrayType is equal to 1 or 2, the following applies.

      xO = InverseRasterScan( chroma4x4BlkIdx, 4, 4, 8, 0 ) (8-415)

      yO = InverseRasterScan( chroma4x4BlkIdx, 4, 4, 8, 1 ) (8-416)

    – Otherwise (ChromaArrayType is equal to 3), the position of the upper-left sample of the 4x4 Cb block with index cb4x4BlkIdx or the 4x4 Cr block with index cr4x4BlkIdx inside the macroblock is derived by invoking the inverse 4x4 Cb or Cr block scanning process in subclause 6.4.4 with cb4x4BlkIdx or cr4x4BlkIdx as the input and the output being assigned to ( xO, yO ).

  – Otherwise (u is an 8x8 Cb or Cr block when ChromaArrayType is equal to 3), the variables nW and nH are set equal to 8 and the position of the upper-left sample of the 8x8 Cb block with index cb8x8BlkIdx or the Cr block with index cr8x8BlkIdx inside the macroblock is derived by invoking the inverse 8x8 Cb or Cr block scanning process in subclause 6.4.6 with cb8x8BlkIdx or cr8x8BlkIdx as the input and the output being assigned to ( xO, yO ).

– Depending on the variable MbaffFrameFlag and the current macroblock, the following applies.

  – If MbaffFrameFlag is equal to 1 and the current macroblock is a field macroblock

    $$S'_C[\ (\ xP / subWidthC\ ) + xO + j,\ (\ (\ yP + SubHeightC - 1\ ) / SubHeightC\ ) + 2 * (\ yO + i\ )\ ] = u_{ij}$$
    with i = 0..nH – 1 and j = 0..nW – 1 (8-417)

  – Otherwise (MbaffFrameFlag is equal to 0 or the current macroblock is a frame macroblock),

    $$S'_C[\ (\ xP/\ subWidthC\ ) + xO + j,\ (\ yP / SubHeightC\ ) + yO + i\ ] = u_{ij}$$
    with i = 0..nH – 1 and j = 0..nW – 1 (8-418)

### 8.5.14 Intra residual transform-bypass decoding process

This process is invoked when qpprime_y_zero_transform_bypass_flag is equal to 1, $QP'_Y$ is equal to 0, the macroblock prediction mode is equal to Intra_4x4, Intra_8x8, or Intra_16x16, and the applicable intra prediction mode is equal to the vertical or horizontal mode. The process for the Cb and Cr components is applied in the same way as for the luma (L or Y) component.

Inputs to this process are

– two variables nW and nH

– a variable horPredFlag

– an (nW)x(nH) array r with elements $r_{ij}$ which is either an array relating to a residual transform-bypass block of the luma component or an array relating to a residual transform-bypass block of the Cb and Cr component.

Output of this process is a modified version of the (nW)x(nH) array r with elements $r_{ij}$ containing the result of the intra residual transform-bypass decoding process.

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Let f be a temporary (nW)x(nH) array with elements $f_{ij}$, which are derived by

$$f_{ij} = r_{ij} \quad \text{with } i = 0..nH - 1 \text{ and } j = 0..nW - 1 \tag{8-419}$$

Depending on horPredFlag, the following applies.

– If horPredFlag is equal to 0, the modified array r is derived by.

$$r_{ij} = \sum_{k=0}^{i} f_{kj} \quad \text{with } i = 0..nH - 1 \text{ and } j = 0..nW - 1 \tag{8-420}$$

– Otherwise (horPredFlag is equal to 1), the modified array r is derived by

$$r_{ij} = \sum_{k=0}^{j} f_{ik} \quad \text{with } i = 0..nH - 1 \text{ and } j = 0..nW - 1 \tag{8-421}$$

## 8.6 Decoding process for P macroblocks in SP slices or SI macroblocks

This process is invoked when decoding P macroblock types in an SP slice type or an SI macroblock type in SI slices.

Inputs to this process are the prediction residual transform coefficient levels and the predicted samples for the current macroblock.

Outputs of this process are the decoded samples of the current macroblock prior to the deblocking filter process.

This subclause specifies the transform coefficient decoding process and picture construction process for P macroblock types in SP slices and SI macroblock type in SI slices.

NOTE – SP slices make use of Inter predictive coding to exploit temporal redundancy in the sequence, in a similar manner to P slice coding. Unlike P slice coding, however, SP slice coding allows identical reconstruction of a slice even when different reference pictures are being used. SI slices make use of spatial prediction, in a similar manner to I slices. SI slice coding allows identical reconstruction to a corresponding SP slice. The properties of SP and SI slices aid in providing functionalities for bitstream switching, splicing, random access, fast-forward, fast reverse, and error resilience/recovery.

An SP slice consists of macroblocks coded either as I macroblock types or P macroblock types.

An SI slice consists of macroblocks coded either as I macroblock types or SI macroblock type.

The transform coefficient decoding process and picture construction process prior to deblocking filter process for I macroblock types in SI slices is invoked as specified in subclause 8.5. SI macroblock type is decoded as described below.

When the current macroblock is coded as P_Skip, all values of LumaLevel, ChromaDCLevel, ChromaACLevel are set equal to 0 for the current macroblock.

### 8.6.1 SP decoding process for non-switching pictures

This process is invoked, when decoding P macroblock types in SP slices in which sp_for_switch_flag is equal to 0.

Inputs to this process are Inter prediction samples for the current macroblock from subclause 8.4 and the prediction residual transform coefficient levels.

Outputs of this process are the decoded samples of the current macroblock prior to the deblocking filter process.

This subclause applies to all macroblocks in SP slices in which sp_for_switch_flag is equal to 0, except those with macroblock prediction mode equal to Intra_4x4 or Intra_16x16. It does not apply to SI slices.

#### 8.6.1.1 Luma transform coefficient decoding process

Inputs to this process are Inter prediction luma samples for the current macroblock $pred_L$ from subclause 8.4 and the prediction residual transform coefficient levels, LumaLevel, and the index of the 4x4 luma block luma4x4BlkIdx.

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The position of the upper-left sample of the 4x4 luma block with index luma4x4BlkIdx inside the current macroblock is derived by invoking the inverse 4x4 luma block scanning process in subclause 6.4.3 with luma4x4BlkIdx as the input and the output being assigned to ( x, y ).

Let the variable p be a 4x4 array of prediction samples with element $p_{ij}$ being derived as follows.

$$p_{ij} = pred_L[\, x + j, y + i \,] \quad \text{with } i, j = 0..3 \tag{8-422}$$

The variable p is transformed producing transform coefficients $c^p$ according to:

$$c^p = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 2 & 1 & -1 & -2 \\ 1 & -1 & -1 & 1 \\ 1 & -2 & 2 & -1 \end{bmatrix} \begin{bmatrix} p_{00} & p_{01} & p_{02} & p_{03} \\ p_{10} & p_{11} & p_{12} & p_{13} \\ p_{20} & p_{21} & p_{22} & p_{23} \\ p_{30} & p_{31} & p_{32} & p_{33} \end{bmatrix} \begin{bmatrix} 1 & 2 & 1 & 1 \\ 1 & 1 & -1 & -2 \\ 1 & -1 & -1 & 2 \\ 1 & -2 & 1 & -1 \end{bmatrix} \tag{8-423}$$

The inverse transform coefficient scanning process as described in subclause 8-5.6 is invoked with LumaLevel[ luma4x4BlkIdx ] as the input and the two-dimensional array $c^r$ with elements $c_{ij}^r$ as the output.

The prediction residual transform coefficients $c^r$ are scaled using quantisation parameter $QP_Y$, and added to the transform coefficients of the prediction block $c^p$ with i, j = 0..3 as follows.

$$c_{ij}^s = c_{ij}^p + ( ( ( c_{ij}^r * LevelScale( QP_Y \% 6, i, j ) * A_{ij} ) << ( QP_Y / 6 ) ) >> 10 ) \tag{8-424}$$

where LevelScale( m, i, j ) is specified in Equation 8-319, and where $A_{ij}$ is specified as:

$$A_{ij} = \begin{cases} 16 & \text{for } (i, j) \in \{(0,0), (0,2), (2,0), (2,2)\}, \\ 25 & \text{for } (i, j) \in \{(1,1), (1,3), (3,1), (3,3)\}, \\ 20 & \text{otherwise;} \end{cases} \tag{8-425}$$

The function LevelScale2( m, i, j ), used in the formulas below, is specified as:

$$LevelScale2(m, i, j) = \begin{cases} w_{m0} & \text{for } (i, j) \in \{(0,0), (0,2), (2,0), (2,2)\}, \\ w_{m1} & \text{for } (i, j) \in \{(1,1), (1,3), (3,1), (3,3)\}, \\ w_{m2} & \text{otherwise;} \end{cases} \tag{8-426}$$

where the first and second subscripts of w are row and column indices, respectively, of the matrix specified as:

$$w = \begin{bmatrix} 13107 & 5243 & 8066 \\ 11916 & 4660 & 7490 \\ 10082 & 4194 & 6554 \\ 9362 & 3647 & 5825 \\ 8192 & 3355 & 5243 \\ 7282 & 2893 & 4559 \end{bmatrix} \tag{8-427}$$

The resulting sum, $c^s$, is quantised with a quantisation parameter $QS_Y$ and with i, j = 0..3 as follows.

$$c_{ij} = Sign( c_{ij}^s ) * ( ( Abs( c_{ij}^s ) * LevelScale2( QS_Y \% 6, i, j ) + ( 1 << ( 14 + QS_Y / 6 ) ) ) >> ( 15 + QS_Y / 6 ) ) \tag{8-428}$$

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The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c as the input and r as the output.

The 4x4 array u with elements $u_{ij}$ is derived as follows.

$$u_{ij} = \text{Clip1}_Y( r_{ij} ) \text{ with } i, j = 0..3 \quad (8\text{-}429)$$

The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with luma4x4BlkIdx and u as the inputs.

#### 8.6.1.2 Chroma transform coefficient decoding process

Inputs to this process are Inter prediction chroma samples for the current macroblock from subclause 8.4 and the prediction residual transform coefficient levels, ChromaDCLevel and ChromaACLevel.

This process is invoked twice: once for the Cb component and once for the Cr component. The component is referred to by replacing C with Cb for the Cb component and C with Cr for the Cr component. Let iCbCr select the current chroma component.

For each 4x4 block of the current chroma component indexed using chroma4x4BlkIdx with chroma4x4BlkIdx equal to 0..3, the following applies.

– The position of the upper-left sample of a 4x4 chroma block with index chroma4x4BlkIdx inside the macroblock is derived as follows.

$$x = \text{InverseRasterScan}( \text{chroma4x4BlkIdx}, 4, 4, 8, 0 ) \quad (8\text{-}430)$$

$$y = \text{InverseRasterScan}( \text{chroma4x4BlkIdx}, 4, 4, 8, 1 ) \quad (8\text{-}431)$$

– Let p be a 4x4 array of prediction samples with elements $p_{ij}$ being derived as follows.

$$p_{ij} = \text{pred}_C[ x + j, y + i ] \quad \text{with } i, j = 0..3 \quad (8\text{-}432)$$

– The 4x4 array p is transformed producing transform coefficients $c^p$( chroma4x4BlkIdx ) using Equation 8-423.

– The variable chromaList, which is a list of 16 entries, is derived. chromaList[ 0 ] is set equal to 0. chromaList[ k ] with index k = 1..15 are specified as follows.

$$\text{chromaList}[ k ] = \text{ChromaACLevel}[ \text{iCbCr} ][ \text{chroma4x4BlkIdx} ][ k - 1 ] \quad (8\text{-}433)$$

– The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with chromaList as the input and the 4x4 array $c^r$ as the output.

– The prediction residual transform coefficients $c^r$ are scaled using quantisation parameter QPC, and added to the transform coefficients of the prediction block $c^p$ with i, j = 0..3 except for the combination i = 0, j = 0 as follows.

$$c_{ij}^s = c_{ij}^p( \text{chroma4x4BlkIdx} ) + ( ( ( c_{ij}^r * \text{LevelScale}( QP_C \% 6, i, j ) * A_{ij} ) << ( QP_C / 6 ) ) >> 10 ) \quad (8\text{-}434)$$

– The resulting sum, $c^s$, is quantised with a quantisation parameter $QS_C$ and with i, j = 0..3 except for the combination i = 0, j = 0 as follows. The derivation of $c_{00}$( chroma4x4BlkIdx ) is described below in this subclause.

$$c_{ij}( \text{chroma4x4BlkIdx} ) = ( \text{Sign}( c_{ij}^s ) * ( \text{Abs}( c_{ij}^s ) * \text{LevelScale2}( QS_C \% 6, i, j ) + ( 1 << ( 14 + QS_C / 6 ) ) ) ) >> ( 15 + QS_C / 6 ) \quad (8\text{-}435)$$

– The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c( chroma4x4BlkIdx ) as the input and r as the output.

– The 4x4 array u with elements $u_{ij}$ is derived as follows.

$$u_{ij} = \text{Clip1}_C( r_{ij} ) \text{ with } i, j = 0..3 \quad (8\text{-}436)$$

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– The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with chroma4x4BlkIdx and u as the inputs.

The derivation of the DC transform coefficient level $c_{00}$( chroma4x4BlkIdx ) is specified as follows. The DC transform coefficients of the 4 prediction chroma 4x4 blocks of the current component of the macroblock are assembled into a 2x2 matrix with elements $c_{00}^{p}$(chroma4x4BlkIdx) and a 2x2 transform is applied to the DC transform coefficients as follows

$$dc^{p} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} c_{00}^{p}(0) & c_{00}^{p}(1) \\ c_{00}^{p}(2) & c_{00}^{p}(3) \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \quad (8\text{-}437)$$

The chroma DC prediction residual transform coefficient levels, ChromaDCLevel[ iCbCr ][ k ] with k = 0..3 are scaled using quantisation parameter QP, and added to the prediction DC transform coefficients as follows.

$$dc_{ij}^{s} = dc_{ij}^{p} + ( ( ( \text{ChromaDCLevel}[ \text{iCbCr} ][ j * 2 + i ] * \text{LevelScale}( QP_C \% 6, 0, 0) * A_{00} ) << ( QP_C / 6 ) ) >> 9 ) \text{ with } i, j = 0, 1 \quad (8\text{-}438)$$

The 2x2 array $dc^{s}$, is quantised using the quantisation parameter $QS_C$ as follows.

$$dc_{ij}^{r} = ( \text{Sign}( dc_{ij}^{s} ) * ( \text{Abs}( dc_{ij}^{s} ) * \text{LevelScale2}( QS_C \% 6, 0, 0) + ( 1 << ( 15 + QS_C / 6 ) ) ) ) >> ( 16 + QS_C / 6 ) \text{ with } i, j = 0, 1 \quad (8\text{-}439)$$

The 2x2 array f with elements $f_{ij}$ and i, j = 0..1 is derived as follows.

$$f = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} dc_{00}^{r} & dc_{01}^{r} \\ dc_{10}^{r} & dc_{11}^{r} \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}. \quad (8\text{-}440)$$

Scaling of the elements $f_{ij}$ of f is performed as follows.

$$c_{00}( j * 2 + i ) = ( ( f_{ij} * \text{LevelScale}( QS_C \% 6, 0, 0 ) ) << ( QS_C / 6 ) ) >> 5 \text{ with } i, j = 0, 1 \quad (8\text{-}441)$$

### 8.6.2 SP and SI slice decoding process for switching pictures

This process is invoked, when decoding P macroblock types in SP slices in which sp_for_switch_flag is equal to 1 and when decoding SI macroblock type in SI slices.

Inputs to this process are the prediction residual transform coefficient levels and the prediction sample arrays $pred_L$, $pred_{Cb}$ and $pred_{Cr}$ for the current macroblock.

#### 8.6.2.1 Luma transform coefficient decoding process

Inputs to this process are prediction luma samples $pred_L$ and the luma prediction residual transform coefficient levels, LumaLevel.

The 4x4 array p with elements $p_{ij}$ with i, j = 0..3 is derived as in subclause 8.6.1.1, is transformed according to Equation 8-423 to produce transform coefficients $c^{p}$. These transform coefficients are then quantised with the quantisation parameter $QS_Y$, as follows:

$$c_{ij}^{s} = \text{Sign}( c_{ij}^{p} ) * ( ( \text{Abs}( c_{ij}^{p} ) * \text{LevelScale2}( QS_Y \% 6, i, j ) + ( 1 << ( 14 + QS_Y / 6 ) ) ) >> ( 15 + QS_Y / 6 ) ) \text{ with } i, j = 0..3 \quad (8\text{-}442)$$

The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with LumaLevel[ luma4x4BlkIdx ] as the input and the two-dimensional array $c^{r}$ with elements $c_{ij}^{r}$ as the output.

The 4x4 array c with elements $c_{ij}$ with i, j = 0..3 is derived as follows.

$$c_{ij} = c_{ij}^{r} + c_{ij}^{s} \text{ with } i, j = 0..3 \quad (8\text{-}443)$$

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The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c as the input and r as the output.

The 4x4 array u with elements $u_{ij}$ is derived as follows.

$$u_{ij} = \text{Clip1}_Y( r_{ij} ) \text{ with } i, j = 0..3 \quad (8\text{-}444)$$

The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with luma4x4BlkIdx and u as the inputs.

### 8.6.2.2 Chroma transform coefficient decoding process

Inputs to this process are predicted chroma samples for the current macroblock from subclause 8.4 and the prediction residual transform coefficient levels, ChromaDCLevel and ChromaACLevel.

This process is invoked twice: once for the Cb component and once for the Cr component. The component is referred to by replacing C with Cb for the Cb component and C with Cr for the Cr component. Let iCbCr select the current chroma component.

For each 4x4 block of the current chroma component indexed using chroma4x4BlkIdx with chroma4x4BlkIdx equal to 0..3, the following applies.

1. The 4x4 array p with elements $p_{ij}$ with i, j = 0..3 is derived as in subclause 8.6.1.2, is transformed according to Equation 8-423 to produce transform coefficients $c^p$( chroma4x4BlkIdx ). These transform coefficients are then quantised with the quantisation parameter $QS_C$, with i, j = 0..3 except for the combination i = 0, j = 0 as follows. The processing of $c_{00}^p$( chroma4x4BlkIdx ) is described below in this subclause.

$$c_{ij}^s = ( \text{Sign}( c_{ij}^p( \text{chroma4x4BlkIdx} ) ) * ( \text{Abs}( c_{ij}^p( \text{chroma4x4BlkIdx} ) ) * \text{LevelScale2}( QS_C \% 6, i, j ) + ( 1 << ( 14 + QS_C / 6 ) ) ) ) >> ( 15 + QS_C / 6 ) \quad (8\text{-}445)$$

– The variable chromaList, which is a list of 16 entries, is derived. chromaList[ 0 ] is set equal to 0. chromaList[ k ] with index k = 1..15 are specified as follows.

$$\text{chromaList}[ k ] = \text{ChromaACLevel}[ \text{iCbCr} ][ \text{chroma4x4BlkIdx} ][ k - 1 ] \quad (8\text{-}446)$$

– The inverse transform coefficient scanning process as described in subclause 8.5.6 is invoked with chromaList as the input and the two-dimensional array $c^r$( chroma4x4BlkIdx ) with elements $c_{ij}^r$( chroma4x4BlkIdx ) as the output.

– The 4x4 array c( chroma4x4BlkIdx ) with elements $c_{ij}$( chroma4x4BlkIdx ) with i, j = 0..3 except for the combination i = 0, j = 0 is derived as follows. The derivation of $c_{00}$( chroma4x4BlkIdx ) is described below.

$$c_{ij}( \text{chroma4x4BlkIdx} ) = c_{ij}^r( \text{chroma4x4BlkIdx} ) + c_{ij}^s \quad (8\text{-}447)$$

– The scaling and transformation process for residual 4x4 blocks as specified in subclause 8.5.11 is invoked with c( chroma4x4BlkIdx ) as the input and r as the output.

– The 4x4 array u with elements $u_{ij}$ is derived as follows.

$$u_{ij} = \text{Clip1}_C( r_{ij} ) \text{ with } i, j = 0..3 \quad (8\text{-}448)$$

– The picture construction process prior to deblocking filter process in subclause 8.5.13 is invoked with chroma4x4BlkIdx and u as the inputs.

The derivation of the DC transform coefficient level $c_{00}$( chroma4x4BlkIdx ) is specified as follows. The DC transform coefficients of the 4 prediction 4x4 chroma blocks of the current component of the macroblock, $c_{00}^p$( chroma4x4BlkIdx ), are assembled into a 2x2 matrix, and a 2x2 transform is applied to the DC transform coefficients of these blocks according to Equation 8-437 resulting in DC transform coefficients $dc_{ij}^p$.

These DC transform coefficients are then quantised with the quantisation parameter $QS_C$, as given by:

$$dc_{ij}^s = ( \text{Sign}( dc_{ij}^p ) * ( \text{Abs}( dc_{ij}^p ) * \text{LevelScale2}( QS_C \% 6, 0, 0 ) + ( 1 << ( 15 + QS_C / 6 ) ) ) ) >> ( 16 + QS_C / 6 ) \text{ with } i, j = 0, 1 \quad (8\text{-}449)$$

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The parsed chroma DC prediction residual transform coefficients, ChromaDCLevel[ iCbCr ][ k ] with k = 0..3 are added to these quantised DC transform coefficients of the prediction block, as given by:

$$dc_{ij}^{r} = dc_{ij}^{s} + \text{ChromaDCLevel[ iCbCr ][ } j * 2 + i \text{ ]} \quad \text{with } i, j = 0, 1 \tag{8-450}$$

The 2x2 array f with elements $f_{ij}$ and i, j = 0..1 is derived using Equation 8-440.

The 2x2 array f with elements $f_{ij}$ and i, j = 0..1 is copied as follows.

$$c_{00}( j * 2 + i ) = f_{ij} \quad \text{with } i, j = 0, 1 \tag{8-451}$$

## 8.7 Deblocking filter process

A conditional filtering process is specified in this subclause that is an integral part of the decoding process which shall be applied by decoders conforming to the Baseline, Extended, Main, High, High 10, High 4:2:2, and High 4:4:4 Predictive profiles. For decoders conforming to the High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles, the filtering process specified in this subclause, or one similar to it, should be applied but is not required.

The conditional filtering process is applied to all NxN (where N = 4 or N = 8 for luma, N = 4 for chroma when ChromaArrayType is equal to 1 or 2, and N = 4 or N = 8 for chroma when ChromaArrayType is equal to 3) block edges of a picture, except edges at the boundary of the picture and any edges for which the deblocking filter process is disabled by disable_deblocking_filter_idc, as specified below. This filtering process is performed on a macroblock basis after the completion of the picture construction process prior to deblocking filter process (as specified in subclauses 8.5 and 8.6) for the entire decoded picture, with all macroblocks in a picture processed in order of increasing macroblock addresses.

NOTE 1 – Prior to the operation of the deblocking filter process for each macroblock, the deblocked samples of the macroblock or macroblock pair above (if any) and the macroblock or macroblock pair to the left (if any) of the current macroblock are always available because the deblocking filter process is performed after the completion of the picture construction process prior to deblocking filter process for the entire decoded picture. However, for purposes of determining which edges are to be filtered when disable_deblocking_filter_idc is equal to 2, macroblocks in different slices are considered not available during specified steps of the operation of the deblocking filter process.

The deblocking filter process is invoked for the luma and chroma components separately. For each macroblock and each component, vertical edges are filtered first, starting with the edge on the left-hand side of the macroblock proceeding through the edges towards the right-hand side of the macroblock in their geometrical order, and then horizontal edges are filtered, starting with the edge on the top of the macroblock proceeding through the edges towards the bottom of the macroblock in their geometrical order. Figure 8-10 shows edges of a macroblock which can be interpreted as luma or chroma edges.

When interpreting the edges in Figure 8-10 as luma edges, depending on the transform_size_8x8_flag, the following applies.

– If transform_size_8x8_flag is equal to 0, both types, the solid bold and dashed bold luma edges are filtered.

– Otherwise (transform_size_8x8_flag is equal to 1), only the solid bold luma edges are filtered.

When interpreting the edges in Figure 8-10 as chroma edges, depending on ChromaArrayType, the following applies.

– If ChromaArrayType is equal to 1 (4:2:0 format), only the solid bold chroma edges are filtered.

– Otherwise, if ChromaArrayType is equal to 2 (4:2:2 format), the solid bold vertical chroma edges are filtered and both types, the solid bold and dashed bold horizontal chroma edges are filtered.

– Otherwise, if ChromaArrayType is equal to 3 (4:4:4 format), the following applies.

  – If transform_size_8x8_flag is equal to 0, both types, the solid bold and dashed bold chroma edges are filtered.

  – Otherwise (transform_size_8x8_flag is equal to 1), only the solid bold chroma edges are filtered.

– Otherwise (ChromaArrayType is equal to 0), no chroma edges are filtered.

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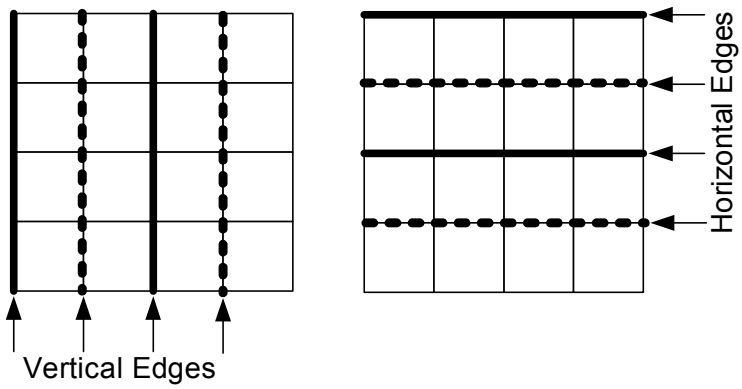


**Figure 8-10 – Boundaries in a macroblock to be filtered**

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For the current macroblock address CurrMbAddr proceeding over values 0..PicSizeInMbs – 1, the following applies.

1. The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

2. The variables fieldModeMbFlag, filterInternalEdgesFlag, filterLeftMbEdgeFlag and filterTopMbEdgeFlag are derived as follows.

   – The variable fieldModeMbFlag is derived as follows.

     – If any of the following conditions is true, fieldModeMbFlag is set equal to 1.

       – field_pic_flag is equal to 1

       – MbaffFrameFlag is equal to 1 and the macroblock CurrMbAddr is a field macroblock

     – Otherwise, fieldModeMbFlag is set equal to 0.

   – The variable filterInternalEdgesFlag is derived as follows.

     – If disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 1, the variable filterInternalEdgesFlag is set equal to 0;

     – Otherwise (disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is not equal to 1), the variable filterInternalEdgesFlag is set equal to 1.

   – The variable filterLeftMbEdgeFlag is derived as follows.

     – If any of the following conditions is true, the variable filterLeftMbEdgeFlag is set equal to 0.

       – MbaffFrameFlag is equal to 0 and CurrMbAddr % PicWidthInMbs is equal to 0.

       – MbaffFrameFlag is equal to 1 and ( CurrMbAddr >> 1 ) % PicWidthInMbs is equal to 0

       – disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 1

       – disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 2 and the macroblock mbAddrA is not available

     – Otherwise, the variable filterLeftMbEdgeFlag is set equal to 1.

   – The variable filterTopMbEdgeFlag is derived as follows.

     – If any of the following conditions is true, the variable filterTopMbEdgeFlag is set equal to 0.

       – MbaffFrameFlag is equal to 0 and CurrMbAddr is less than PicWidthInMbs.

       – MbaffFrameFlag is equal to 1, ( CurrMbAddr >> 1 ) is less than PicWidthInMbs, and the macroblock CurrMbAddr is a field macroblock.

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- MbaffFrameFlag is equal to 1, ( CurrMbAddr >> 1 ) is less than PicWidthInMbs, the macroblock CurrMbAddr is a frame macroblock, and CurrMbAddr % 2 is equal to 0.
- disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 1
- disable_deblocking_filter_idc for the slice that contains the macroblock CurrMbAddr is equal to 2 and the macroblock mbAddrB is not available

– Otherwise, the variable filterTopMbEdgeFlag is set equal to 1.

3. Given the variables fieldModeMbFlag, filterInternalEdgesFlag, filterLeftMbEdgeFlag and filterTopMbEdgeFlag the deblocking filtering is controlled as follows.

– When filterLeftMbEdgeFlag is equal to 1, the filtering of the left vertical luma edge is specified as follows.
  – The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (0, k)$ with k = 0..15 as input and $S'_L$ as output.

– When filterInternalEdgesFlag is equal to 1, the filtering of the internal vertical luma edges is specified as follows.
  – When transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (4, k)$ with k = 0..15 as input and $S'_L$ as output.
  – The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (8, k)$ with k = 0..15 as input and $S'_L$ as output.
  – When transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (12, k)$ with k = 0..15 as input and $S'_L$ as output.

– When filterTopMbEdgeFlag is equal to 1, the filtering of the top horizontal luma edge is specified as follows.
  – If MbaffFrameFlag is equal to 1, (CurrMbAddr % 2) is equal to 0, CurrMbAddr is greater than or equal to 2 * PicWidthInMbs, the macroblock CurrMbAddr is a frame macroblock, and the macroblock (CurrMbAddr - 2 * PicWidthInMbs + 1) is a field macroblock, the following applies.
    – The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = 1, and $(xE_k, yE_k) = (k, 0)$ with k = 0..15 as input and $S'_L$ as output.
    – The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = 1, and $(xE_k, yE_k) = (k, 1)$ with k = 0..15 as input and $S'_L$ as output.
  – Otherwise, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 0)$ with k = 0..15 as input and $S'_L$ as output.

– When filterInternalEdgesFlag is equal to 1, the filtering of the internal horizontal luma edges is specified as follows.
  – When transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 4)$ with k = 0..15 as input and $S'_L$ as output.
  – The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 8)$ with k = 0..15 as input and $S'_L$ as output.
  – When transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 0, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 12)$ with k = 0..15 as input and $S'_L$ as output.

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– When ChromaArrayType is not equal to 0, for the filtering of both chroma components, with iCbCr = 0 for Cb and iCbCr = 1 for Cr, the following applies.
  – When filterLeftMbEdgeFlag is equal to 1, the filtering of the left vertical chroma edge is specified as follows.
  – The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (0, k)$ with k = 0..MbHeightC - 1 as input and $S'_C$ with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.
  – When filterInternalEdgesFlag is equal to 1, the filtering of the internal vertical chroma edge is specified as follows.
    – When ChromaArrayType is not equal to 3 or transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (4, k)$ with k = 0..MbHeightC - 1 as input and $S'_C$ with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.
    – When ChromaArrayType is equal to 3, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (8, k)$ with k = 0..MbHeightC - 1 as input and $S'_C$ with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.
    – When ChromaArrayType is equal to 3 or transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 1, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (12, k)$ with k = 0..MbHeightC - 1 as input and $S'_C$ with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.
  – When filterTopMbEdgeFlag is equal to 1, the filtering of the top horizontal chroma edge is specified as follows.
    – If MbaffFrameFlag is equal to 1, (CurrMbAddr % 2) is equal to 0, CurrMbAddr is greater than or equal to 2 * PicWidthInMbs, the macroblock CurrMbAddr is a frame macroblock, and the macroblock (CurrMbAddr – 2 * PicWidthInMbs + 1) is a field macroblock, the following applies.
      – The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = 1, and $(xE_k, yE_k) = (k, 0)$ with k = 0..MbWidthC - 1 as input and $S'_C$ with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.
      – The process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = 1, and $(xE_k, yE_k) = (k, 1)$ with k = 0..MbWidthC - 1 as input and $S'_C$ with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.
    – Otherwise, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 0)$ with k = 0..MbWidthC - 1 as input and $S'_C$ with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.
  – When filterInternalEdgesFlag is equal to 1, the filtering of the internal horizontal chroma edge is specified as follows.
    – When ChromaArrayType is not equal to 3 or transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 4)$ with k = 0..MbWidthC - 1 as input and $S'_C$ with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.
    – When ChromaArrayType is not equal to 1, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and $(xE_k, yE_k) = (k, 8)$ with k = 0..MbWidthC - 1 as input and $S'_C$ with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

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– When ChromaArrayType is equal to 2, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and ($xE_k$, $yE_k$) = (k, 12) with k = 0..MbWidthC - 1 as input and $S'_C$ with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

– When ChromaArrayType is equal to 3 or transform_size_8x8_flag is equal to 0, the process specified in subclause 8.7.1 is invoked with chromaEdgeFlag = 1, iCbCr, verticalEdgeFlag = 0, fieldModeFilteringFlag = fieldModeMbFlag, and ($xE_k$, $yE_k$) = (k, 12) with k = 0..MbWidthC – 1 as input and $S'_C$ with C being replaced by Cb for iCbCr = 0 and C being replaced by Cr for iCbCr = 1 as output.

NOTE 2 – When field mode filtering (fieldModeFilteringFlag is equal to 1) is applied across the top horizontal edges of a frame macroblock, this vertical filtering across the top or bottom macroblock boundary may involve some samples that extend across an internal block edge that is also filtered internally in frame mode.

NOTE 3 – For example, in 4:2:0 chroma format when transform_size_8x8_flag is equal to 0, the following applies. 3 horizontal luma edges, 1 horizontal chroma edge for Cb, and 1 horizontal chroma edge for Cr are filtered that are internal to a macroblock. When field mode filtering (fieldModeFilteringFlag is equal to 1) is applied to the top edges of a frame macroblock, 2 horizontal luma, 2 horizontal chroma edges for Cb, and 2 horizontal chroma edges for Cr between the frame macroblock and the above macroblock pair are filtered using field mode filtering, for a total of up to 5 horizontal luma edges, 3 horizontal chroma edges for Cb, and 3 horizontal chroma edges for Cr filtered that are considered to be controlled by the frame macroblock. In all other cases, at most 4 horizontal luma, 2 horizontal chroma edges for Cb, and 2 horizontal chroma edges for Cr are filtered that are considered to be controlled by a particular macroblock.

Depending on separate_colour_plane_flag the following applies.

– If separate_colour_plane_flag is equal to 0, the arrays $S'_L$, $S'_{Cb}$, $S'_{Cr}$ are assigned to the arrays $S_L$, $S_{Cb}$, $S_{Cr}$ (which represent the decoded picture), respectively.

– Otherwise (separate_colour_plane_flag is equal to 1), the following applies.

  – If colour_plane_id is equal to 0, the arrays $S'_L$ is assigned to the array $S_L$ (which represent the luma component of the decoded picture).

  – Otherwise, if colour_plane_id is equal to 1, the arrays $S'_L$ is assigned to the array $S_{Cb}$ (which represents the Cb component of the decoded picture).

  – Otherwise (colour_plane_id is equal to 2), the arrays $S'_L$ is assigned to the array $S_{Cr}$ (which represents the Cr component of the decoded picture).

### 8.7.1 Filtering process for block edges

Inputs to this process are chromaEdgeFlag, the chroma component index iCbCr (when chromaEdgeFlag is equal to 1), verticalEdgeFlag, fieldModeFilteringFlag, and a set of nE sample locations ($xE_k$, $yE_k$), with k = 0..nE - 1, expressed relative to the upper left corner of the macroblock CurrMbAddr. The set of sample locations ($xE_k$, $yE_k$) represent the sample locations immediately to the right of a vertical edge (when verticalEdgeFlag is equal to 1) or immediately below a horizontal edge (when verticalEdgeFlag is equal to 0).

The variable nE is derived as follows.

– If chromaEdgeFlag is equal to 0, nE is set equal to 16.

– Otherwise (chromaEdgeFlag is equal to 1), nE is set equal to ( verticalEdgeFlag == 1 ) ? MbHeightC : MbWidthC.

Let s' be a variable specifying a luma or chroma sample array, be derived as follows.

– If chromaEdgeFlag is equal to 0, s' represents the luma sample array $S'_L$ of the current picture.

– Otherwise, if chromaEdgeFlag is equal to 1 and iCbCr is equal to 0, s' represents the chroma sample array $S'_{Cb}$ of the chroma component Cb of the current picture.

– Otherwise (chromaEdgeFlag is equal to 1 and iCbCr is equal to 1), s' represents the chroma sample array $S'_{Cr}$ of the chroma component Cr of the current picture.

The variable dy is derived as follows.

– If fieldModeFilteringFlag is equal to 1 and MbaffFrameFlag is equal to 1, dy is set equal to 2.

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– Otherwise (fieldModeFilteringFlag is equal to 0 or MbaffFrameFlag is equal to 0), dy is set equal to 1.

The position of the upper-left luma sample of the macroblock CurrMbAddr is derived by invoking the inverse macroblock scanning process in subclause 6.4.1 with mbAddr = CurrMbAddr as input and the output being assigned to ( xI, yI ).

The variables xP and yP are derived as follows.

– If chromaEdgeFlag is equal to 0, xP is set equal to xI and yP is set equal to yI.

– Otherwise (chromaEdgeFlag is equal to 1), xP is set equal to xI / SubWidthC and yP is set equal to (yI + SubHeightC – 1) / SubHeightC.

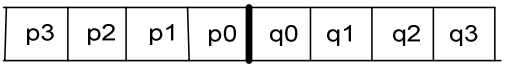


**Figure 8-11 – Convention for describing samples across a 4x4 block horizontal or vertical boundary**

For each sample location ( $xE_k$, $yE_k$ ), k = 0 .. nE - 1, the following applies.

– The filtering process is applied to a set of eight samples across a 4x4 block horizontal or vertical edge denoted as $p_i$ and $q_i$ with i = 0..3 as shown in Figure 8-11 with the edge lying between $p_0$ and $q_0$. $p_i$ and $q_i$ with i = 0..3 are specified as follows.

  – If verticalEdgeFlag is equal to 1,

$$q_i = s'[\ xP + xE_k + i,\ yP + dy * yE_k\ ] \quad (8\text{-}452)$$

$$p_i = s'[\ xP + xE_k - i - 1,\ yP + dy * yE_k\ ] \quad (8\text{-}453)$$

  – Otherwise (verticalEdgeFlag is equal to 0),

$$q_i = s'[\ xP + xE_k,\ yP + dy * (\ yE_k + i\ ) - (yE_k \% 2\ )\ ] \quad (8\text{-}454)$$

$$p_i = s'[\ xP + xE_k,\ yP + dy * (\ yE_k - i - 1\ ) - (yE_k \% 2\ )\ ] \quad (8\text{-}455)$$

– The process specified in subclause 8.7.2 is invoked with the sample values $p_i$ and $q_i$ (i = 0..3), chromaEdgeFlag, verticalEdgeFlag, and fieldModeFilteringFlag as input, and the output is assigned to the filtered result sample values $p'_i$ and $q'_i$ with i = 0..2.

– The input sample values $p_i$ and $q_i$ with i = 0..2 are replaced by the corresponding filtered result sample values $p'_i$ and $q'_i$ with i = 0..2 inside the sample array s' as follows.

  – If verticalEdgeFlag is equal to 1,

$$s'[\ xP + xE_k + i,\ yP + dy * yE_k\ ] = q'_i \quad (8\text{-}456)$$

$$s'[\ xP + xE_k - i - 1,\ yP + dy * yE_k\ ] = p'_i \quad (8\text{-}457)$$

  – Otherwise (verticalEdgeFlag is equal to 0),

$$s'[\ xP + xE_k,\ yP + dy * (\ yE_k + i\ ) - (\ yE_k \% 2\ )\ ] = q'_i \quad (8\text{-}458)$$

$$s'[\ xP + xE_k,\ yP + dy * (\ yE_k - i - 1\ ) - (\ yE_k \% 2\ )\ ] = p'_i \quad (8\text{-}459)$$

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### 8.7.2 Filtering process for a set of samples across a horizontal or vertical block edge

Inputs to this process are the input sample values $p_i$ and $q_i$ with i in the range of 0..3 of a single set of samples across an edge that is to be filtered, chromaEdgeFlag, verticalEdgeFlag, and fieldModeFilteringFlag.

Outputs of this process are the filtered result sample values $p'_i$ and $q'_i$ with i in the range of 0..2.

The content dependent boundary filtering strength variable bS is derived as follows.

– If chromaEdgeFlag is equal to 0, the derivation process for the content dependent boundary filtering strength specified in subclause 8.7.2.1 is invoked with $p_0$, $q_0$, and verticalEdgeFlag as input, and the output is assigned to bS.

– Otherwise (chromaEdgeFlag is equal to 1), the bS used for filtering a set of samples of a horizontal or vertical chroma edge is set equal to the value of bS for filtering the set of samples of a horizontal or vertical luma edge, respectively, that contains the luma sample at location ( SubWidthC * x, SubHeightC * y ) inside the luma array of the same field, where ( x, y ) is the location of the chroma sample $q_0$ inside the chroma array for that field.

Let filterOffsetA and filterOffsetB be the values of FilterOffsetA and FilterOffsetB as specified in subclause 7.4.3 for the slice that contains the macroblock containing sample $q_0$.

Let $qP_p$ and $qP_q$ be variables specifying quantisation parameter values for the macroblocks containing the samples $p_0$ and $q_0$, respectively. The variables $qP_z$ (with z being replaced by p or q) are derived as follows.

– If chromaEdgeFlag is equal to 0, the following applies.

  – If the macroblock containing the sample $z_0$ is an I_PCM macroblock, $qP_z$ is set to 0.

  – Otherwise (the macroblock containing the sample $z_0$ is not an I_PCM macroblock), $qP_z$ is set to the value of $QP_Y$ of the macroblock containing the sample $z_0$.

– Otherwise (chromaEdgeFlag is equal to 1), the following applies.

  – If the macroblock containing the sample $z_0$ is an I_PCM macroblock, $qP_z$ is equal set to the value of $QP_C$ that corresponds to a value of 0 for $QP_Y$ as specified in subclause 8.5.8.

  – Otherwise (the macroblock containing the sample $z_0$ is not an I_PCM macroblock), $qP_z$ is set equal to the value of $QP_C$ that corresponds to the value $QP_Y$ of the macroblock containing the sample $z_0$ as specified in subclause 8.5.8.

The process specified in subclause 8.7.2.2 is invoked with $p_0$, $q_0$, $p_1$, $q_1$, chromaEdgeFlag, bS, filterOffsetA, filterOffsetB, $qP_p$, and $qP_q$ as inputs, and the outputs are assigned to filterSamplesFlag, indexA, $\alpha$, and $\beta$.

The variable chromaStyleFiltering is set by

chromaStyleFiltering = chromaEdgeFlag && ( ChromaArrayType != 3 ) (8-460)

Depending on the variable filterSamplesFlag, the following applies.

– If filterSamplesFlag is equal to 1, the following applies.

  – If bS is less than 4, the process specified in subclause 8.7.2.3 is invoked with $p_i$ and $q_i$ (i = 0..2), chromaEdgeFlag, chromaStyleFiltering, bS, $\beta$, and indexA given as input, and the output is assigned to $p'_i$ and $q'_i$ (i = 0..2).

  – Otherwise (bS is equal to 4), the process specified in subclause 8.7.2.4 is invoked with $p_i$ and $q_i$ (i = 0..3), chromaEdgeFlag, chromaStyleFiltering, $\alpha$, and $\beta$ given as input, and the output is assigned to $p'_i$ and $q'_i$ (i = 0..2).

– Otherwise (filterSamplesFlag is equal to 0), the filtered result samples $p'_i$ and $q'_i$ (i = 0..2) are replaced by the corresponding input samples $p_i$ and $q_i$:

for i = 0..2, $p'_i = p_i$ (8-461)

for i = 0..2, $q'_i = q_i$ (8-462)

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#### 8.7.2.1 Derivation process for the luma content dependent boundary filtering strength

Inputs to this process are the input sample values $p_0$ and $q_0$ of a single set of samples across an edge that is to be filtered and verticalEdgeFlag.

Output of this process is the variable bS.

Let the variable mixedModeEdgeFlag be derived as follows.

– If MbaffFrameFlag is equal to 1 and the samples $p_0$ and $q_0$ are in different macroblock pairs, one of which is a field macroblock pair and the other is a frame macroblock pair, mixedModeEdgeFlag is set equal to 1

– Otherwise, mixedModeEdgeFlag is set equal to 0.

The variable bS is derived as follows.

– If the block edge is also a macroblock edge and any of the following conditions are true, a value of bS equal to 4 is the output:

  – the samples $p_0$ and $q_0$ are both in frame macroblocks and either or both of the samples $p_0$ or $q_0$ is in a macroblock coded using an Intra macroblock prediction mode

  – the samples $p_0$ and $q_0$ are both in frame macroblocks and either or both of the samples $p_0$ or $q_0$ is in a macroblock that is in a slice with slice_type equal to SP or SI

  – MbaffFrameFlag is equal to 1 or field_pic_flag is equal to 1, and verticalEdgeFlag is equal to 1, and either or both of the samples $p_0$ or $q_0$ is in a macroblock coded using an Intra macroblock prediction mode

  – MbaffFrameFlag is equal to 1 or field_pic_flag is equal to 1, and verticalEdgeFlag is equal to 1, and either or both of the samples $p_0$ or $q_0$ is in a macroblock that is in a slice with slice_type equal to SP or SI

– Otherwise, if any of the following conditions are true, a value of bS equal to 3 is the output:

  – mixedModeEdgeFlag is equal to 0 and either or both of the samples $p_0$ or $q_0$ is in a macroblock coded using an Intra macroblock prediction mode

  – mixedModeEdgeFlag is equal to 0 and either or both of the samples $p_0$ or $q_0$ is in a macroblock that is in a slice with slice_type equal to SP or SI

  – mixedModeEdgeFlag is equal to 1, verticalEdgeFlag is equal to 0, and either or both of the samples $p_0$ or $q_0$ is in a macroblock coded using an Intra macroblock prediction mode

  – mixedModeEdgeFlag is equal to 1, verticalEdgeFlag is equal to 0, and either or both of the samples $p_0$ or $q_0$ is in a macroblock that is in a slice with slice_type equal to SP or SI

– Otherwise, if the following condition is true, a value of bS equal to 2 is the output:

  – the luma block containing sample $p_0$ or the luma block containing sample $q_0$ contains non-zero transform coefficient levels

– Otherwise, if any of the following conditions are true, a value of bS equal to 1 is the output:

  – mixedModeEdgeFlag is equal to 1

  – mixedModeEdgeFlag is equal to 0 and for the prediction of the macroblock/sub-macroblock partition containing the sample $p_0$ different reference pictures or a different number of motion vectors are used than for the prediction of the macroblock/sub-macroblock partition containing the sample $q_0$.

    NOTE 1 – The determination of whether the reference pictures used for the two macroblock/sub-macroblock partitions are the same or different is based only on which pictures are referenced, without regard to whether a prediction is formed using an index into reference picture list 0 or an index into reference picture list 1, and also without regard to whether or not the index position within a reference picture list is different or not.

  – mixedModeEdgeFlag is equal to 0 and one motion vector is used to predict the macroblock/sub-macroblock partition containing the sample $p_0$ and one motion vector is used to predict the macroblock/sub-macroblock partition containing the sample $q_0$ and the absolute difference between the horizontal or vertical component of the motion vectors used is greater than or equal to 4 in units of quarter luma frame samples.

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– mixedModeEdgeFlag is equal to 0 and two motion vectors and two different reference pictures are used to predict the macroblock/sub-macroblock partition containing the sample $p_0$ and two motion vectors for the same two reference pictures are used to predict the macroblock/sub-macroblock partition containing the sample $q_0$ and the absolute difference between the horizontal or vertical component of the two motion vectors used in the prediction of the two macroblock/sub-macroblock partitions for the same reference picture is greater than or equal to 4 in units of quarter luma frame samples.

– mixedModeEdgeFlag is equal to 0 and two motion vectors for the same reference picture are used to predict the macroblock/sub-macroblock partition containing the sample $p_0$ and two motion vectors for the same reference picture are used to predict the macroblock/sub-macroblock partition containing the sample $q_0$ and both of the following conditions are true:

  – The absolute difference between the horizontal or vertical component of list 0 motion vectors used in the prediction of the two macroblock/sub-macroblock partitions is greater than or equal to 4 in quarter luma frame samples or the absolute difference between the horizontal or vertical component of the list 1 motion vectors used in the prediction of the two macroblock/sub-macroblock partitions is greater than or equal to 4 in units of quarter luma frame samples.

  – The absolute difference between the horizontal or vertical component of list 0 motion vector used in the prediction of the macroblock/sub-macroblock partition containing the sample $p_0$ and the list 1 motion vector used in the prediction of the macroblock/sub-macroblock partition containing the sample $q_0$ is greater than or equal to 4 in units of quarter luma frame samples or the absolute difference between the horizontal or vertical component of the list 1 motion vector used in the prediction of the macroblock/sub-macroblock partition containing the sample $p_0$ and list 0 motion vector used in the prediction of the macroblock/sub-macroblock partition containing the sample $q_0$ is greater than or equal to 4 in units of quarter luma frame samples.

    NOTE 2 – A vertical difference of 4 in units of quarter luma frame samples is a difference of 2 in units of quarter luma field samples

– Otherwise, a value of bS equal to 0 is the output.

#### 8.7.2.2 Derivation process for the thresholds for each block edge

Inputs to this process are

– the input sample values $p_0$, $q_0$, $p_1$ and $q_1$ of a single set of samples across an edge that is to be filtered,

– the variables chromaEdgeFlag and bS, for the set of input samples, as specified in 8.7.2,

– the variables filterOffsetA, filterOffsetB, $qP_p$, and $qP_q$.

Outputs of this process are the variable filterSamplesFlag, which indicates whether the input samples are filtered, the value of indexA, and the values of the threshold variables $\alpha$ and $\beta$.

Let $qP_{av}$ be a variable specifying an average quantisation parameter. It is derived as follows.

$$qP_{av} = ( qP_p + qP_q + 1 ) >> 1 \quad (8\text{-}463)$$

NOTE – In SP and SI slices, $qP_{av}$ is derived in the same way as in other slice types. $QS_Y$ from Equation 7-29 is not used in the deblocking filter.

Let indexA be a variable that is used to access the $\alpha$ table (Table 8-16) as well as the $t_{C0}$ table (Table 8-17), which is used in filtering of edges with bS less than 4 as specified in subclause 8.7.2.3, and let indexB be a variable that is used to access the $\beta$ table (Table 8-16). The variables indexA and indexB are derived as follows.

$$indexA = Clip3( 0, 51, qP_{av} + filterOffsetA ) \quad (8\text{-}464)$$

$$indexB = Clip3( 0, 51, qP_{av} + filterOffsetB ) \quad (8\text{-}465)$$

The variables $\alpha'$ and $\beta'$ depending on the values of indexA and indexB are specified in Table 8-16. Depending on chromaEdgeFlag, the corresponding threshold variables $\alpha$ and $\beta$ are derived as follows.

– If chromaEdgeFlag is equal to 0,

$$\alpha = \alpha' * (1 << ( BitDepth_Y - 8 ) ) \quad (8\text{-}466)$$

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$$\beta = \beta' * (1 << ( BitDepth_Y - 8 ) ) \quad (8\text{-}467)$$

– Otherwise (chromaEdgeFlag is equal to 1),

$$\alpha = \alpha' * (1 << ( BitDepth_C - 8 ) ) \quad (8\text{-}468)$$

$$\beta = \beta' * (1 << ( BitDepth_C - 8 ) ) \quad (8\text{-}469)$$

The variable filterSamplesFlag is derived by

$$filterSamplesFlag = ( bS != 0 \ \&\& \ Abs( p_0 - q_0 ) < \alpha \ \&\& \ Abs( p_1 - p_0 ) < \beta \ \&\& \ Abs( q_1 - q_0 ) < \beta ) \quad (8\text{-}470)$$

**Table 8-16 – Derivation of offset dependent threshold variables α' and β' from indexA and indexB**

| | indexA (for α') or indexB (for β') | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| α' | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 13 |
| β' | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 4 |

**Table 8-16 (concluded) – Derivation of indexA and indexB from offset dependent threshold variables α' and β'**

| | indexA (for α') or indexB (for β') | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 |
| α' | 15 | 17 | 20 | 22 | 25 | 28 | 32 | 36 | 40 | 45 | 50 | 56 | 63 | 71 | 80 | 90 | 101 | 113 | 127 | 144 | 162 | 182 | 203 | 226 | 255 | 255 |
| β' | 6 | 6 | 7 | 7 | 8 | 8 | 9 | 9 | 10 | 10 | 11 | 11 | 12 | 12 | 13 | 13 | 14 | 14 | 15 | 15 | 16 | 16 | 17 | 17 | 18 | 18 |

#### 8.7.2.3 Filtering process for edges with bS less than 4

Inputs to this process are the input sample values $p_i$ and $q_i$ (i = 0..2) of a single set of samples across an edge that is to be filtered, chromaEdgeFlag, chromaStyleFiltering, bS, β, and indexA, for the set of input samples, as specified in 8.7.2.

Outputs of this process are the filtered result sample values $p'_i$ and $q'_i$ (i = 0..2) for the set of input sample values.

Let Clip1( ) be a function that is replaced by $Clip1_Y( )$ when chromaStyleFiltering is equal to 0 and by $Clip1_C( )$ when chromaStyleFiltering is equal to 1.

The filtered result samples $p'_0$ and $q'_0$ are derived by

$$\Delta = Clip3( -t_C, t_C, ( ( ( ( q_0 - p_0 ) << 2 ) + ( p_1 - q_1 ) + 4 ) >> 3 ) ) \quad (8\text{-}471)$$

$$p'_0 = Clip1( p_0 + \Delta ) \quad (8\text{-}472)$$

$$q'_0 = Clip1( q_0 - \Delta ) \quad (8\text{-}473)$$

where the threshold $t_C$ is determined as follows.

– If chromaStyleFiltering is equal to 0,

$$t_C = t_{C0} + ( ( a_p < \beta ) \ ? \ 1 : 0 ) + ( ( a_q < \beta ) \ ? \ 1 : 0 ) \quad (8\text{-}474)$$

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– Otherwise (chromaStyleFiltering is equal to 1),

$$t_C = t_{C0} + 1 \tag{8-475}$$

Depending on the values of indexA and bS the variable $t'_{C0}$ is specified in Table 8-17. Depending on chromaEdgeFlag, the corresponding threshold variable $t_{C0}$ is derived as follows.

– If chromaEdgeFlag is equal to 0,

$$t_{C0} = t'_{C0} * (1 << ( \text{BitDepth}_Y - 8 ) ) \tag{8-476}$$

– Otherwise (chromaEdgeFlag is equal to 1),

$$t_{C0} = t'_{C0} * (1 << ( \text{BitDepth}_C - 8 ) ) \tag{8-477}$$

Let $a_p$ and $a_q$ be two threshold variables specified by

$$a_p = \text{Abs}( p_2 - p_0 ) \tag{8-478}$$

$$a_q = \text{Abs}( q_2 - q_0 ) \tag{8-479}$$

The filtered result sample $p'_1$ is derived as follows

– If chromaStyleFiltering is equal to 0 and $a_p$ is less than $\beta$,

$$p'_1 = p_1 + \text{Clip3}( -t_{C0}, t_{C0}, ( p_2 + ( ( p_0 + q_0 + 1 ) >> 1 ) - ( p_1 << 1 ) ) >> 1 ) \tag{8-480}$$

– Otherwise (chromaStyleFiltering is equal to 1 or $a_p$ is greater than or equal to $\beta$),

$$p'_1 = p_1 \tag{8-481}$$

The filtered result sample $q'_1$ is derived as follows

– If chromaStyleFiltering is equal to 0 and $a_q$ is less than $\beta$,

$$q'_1 = q_1 + \text{Clip3}( -t_{C0}, t_{C0}, ( q_2 + ( ( p_0 + q_0 + 1 ) >> 1 ) - ( q_1 << 1 ) ) >> 1 ) \tag{8-482}$$

– Otherwise (chromaStyleFiltering is equal to 1 or $a_q$ is greater than or equal to $\beta$),

$$q'_1 = q_1 \tag{8-483}$$

The filtered result samples $p'_2$ and $q'_2$ are always set equal to the input samples $p_2$ and $q_2$:

$$p'_2 = p_2 \tag{8-484}$$

$$q'_2 = q_2 \tag{8-485}$$

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**Table 8-17 – Value of variable $t'_{C0}$ as a function of indexA and bS**

| | indexA | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| bS = 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| bS = 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| bS = 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Table 8-17 (concluded) – Value of variable $t'_{C0}$ as a function of indexA and bS**

| | indexA | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 |
| bS = 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 6 | 6 | 7 | 8 | 9 | 10 | 11 | 13 |
| bS = 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 7 | 8 | 8 | 10 | 11 | 12 | 13 | 15 | 17 |
| bS = 3 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 6 | 6 | 7 | 8 | 9 | 10 | 11 | 13 | 14 | 16 | 18 | 20 | 23 | 25 |

#### 8.7.2.4 Filtering process for edges for bS equal to 4

Inputs to this process are the input sample values $p_i$ and $q_i$ (i = 0..3) of a single set of samples across an edge that is to be filtered, chromaEdgeFlag, chromaStyleFiltering, and the values of the threshold variables $\alpha$ and $\beta$ for the set of samples, as specified in subclause 8.7.2.

Outputs of this process are the filtered result sample values $p'_i$ and $q'_i$ (i = 0..2) for the set of input sample values.

Let $a_p$ and $a_q$ be two threshold variables as specified in Equations 8-478 and 8-479, respectively, in subclause 8.7.2.3.

The filtered result samples $p'_i$ (i = 0..2) are derived as follows.

– If chromaStyleFiltering is equal to 0 and the following condition holds,

$$a_p < \beta \;\&\&\; Abs( p_0 - q_0 ) < ( ( \alpha >> 2 ) + 2 ) \tag{8-486}$$

then the variables $p'_0$, $p'_1$, and $p'_2$ are derived by

$$p'_0 = ( p_2 + 2*p_1 + 2*p_0 + 2*q_0 + q_1 + 4 ) >> 3 \tag{8-487}$$

$$p'_1 = ( p_2 + p_1 + p_0 + q_0 + 2 ) >> 2 \tag{8-488}$$

$$p'_2 = ( 2*p_3 + 3*p_2 + p_1 + p_0 + q_0 + 4 ) >> 3 \tag{8-489}$$

– Otherwise (chromaStyleFiltering is equal to 1 or the condition in Equation 8-486 does not hold), the variables $p'_0$, $p'_1$, and $p'_2$ are derived by

$$p'_0 = ( 2*p_1 + p_0 + q_1 + 2 ) >> 2 \tag{8-490}$$

$$p'_1 = p_1 \tag{8-491}$$

$$p'_2 = p_2 \tag{8-492}$$

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The filtered result samples $q'_i$ (i = 0..2) are derived as follows.

– If chromaStyleFiltering is equal to 0 and the following condition holds,

$$a_q < \beta \;\&\&\; Abs( p_0 - q_0 ) < ( ( \alpha >> 2 ) + 2 ) \quad (8\text{-}493)$$

then the variables $q'_0$, $q'_1$, and $q'_2$ are derived by

$$q'_0 = ( p_1 + 2*p_0 + 2*q_0 + 2*q_1 + q_2 + 4 ) >> 3 \quad (8\text{-}494)$$

$$q'_1 = ( p_0 + q_0 + q_1 + q_2 + 2 ) >> 2 \quad (8\text{-}495)$$

$$q'_2 = ( 2*q_3 + 3*q_2 + q_1 + q_0 + p_0 + 4 ) >> 3 \quad (8\text{-}496)$$

– Otherwise (chromaStyleFiltering is equal to 1 or the condition in Equation 8-493 does not hold), the variables $q'_0$, $q'_1$, and $q'_2$ are derived by

$$q'_0 = ( 2*q_1 + q_0 + p_1 + 2 ) >> 2 \quad (8\text{-}497)$$

$$q'_1 = q_1 \quad (8\text{-}498)$$

$$q'_2 = q_2 \quad (8\text{-}499)$$

# 9 Parsing process

Inputs to this process are bits from the RBSP.

Outputs of this process are syntax element values.

This process is invoked when the descriptor of a syntax element in the syntax tables in subclause 7.3 is equal to ue(v), me(v), se(v), te(v) (see subclause 9.1), ce(v) (see subclause 9.2), or ae(v) (see subclause 9.3).

## 9.1 Parsing process for Exp-Golomb codes

This process is invoked when the descriptor of a syntax element in the syntax tables in subclause 7.3 is equal to ue(v), me(v), se(v), or te(v). For syntax elements in subclauses 7.3.4 and 7.3.5, this process is invoked only when entropy_coding_mode_flag is equal to 0.

Inputs to this process are bits from the RBSP.

Outputs of this process are syntax element values.

Syntax elements coded as ue(v), me(v), or se(v) are Exp-Golomb-coded. Syntax elements coded as te(v) are truncated Exp-Golomb-coded. The parsing process for these syntax elements begins with reading the bits starting at the current location in the bitstream up to and including the first non-zero bit, and counting the number of leading bits that are equal to 0. This process is specified as follows:

```
leadingZeroBits = -1;
for( b = 0; !b; leadingZeroBits++ )
    b = read_bits( 1 )
```

The variable codeNum is then assigned as follows:

$$codeNum = 2^{leadingZeroBits} - 1 + read_bits( leadingZeroBits )$$

where the value returned from read_bits( leadingZeroBits ) is interpreted as a binary representation of an unsigned integer with most significant bit written first.

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Table 9-1 illustrates the structure of the Exp-Golomb code by separating the bit string into "prefix" and "suffix" bits. The "prefix" bits are those bits that are parsed in the above pseudo-code for the computation of leadingZeroBits, and are shown as either 0 or 1 in the bit string column of Table 9-1. The "suffix" bits are those bits that are parsed in the computation of codeNum and are shown as $x_i$ in Table 9-1, with i being in the range 0 to leadingZeroBits - 1, inclusive. Each $x_i$ can take on values 0 or 1.

**Table 9-1 – Bit strings with "prefix" and "suffix" bits and assignment to codeNum ranges (informative)**

| Bit string form | Range of codeNum |
|---|---|
| 1 | 0 |
| 0 1 $x_0$ | 1-2 |
| 0 0 1 $x_1$ $x_0$ | 3-6 |
| 0 0 0 1 $x_2$ $x_1$ $x_0$ | 7-14 |
| 0 0 0 0 1 $x_3$ $x_2$ $x_1$ $x_0$ | 15-30 |
| 0 0 0 0 0 1 $x_4$ $x_3$ $x_2$ $x_1$ $x_0$ | 31-62 |
| ... | ... |

Table 9-2 illustrates explicitly the assignment of bit strings to codeNum values.

**Table 9-2 – Exp-Golomb bit strings and codeNum in explicit form and used as ue(v) (informative)**

| Bit string | codeNum |
|---|---|
| 1 | 0 |
| 0 1 0 | 1 |
| 0 1 1 | 2 |
| 0 0 1 0 0 | 3 |
| 0 0 1 0 1 | 4 |
| 0 0 1 1 0 | 5 |
| 0 0 1 1 1 | 6 |
| 0 0 0 1 0 0 0 | 7 |
| 0 0 0 1 0 0 1 | 8 |
| 0 0 0 1 0 1 0 | 9 |
| ... | ... |

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Depending on the descriptor, the value of a syntax element is derived as follows.

– If the syntax element is coded as ue(v), the value of the syntax element is equal to codeNum.

– Otherwise, if the syntax element is coded as se(v), the value of the syntax element is derived by invoking the mapping process for signed Exp-Golomb codes as specified in subclause 9.1.1 with codeNum as the input.

– Otherwise, if the syntax element is coded as me(v), the value of the syntax element is derived by invoking the mapping process for coded block pattern as specified in subclause 9.1.2 with codeNum as the input.

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– Otherwise (the syntax element is coded as te(v)), the range of possible values for the syntax element is determined first. The range of this syntax element may be between 0 and x, with x being greater than or equal to 1 and the range is used in the derivation of the value of the syntax element value as follows

  – If x is greater than 1, codeNum and the value of the syntax element is derived in the same way as for syntax elements coded as ue(v)

  – Otherwise (x is equal to 1), the parsing process for codeNum which is equal to the value of the syntax element is given by a process equivalent to:

```
b = read_bits( 1 )
codeNum = !b
```

### 9.1.1 Mapping process for signed Exp-Golomb codes

Input to this process is codeNum as specified in subclause 9.1.

Output of this process is a value of a syntax element coded as se(v).

The syntax element is assigned to the codeNum by ordering the syntax element by its absolute value in increasing order and representing the positive value for a given absolute value with the lower codeNum. Table 9-3 provides the assignment rule.

**Table 9-3 – Assignment of syntax element to codeNum for signed Exp-Golomb coded syntax elements se(v)**

| codeNum | syntax element value |
|---|---|
| 0 | 0 |
| 1 | 1 |
| 2 | –1 |
| 3 | 2 |
| 4 | –2 |
| 5 | 3 |
| 6 | –3 |
| k | $(-1)^{k+1}$ Ceil( k÷2 ) |

### 9.1.2 Mapping process for coded block pattern

Input to this process is codeNum as specified in subclause 9.1.

Output of this process is a value of the syntax element coded_block_pattern coded as me(v).

Table 9-4 shows the assignment of coded_block_pattern to codeNum depending on whether the macroblock prediction mode is equal to Intra_4x4, Intra_8x8 or Inter.

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**Table 9-4 – Assignment of codeNum to values of coded_block_pattern for macroblock prediction modes**

**(a) ChromaArrayType is equal to 1 or 2**

| codeNum | coded_block_pattern | |
|---|---|---|
| | Intra_4x4, Intra_8x8 | Inter |
| 0 | 47 | 0 |
| 1 | 31 | 16 |
| 2 | 15 | 1 |
| 3 | 0 | 2 |
| 4 | 23 | 4 |
| 5 | 27 | 8 |
| 6 | 29 | 32 |
| 7 | 30 | 3 |
| 8 | 7 | 5 |
| 9 | 11 | 10 |
| 10 | 13 | 12 |
| 11 | 14 | 15 |
| 12 | 39 | 47 |
| 13 | 43 | 7 |
| 14 | 45 | 11 |
| 15 | 46 | 13 |
| 16 | 16 | 14 |
| 17 | 3 | 6 |
| 18 | 5 | 9 |
| 19 | 10 | 31 |
| 20 | 12 | 35 |
| 21 | 19 | 37 |
| 22 | 21 | 42 |
| 23 | 26 | 44 |
| 24 | 28 | 33 |
| 25 | 35 | 34 |
| 26 | 37 | 36 |
| 27 | 42 | 40 |
| 28 | 44 | 39 |
| 29 | 1 | 43 |
| 30 | 2 | 45 |
| 31 | 4 | 46 |
| 32 | 8 | 17 |

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| codeNum | coded_block_pattern | |
|---|---|---|
| | Intra_4x4, Intra_8x8 | Inter |
| 33 | 17 | 18 |
| 34 | 18 | 20 |
| 35 | 20 | 24 |
| 36 | 24 | 19 |
| 37 | 6 | 21 |
| 38 | 9 | 26 |
| 39 | 22 | 28 |
| 40 | 25 | 23 |
| 41 | 32 | 27 |
| 42 | 33 | 29 |
| 43 | 34 | 30 |
| 44 | 36 | 22 |
| 45 | 40 | 25 |
| 46 | 38 | 38 |
| 47 | 41 | 41 |

**(b) ChromaArrayType is equal to 0 or 3**

| codeNum | coded_block_pattern | |
|---|---|---|
| | Intra_4x4, Intra_8x8 | Inter |
| 0 | 15 | 0 |
| 1 | 0 | 1 |
| 2 | 7 | 2 |
| 3 | 11 | 4 |
| 4 | 13 | 8 |
| 5 | 14 | 3 |
| 6 | 3 | 5 |
| 7 | 5 | 10 |
| 8 | 10 | 12 |
| 9 | 12 | 15 |
| 10 | 1 | 7 |
| 11 | 2 | 11 |
| 12 | 4 | 13 |
| 13 | 8 | 14 |
| 14 | 6 | 6 |
| 15 | 9 | 9 |

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## 9.2 CAVLC parsing process for transform coefficient levels

This process is invoked when parsing syntax elements with descriptor equal to ce(v) in subclause 7.3.5.3.2 and when entropy_coding_mode_flag is equal to 0.

Inputs to this process are bits from slice data, a maximum number of non-zero transform coefficient levels maxNumCoeff, the luma block index luma4x4BlkIdx or the chroma block index chroma4x4BlkIdx, cb4x4BlkIdx or cr4x4BlkIdx of the current block of transform coefficient levels.

Output of this process is the list coeffLevel containing transform coefficient levels of the luma block with block index luma4x4BlkIdx or the chroma block with block index chroma4x4BlkIdx, cb4x4BlkIdx or cr4x4BlkIdx.

The process is specified in the following ordered steps:

1. All transform coefficient levels, with indices from 0 to maxNumCoeff - 1, in the list coeffLevel are set equal to 0.
2. The total number of non-zero transform coefficient levels TotalCoeff( coeff_token ) and the number of trailing one transform coefficient levels TrailingOnes( coeff_token ) are derived by parsing coeff_token (see subclause 9.2.1) as follows.
   - If the number of non-zero transform coefficient levels TotalCoeff( coeff_token ) is equal to 0, the list coeffLevel containing 0 values is returned and no further step is carried out.
   - Otherwise, the following steps are carried out.
     a. The non-zero transform coefficient levels are derived by parsing trailing_ones_sign_flag, level_prefix, and level_suffix (see subclause 9.2.2).
     b. The runs of zero transform coefficient levels before each non-zero transform coefficient level are derived by parsing total_zeros and run_before (see subclause 9.2.3).
     c. The level and run information are combined into the list coeffLevel (see subclause 9.2.4).

### 9.2.1 Parsing process for total number of transform coefficient levels and trailing ones

Inputs to this process are bits from slice data, a maximum number of non-zero transform coefficient levels maxNumCoeff, the luma block index luma4x4BlkIdx or the chroma block index chroma4x4BlkIdx, cb4x4BlkIdx or cr4x4BlkIdx of the current block of transform coefficient levels.

Outputs of this process are TotalCoeff( coeff_token ), TrailingOnes( coeff_token ), and the variable nC.

The syntax element coeff_token is decoded using one of the six VLCs specified in the six right-most columns of Table 9-5. Each VLC specifies both TotalCoeff( coeff_token ) and TrailingOnes( coeff_token ) for a given codeword coeff_token. VLC selection is dependent upon a variable nC that is derived as follows.

– If the CAVLC parsing process is invoked for ChromaDCLevel, nC is derived as follows.
  – If ChromaArrayType is equal to 1, nC is set equal to -1,
  – Otherwise (ChromaArrayType is equal to 2), nC is set equal to -2,
– Otherwise, the following applies.
  – When the CAVLC parsing process is invoked for Intra16x16DCLevel, luma4x4BlkIdx is set equal to 0.
  – When the CAVLC parsing process is invoked for CbIntra16x16DCLevel, cb4x4BlkIdx is set equal to 0.
  – When the CAVLC parsing process is invoked for CrIntra16x16DCLevel, cr4x4BlkIdx is set equal to 0.
  – The variables blkA and blkB are derived as follows.
    – If the CAVLC parsing process is invoked for Intra16x16DCLevel, Intra16x16ACLevel, or LumaLevel, the process specified in subclause 6.4.10.4 is invoked with luma4x4BlkIdx as the input, and the output is assigned to mbAddrA, mbAddrB, luma4x4BlkIdxA, and luma4x4BlkIdxB. The 4x4 luma block specified by mbAddrA\luma4x4BlkIdxA is assigned to blkA, and the 4x4 luma block specified by mbAddrB\luma4x4BlkIdxB is assigned to blkB.

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- Otherwise, if the CAVLC parsing process is invoked for CbIntra16x16DCLevel, CbIntra16x16ACLevel, or CbLevel, the process specified in subclause 6.4.10.6 is invoked with cb4x4BlkIdx as the input, and the output is assigned to mbAddrA, mbAddrB, cb4x4BlkIdxA, and cb4x4BlkIdxB. The 4x4 Cb block specified by mbAddrA\cb4x4BlkIdxA is assigned to blkA, and the 4x4 Cb block specified by mbAddrB\cb4x4BlkIdxB is assigned to blkB.
- Otherwise, if the CAVLC parsing process is invoked for CrIntra16x16DCLevel, CrIntra16x16ACLevel, or CrLevel, the process specified in subclause 6.4.10.6 is invoked with cr4x4BlkIdx as the input, and the output is assigned to mbAddrA, mbAddrB, cr4x4BlkIdxA, and cr4x4BlkIdxB. The 4x4 Cr block specified by mbAddrA\cr4x4BlkIdxA is assigned to blkA, and the 4x4 Cr block specified by mbAddrB\cr4x4BlkIdxB is assigned to blkB.
- Otherwise (the CAVLC parsing process is invoked for ChromaACLevel), the process specified in subclause 6.4.10.5 is invoked with chroma4x4BlkIdx as input, and the output is assigned to mbAddrA, mbAddrB, chroma4x4BlkIdxA, and chroma4x4BlkIdxB. The 4x4 chroma block specified by mbAddrA\iCbCr\chroma4x4BlkIdxA is assigned to blkA, and the 4x4 chroma block specified by mbAddrB\iCbCr\chroma4x4BlkIdxB is assigned to blkB.

– Let nA and nB be the number of non-zero transform coefficient levels (given by TotalCoeff( coeff_token )) in the block of transform coefficient levels blkA located to the left of the current block and the block of transform coefficient levels blkB located above the current block, respectively.

– With N replaced by A and B, in mbAddrN, blkN, and nN the following applies.

  - If any of the following conditions is true, nN is set equal to 0.
    - mbAddrN is not available
    - The current macroblock is coded using an Intra prediction mode, constrained_intra_pred_flag is equal to 1 and mbAddrN is coded using Inter prediction and slice data partitioning is in use (nal_unit_type is in the range of 2 to 4, inclusive).
    - The macroblock mbAddrN has mb_type equal to P_Skip or B_Skip
    - All AC residual transform coefficient levels of the neighbouring block blkN are equal to 0 due to the corresponding bit of CodedBlockPatternLuma or CodedBlockPatternChroma being equal to 0
  - Otherwise, if mbAddrN is an I_PCM macroblock, nN is set equal to 16.
  - Otherwise, nN is set equal to the value TotalCoeff( coeff_token ) of the neighbouring block blkN.

    NOTE 1 – The values nA and nB that are derived using TotalCoeff( coeff_token ) do not include the DC transform coefficient levels in Intra_16x16 macroblocks or DC transform coefficient levels in chroma blocks, because these transform coefficient levels are decoded separately. When the block above or to the left belongs to an Intra_16x16 macroblock, or is a chroma block, nA and nB is the number of decoded non-zero AC transform coefficient levels.

    NOTE 2 – When parsing for Intra16x16DCLevel, CbIntra16x16DCLevel, or CrIntra16x16DCLevel, the values nA and nB are based on the number of non-zero transform coefficient levels in adjacent 4x4 blocks and not on the number of non-zero DC transform coefficient levels in adjacent 16x16 blocks.

– Given the values of nA and nB, the variable nC is derived as follows.

  - If both mbAddrA and mbAddrB are available, the variable nC is set equal to ( nA + nB + 1 ) >> 1.
  - Otherwise (mbAddrA is not available or mbAddrB is not available), the variable nC is set equal to nA + nB.

The value of TotalCoeff( coeff_token ) resulting from decoding coeff_token shall be in the range of 0 to maxNumCoeff, inclusive.

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**Table 9-5 – coeff_token mapping to TotalCoeff( coeff_token ) and TrailingOnes( coeff_token )**

| TrailingOnes ( coeff_token ) | TotalCoeff ( coeff_token ) | 0 <= nC < 2 | 2 <= nC < 4 | 4 <= nC < 8 | 8 <= nC | nC = = -1 | nC = = -2 |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 1 | 11 | 1111 | 0000 11 | 01 | 1 |
| 0 | 1 | 0001 01 | 0010 11 | 0011 11 | 0000 00 | 0001 11 | 0001 111 |
| 1 | 1 | 01 | 10 | 1110 | 0000 01 | 1 | 01 |
| 0 | 2 | 0000 0111 | 0001 11 | 0010 11 | 0001 00 | 0001 00 | 0001 110 |
| 1 | 2 | 0001 00 | 0011 1 | 0111 1 | 0001 01 | 0001 10 | 0001 101 |
| 2 | 2 | 001 | 011 | 1101 | 0001 10 | 001 | 001 |
| 0 | 3 | 0000 0011 1 | 0000 111 | 0010 00 | 0010 00 | 0000 11 | 0000 0011 1 |
| 1 | 3 | 0000 0110 | 0010 10 | 0110 0 | 0010 01 | 0000 011 | 0001 100 |
| 2 | 3 | 0000 101 | 0010 01 | 0111 0 | 0010 10 | 0000 010 | 0001 011 |
| 3 | 3 | 0001 1 | 0101 | 1100 | 0010 11 | 0001 01 | 0000 1 |
| 0 | 4 | 0000 0001 11 | 0000 0111 | 0001 111 | 0011 00 | 0000 10 | 0000 0011 0 |
| 1 | 4 | 0000 0011 0 | 0001 10 | 0101 0 | 0011 01 | 0000 0011 | 0000 0010 1 |
| 2 | 4 | 0000 0101 | 0001 01 | 0101 1 | 0011 10 | 0000 0010 | 0001 010 |
| 3 | 4 | 0000 11 | 0100 | 1011 | 0011 11 | 0000 000 | 0000 01 |
| 0 | 5 | 0000 0000 111 | 0000 0100 | 0001 011 | 0100 00 | - | 0000 0001 11 |
| 1 | 5 | 0000 0001 10 | 0000 110 | 0100 0 | 0100 01 | - | 0000 0001 10 |
| 2 | 5 | 0000 0010 1 | 0000 101 | 0100 1 | 0100 10 | - | 0000 0010 0 |
| 3 | 5 | 0000 100 | 0011 0 | 1010 | 0100 11 | - | 0001 001 |
| 0 | 6 | 0000 0000 0111 1 | 0000 0011 1 | 0001 001 | 0101 00 | - | 0000 0000 111 |
| 1 | 6 | 0000 0000 110 | 0000 0110 | 0011 10 | 0101 01 | - | 0000 0000 110 |
| 2 | 6 | 0000 0001 01 | 0000 0101 | 0011 01 | 0101 10 | - | 0000 0001 01 |
| 3 | 6 | 0000 0100 | 0010 00 | 1001 | 0101 11 | - | 0001 000 |
| 0 | 7 | 0000 0000 0101 1 | 0000 0001 111 | 0001 000 | 0110 00 | - | 0000 0000 0111 |
| 1 | 7 | 0000 0000 0111 0 | 0000 0011 0 | 0010 10 | 0110 01 | - | 0000 0000 0110 |
| 2 | 7 | 0000 0000 101 | 0000 0010 1 | 0010 01 | 0110 10 | - | 0000 0000 101 |
| 3 | 7 | 0000 0010 0 | 0001 00 | 1000 | 0110 11 | - | 0000 0001 00 |
| 0 | 8 | 0000 0000 0100 0 | 0000 0001 011 | 0000 1111 | 0111 00 | - | 0000 0000 0011 1 |
| 1 | 8 | 0000 0000 0101 0 | 0000 0001 110 | 0001 110 | 0111 01 | - | 0000 0000 0101 |
| 2 | 8 | 0000 0000 0110 1 | 0000 0001 101 | 0001 101 | 0111 10 | - | 0000 0000 0100 |
| 3 | 8 | 0000 0001 00 | 0000 100 | 0110 1 | 0111 11 | - | 0000 0000 100 |
| 0 | 9 | 0000 0000 0011 11 | 0000 0000 1111 | 0000 1011 | 1000 00 | - | |
| 1 | 9 | 0000 0000 0011 10 | 0000 0001 010 | 0000 1110 | 1000 01 | - | |
| 2 | 9 | 0000 0000 0100 1 | 0000 0001 001 | 0001 010 | 1000 10 | - | |
| 3 | 9 | 0000 0000 100 | 0000 0010 0 | 0011 00 | 1000 11 | - | |
| 0 | 10 | 0000 0000 0010 11 | 0000 0000 1011 | 0000 0111 1 | 1001 00 | - | |

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| TrailingOnes ( coeff_token ) | TotalCoeff ( coeff_token ) | 0 <= nC < 2 | 2 <= nC < 4 | 4 <= nC < 8 | 8 <= nC | nC = = -1 | nC = = -2 |
|---|---|---|---|---|---|---|---|
| 1 | 10 | 0000 0000 0010 10 | 0000 0000 1110 | 0000 1010 | 1001 01 | - | |
| 2 | 10 | 0000 0000 0011 01 | 0000 0000 1101 | 0000 1101 | 1001 10 | - | |
| 3 | 10 | 0000 0000 0110 0 | 0000 0001 100 | 0001 100 | 1001 11 | - | |
| 0 | 11 | 0000 0000 0001 111 | 0000 0000 1000 | 0000 0101 1 | 1010 00 | - | |
| 1 | 11 | 0000 0000 0001 110 | 0000 0000 1010 | 0000 0111 0 | 1010 01 | - | |
| 2 | 11 | 0000 0000 0010 01 | 0000 0000 1001 | 0000 1001 | 1010 10 | - | |
| 3 | 11 | 0000 0000 0011 00 | 0000 0001 000 | 0000 1100 | 1010 11 | - | |
| 0 | 12 | 0000 0000 0001 011 | 0000 0000 0111 1 | 0000 0100 0 | 1011 00 | - | |
| 1 | 12 | 0000 0000 0001 010 | 0000 0000 0111 0 | 0000 0101 0 | 1011 01 | - | |
| 2 | 12 | 0000 0000 0001 101 | 0000 0000 0110 1 | 0000 0110 1 | 1011 10 | - | |
| 3 | 12 | 0000 0000 0010 00 | 0000 0000 1100 | 0000 1000 | 1011 11 | - | |
| 0 | 13 | 0000 0000 0000 1111 | 0000 0000 0101 1 | 0000 0011 01 | 1100 00 | - | |
| 1 | 13 | 0000 0000 0000 001 | 0000 0000 0101 0 | 0000 0011 1 | 1100 01 | - | |
| 2 | 13 | 0000 0000 0001 001 | 0000 0000 0100 1 | 0000 0100 1 | 1100 10 | - | |
| 3 | 13 | 0000 0000 0001 100 | 0000 0000 0110 0 | 0000 0110 0 | 1100 11 | - | |
| 0 | 14 | 0000 0000 0000 1011 | 0000 0000 0011 1 | 0000 0010 01 | 1101 00 | - | |
| 1 | 14 | 0000 0000 0000 1110 | 0000 0000 0010 11 | 0000 0011 00 | 1101 01 | - | |
| 2 | 14 | 0000 0000 0000 1101 | 0000 0000 0011 0 | 0000 0010 11 | 1101 10 | - | |
| 3 | 14 | 0000 0000 0001 000 | 0000 0000 0100 0 | 0000 0010 10 | 1101 11 | - | |
| 0 | 15 | 0000 0000 0000 0111 | 0000 0000 0010 01 | 0000 0001 01 | 1110 00 | - | |
| 1 | 15 | 0000 0000 0000 1010 | 0000 0000 0010 00 | 0000 0010 00 | 1110 01 | - | |
| 2 | 15 | 0000 0000 0000 1001 | 0000 0000 0010 10 | 0000 0001 11 | 1110 10 | - | |
| 3 | 15 | 0000 0000 0000 1100 | 0000 0000 0000 1 | 0000 0001 10 | 1110 11 | - | |
| 0 | 16 | 0000 0000 0000 0100 | 0000 0000 0001 11 | 0000 0000 01 | 1111 00 | - | |
| 1 | 16 | 0000 0000 0000 0110 | 0000 0000 0001 10 | 0000 0001 00 | 1111 01 | - | |
| 2 | 16 | 0000 0000 0000 0101 | 0000 0000 0001 01 | 0000 0000 11 | 1111 10 | - | |
| 3 | 16 | 0000 0000 0000 1000 | 0000 0000 0001 00 | 0000 0000 10 | 1111 11 | - | |

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### 9.2.2 Parsing process for level information

Inputs to this process are bits from slice data, the number of non-zero transform coefficient levels TotalCoeff( coeff_token ), and the number of trailing one transform coefficient levels TrailingOnes( coeff_token ).

Output of this process is a list with name level containing transform coefficient levels.

Initially an index i is set equal to 0. Then the following procedure is iteratively applied TrailingOnes( coeff_token ) times to decode the trailing one transform coefficient levels (if any):

- A 1-bit syntax element trailing_ones_sign_flag is decoded and evaluated as follows.
  - If trailing_ones_sign_flag is equal to 0, the value +1 is assigned to level[ i ].
  - Otherwise (trailing_ones_sign_flag is equal to 1), the value -1 is assigned to level[ i ].
- The index i is incremented by 1.

Following the decoding of the trailing one transform coefficient levels, a variable suffixLength is initialised as follows.

- If TotalCoeff( coeff_token ) is greater than 10 and TrailingOnes( coeff_token ) is less than 3, suffixLength is set equal to 1.
- Otherwise (TotalCoeff( coeff_token ) is less than or equal to 10 or TrailingOnes( coeff_token ) is equal to 3), suffixLength is set equal to 0.

The following procedure is then applied iteratively ( TotalCoeff( coeff_token ) – TrailingOnes( coeff_token ) ) times to decode the remaining levels (if any):

- The syntax element level_prefix is decoded as specified in subclause 9.2.2.1.
- The variable levelSuffixSize is set equal to the variable suffixLength with the exception of the following two cases.
- When level_prefix is equal to 14 and suffixLength is equal to 0, levelSuffixSize is set equal to 4.
- When level_prefix is greater than or equal to 15, levelSuffixSize is set equal to level_prefix - 3.
- The syntax element level_suffix is decoded as follows.
  - If levelSuffixSize is greater than 0, the syntax element level_suffix is decoded as unsigned integer representation u(v) with levelSuffixSize bits.
  - Otherwise (levelSuffixSize is equal to 0), the syntax element level_suffix is inferred to be equal to 0.
- A variable levelCode is set equal to ( Min( 15, level_prefix ) << suffixLength ) + level_suffix.
- When level_prefix is greater than or equal to 15 and suffixLength is equal to 0, levelCode is incremented by 15.
- When level_prefix is greater than or equal to 16, levelCode is incremented by (1<<( level_prefix – 3 )) – 4096.
- When the index i is equal to TrailingOnes( coeff_token ) and TrailingOnes( coeff_token ) is less than 3, levelCode is incremented by 2.
- The variable level[ i ] is derived as follows.
  - If levelCode is an even number, the value ( levelCode + 2 ) >> 1 is assigned to level[ i ].
  - Otherwise (levelCode is an odd number), the value ( -levelCode – 1) >> 1 is assigned to level[ i ].
- When suffixLength is equal to 0, suffixLength is set equal to 1.
- When the absolute value of level[ i ] is greater than ( 3 << ( suffixLength – 1 ) ) and suffixLength is less than 6, suffixLength is incremented by 1.
- The index i is incremented by 1.

#### 9.2.2.1 Parsing process for level_prefix

Inputs to this process are bits from slice data.

Output of this process is level_prefix.

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The parsing process for this syntax element consists in reading the bits starting at the current location in the bitstream up to and including the first non-zero bit, and counting the number of leading bits that are equal to 0. This process is specified as follows:

```
leadingZeroBits = -1
for( b = 0; !b; leadingZeroBits++ )
    b = read_bits( 1 )
level_prefix = leadingZeroBits
```

Table 9-6 illustrates the codeword table for level_prefix.

**Table 9-6 – Codeword table for level_prefix (informative)**

| level_prefix | bit string |
|---|---|
| 0 | 1 |
| 1 | 01 |
| 2 | 001 |
| 3 | 0001 |
| 4 | 0000 1 |
| 5 | 0000 01 |
| 6 | 0000 001 |
| 7 | 0000 0001 |
| 8 | 0000 0000 1 |
| 9 | 0000 0000 01 |
| 10 | 0000 0000 001 |
| 11 | 0000 0000 0001 |
| 12 | 0000 0000 0000 1 |
| 13 | 0000 0000 0000 01 |
| 14 | 0000 0000 0000 001 |
| 15 | 0000 0000 0000 0001 |
| … | … |

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### 9.2.3 Parsing process for run information

Inputs to this process are bits from slice data, the number of non-zero transform coefficient levels TotalCoeff( coeff_token ), and the maximum number of non-zero transform coefficient levels maxNumCoeff.

Output of this process is a list of runs of zero transform coefficient levels preceding non-zero transform coefficient levels called run.

Initially, an index i is set equal to 0.

The variable zerosLeft is derived as follows.

– If the number of non-zero transform coefficient levels TotalCoeff( coeff_token ) is equal to the maximum number of non-zero transform coefficient levels maxNumCoeff, a variable zerosLeft is set equal to 0.


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– Otherwise (the number of non-zero transform coefficient levels TotalCoeff( coeff_token ) is less than the maximum number of non-zero transform coefficient levels maxNumCoeff), total_zeros is decoded and zerosLeft is set equal to its value.

Let the variable tzVlcIndex be equal to TotalCoeff( coeff_token ).

The VLC used to decode total_zeros is derived as follows:

If maxNumCoeff is equal to 4, one of the VLCs specified in Table 9-9 (a) is used.

– Otherwise, if maxNumCoeff is equal to 8, one of the VLCs specified in Table 9-9 (b) is used.

– Otherwise (maxNumCoeff is not equal to 4 and not equal to 8), VLCs from Table 9-7 and 9-8 are used.

The following procedure is then applied iteratively ( TotalCoeff( coeff_token ) – 1 ) times:

– The variable run[ i ] is derived as follows.
  – If zerosLeft is greater than zero, a value run_before is decoded based on Table 9-10 and zerosLeft. run[ i ] is set equal to run_before.
  – Otherwise (zerosLeft is equal to 0), run[ i ] is set equal to 0.

– The value of run[ i ] is subtracted from zerosLeft and the result assigned to zerosLeft. The result of the subtraction shall be greater than or equal to 0.

– The index i is incremented by 1.

Finally the value of zerosLeft is assigned to run[ i ].

**Table 9-7 – total_zeros tables for 4x4 blocks with tzVlcIndex 1 to 7**

| total_zeros | tzVlcIndex | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | 1 | 111 | 0101 | 0001 1 | 0101 | 0000 01 | 0000 01 |
| 1 | 011 | 110 | 111 | 111 | 0100 | 0000 1 | 0000 1 |
| 2 | 010 | 101 | 110 | 0101 | 0011 | 111 | 101 |
| 3 | 0011 | 100 | 101 | 0100 | 111 | 110 | 100 |
| 4 | 0010 | 011 | 0100 | 110 | 110 | 101 | 011 |
| 5 | 0001 1 | 0101 | 0011 | 101 | 101 | 100 | 11 |
| 6 | 0001 0 | 0100 | 100 | 100 | 100 | 011 | 010 |
| 7 | 0000 11 | 0011 | 011 | 0011 | 011 | 010 | 0001 |
| 8 | 0000 10 | 0010 | 0010 | 011 | 0010 | 0001 | 001 |
| 9 | 0000 011 | 0001 1 | 0001 1 | 0010 | 0000 1 | 001 | 0000 00 |
| 10 | 0000 010 | 0001 0 | 0001 0 | 0001 0 | 0001 | 0000 00 | |
| 11 | 0000 0011 | 0000 11 | 0000 01 | 0000 1 | 0000 0 | | |
| 12 | 0000 0010 | 0000 10 | 0000 1 | 0000 0 | | | |
| 13 | 0000 0001 1 | 0000 01 | 0000 00 | | | | |
| 14 | 0000 0001 0 | 0000 00 | | | | | |
| 15 | 0000 0000 1 | | | | | | |

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**Table 9-8 – total_zeros tables for 4x4 blocks with tzVlcIndex 8 to 15**

| total_zeros | tzVlcIndex | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | 0000 01 | 0000 01 | 0000 1 | 0000 | 0000 | 000 | 00 | 0 |
| 1 | 0001 | 0000 00 | 0000 0 | 0001 | 0001 | 001 | 01 | 1 |
| 2 | 0000 1 | 0001 | 001 | 001 | 01 | 1 | 1 | |
| 3 | 011 | 11 | 11 | 010 | 1 | 01 | | |
| 4 | 11 | 10 | 10 | 1 | 001 | | | |
| 5 | 10 | 001 | 01 | 011 | | | | |
| 6 | 010 | 01 | 0001 | | | | | |
| 7 | 001 | 0000 1 | | | | | | |
| 8 | 0000 00 | | | | | | | |

**Table 9-9 – total_zeros tables for chroma DC 2x2 and 2x4 blocks**

**(a) Chroma DC 2x2 block (4:2:0 chroma sampling)**

| total_zeros | tzVlcIndex | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| 0 | 1 | 1 | 1 |
| 1 | 01 | 01 | 0 |
| 2 | 001 | 00 | |
| 3 | 000 | | |

**(b) Chroma DC 2x4 block (4:2:2 chroma sampling)**

| total_zeros | tzVlcIndex | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | 1 | 000 | 000 | 110 | 00 | 00 | 0 |
| 1 | 010 | 01 | 001 | 00 | 01 | 01 | 1 |
| 2 | 011 | 001 | 01 | 01 | 10 | 1 | |
| 3 | 0010 | 100 | 10 | 10 | 11 | | |
| 4 | 0011 | 101 | 110 | 111 | | | |
| 5 | 0001 | 110 | 111 | | | | |
| 6 | 0000 1 | 111 | | | | | |
| 7 | 0000 0 | | | | | | |

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**Table 9-10 – Tables for run_before**

| run_before | zerosLeft | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | >6 |
| 0 | 1 | 1 | 11 | 11 | 11 | 11 | 111 |
| 1 | 0 | 01 | 10 | 10 | 10 | 000 | 110 |
| 2 | - | 00 | 01 | 01 | 011 | 001 | 101 |
| 3 | - | - | 00 | 001 | 010 | 011 | 100 |
| 4 | - | - | - | 000 | 001 | 010 | 011 |
| 5 | - | - | - | - | 000 | 101 | 010 |
| 6 | - | - | - | - | - | 100 | 001 |
| 7 | - | - | - | - | - | - | 0001 |
| 8 | | - | - | - | - | - | 00001 |
| 9 | - | - | - | - | - | - | 000001 |
| 10 | - | - | - | - | - | - | 0000001 |
| 11 | - | - | - | - | - | - | 00000001 |
| 12 | - | - | - | - | - | - | 000000001 |
| 13 | - | - | - | - | - | - | 0000000001 |
| 14 | - | - | - | - | - | - | 00000000001 |

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### 9.2.4 Combining level and run information

Input to this process are a list of transform coefficient levels called level, a list of runs called run, and the number of non-zero transform coefficient levels TotalCoeff( coeff_token ).

Output of this process is an list coeffLevel of transform coefficient levels.

A variable coeffNum is set equal to -1 and an index i is set equal to ( TotalCoeff( coeff_token ) – 1 ). The following procedure is iteratively applied TotalCoeff( coeff_token ) times:

– coeffNum is incremented by run[ i ] + 1.

– coeffLevel[ coeffNum ] is set equal to level[ i ].

– The index i is decremented by 1.

## 9.3 CABAC parsing process for slice data

This process is invoked when parsing syntax elements with descriptor ae(v) in subclauses 7.3.4 and 7.3.5 when entropy_coding_mode_flag is equal to 1.

Inputs to this process are a request for a value of a syntax element and values of prior parsed syntax elements.

Output of this process is the value of the syntax element.

When starting the parsing of the slice data of a slice in subclause 7.3.4, the initialisation process of the CABAC parsing process is invoked as specified in subclause 9.3.1.

The parsing of syntax elements proceeds as follows:

For each requested value of a syntax element a binarization is derived as described in subclause 9.3.2.

The binarization for the syntax element and the sequence of parsed bins determines the decoding process flow as described in subclause 9.3.3.

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For each bin of the binarization of the syntax element, which is indexed by the variable binIdx, a context index ctxIdx is derived as specified in subclause 9.3.3.1.

For each ctxIdx the arithmetic decoding process is invoked as specified in subclause 9.3.3.2.

The resulting sequence ( $b_0$ .. $b_{binIdx}$ ) of parsed bins is compared to the set of bin strings given by the binarization process after decoding of each bin. When the sequence matches a bin string in the given set, the corresponding value is assigned to the syntax element.

In case the request for a value of a syntax element is processed for the syntax element mb_type and the decoded value of mb_type is equal to I_PCM, the decoding engine is initialised after the decoding of any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data as specified in subclause 9.3.1.2.

The whole CABAC parsing process is illustrated in the flowchart of Figure 9-1 with the abbreviation SE for syntax element.

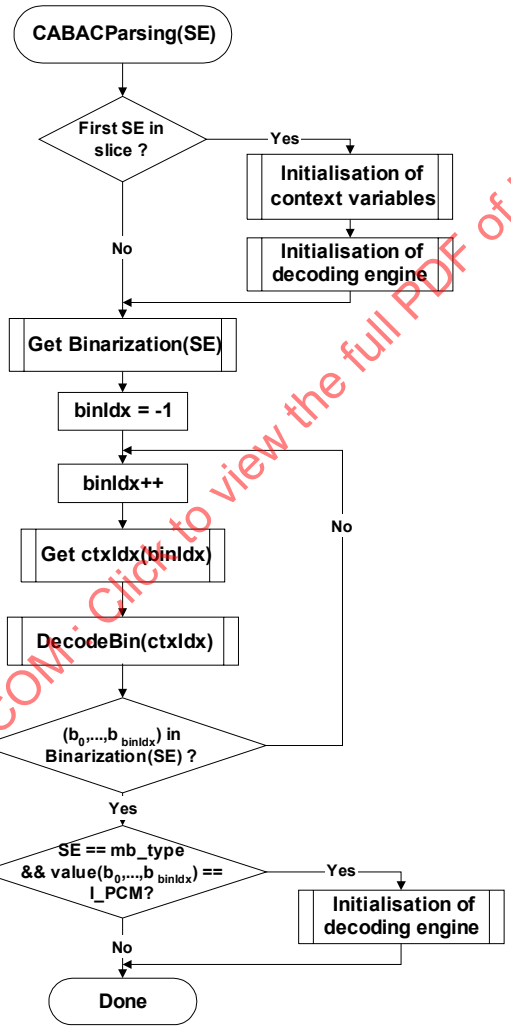


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**Figure 9-1 – Illustration of CABAC parsing process for a syntax element SE (informative)**


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### 9.3.1 Initialisation process

Outputs of this process are initialised CABAC internal variables.

The processes in subclauses 9.3.1.1 and 9.3.1.2 are invoked when starting the parsing of the slice data of a slice in subclause 7.3.4.

The process in subclause 9.3.1.2 is also invoked after decoding any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data for a macroblock of type I_PCM.

#### 9.3.1.1 Initialisation process for context variables

Outputs of this process are the initialised CABAC context variables indexed by ctxIdx.

Table 9-12 to Table 9-23 contain the values of the variables n and m used in the initialisation of context variables that are assigned to all syntax elements in subclauses 7.3.4 and 7.3.5 except for the end-of-slice flag.

For each context variable, the two variables pStateIdx and valMPS are initialised.

NOTE 1 – The variable pStateIdx corresponds to a probability state index and the variable valMPS corresponds to the value of the most probable symbol as further described in subclause 9.3.3.2.

The two values assigned to pStateIdx and valMPS for the initialisation are derived from $SliceQP_Y$, which is derived in Equation 7-28. Given the two table entries ( m, n ),

1. preCtxState = Clip3( 1, 126, ( ( m * Clip3( 0, 51, $SliceQP_Y$ ) ) >> 4 ) + n )
2. if( preCtxState <= 63 ) {

   pStateIdx = 63 - preCtxState

   valMPS = 0

   } else {

   pStateIdx = preCtxState - 64

   valMPS = 1

   }

In Table 9-11, the ctxIdx for which initialisation is needed for each of the slice types are listed. Also listed is the table number that includes the values of m and n needed for the initialisation. For P, SP and B slice type, the initialisation depends also on the value of the cabac_init_idc syntax element. Note that the syntax element names do not affect the initialisation process.

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**Table 9-11 – Association of ctxIdx and syntax elements for each slice type in the initialisation process**

| | Syntax element | Table | Slice type | | | |
|---|---|---|---|---|---|---|
| | | | SI | I | P, SP | B |
| slice_data( ) | mb_skip_flag | Table 9-13<br>Table 9-14 | | | 11-13 | 24-26 |
| | mb_field_decoding_flag | Table 9-18 | 70-72 | 70-72 | 70-72 | 70-72 |
| macroblock_layer( ) | mb_type | Table 9-12<br>Table 9-13<br>Table 9-14 | 0-10 | 3-10 | 14-20 | 27-35 |
| | transform_size_8x8_flag | Table 9-16 | na | 399-401 | 399-401 | 399-401 |
| | coded_block_pattern (luma) | Table 9-18 | 73-76 | 73-76 | 73-76 | 73-76 |
| | coded_block_pattern (chroma) | Table 9-18 | 77-84 | 77-84 | 77-84 | 77-84 |
| | mb_qp_delta | Table 9-17 | 60-63 | 60-63 | 60-63 | 60-63 |
| mb_pred( ) | prev_intra4x4_pred_mode_flag | Table 9-17 | 68 | 68 | 68 | 68 |
| | rem_intra4x4_pred_mode | Table 9-17 | 69 | 69 | 69 | 69 |
| | prev_intra8x8_pred_mode_flag | Table 9-17 | na | 68 | 68 | 68 |
| | rem_intra8x8_pred_mode | Table 9-17 | na | 69 | 69 | 69 |
| | intra_chroma_pred_mode | Table 9-17 | 64-67 | 64-67 | 64-67 | 64-67 |
| mb_pred( ) and sub_mb_pred( ) | ref_idx_l0 | Table 9-16 | | | 54-59 | 54-59 |
| | ref_idx_l1 | Table 9-16 | | | | 54-59 |
| | mvd_l0[ ][ ][ 0 ] | Table 9-15 | | | 40-46 | 40-46 |
| | mvd_l1[ ][ ][ 0 ] | Table 9-15 | | | | 40-46 |
| | mvd_l0[ ][ ][ 1 ] | Table 9-15 | | | 47-53 | 47-53 |
| | mvd_l1[ ][ ][ 1 ] | Table 9-15 | | | | 47-53 |
| sub_mb_pred( ) | sub_mb_type | Table 9-13<br>Table 9-14 | | | 21-23 | 36-39 |
| residual_block_cabac( ) | coded_block_flag | Table 9-18<br>Table 9-25<br>Table 9-33 | 85-104<br>460-483 | 85-104<br>460-483<br>1012-1023 | 85-104<br>460-483<br>1012-1023 | 85-104<br>460-483<br>1012-1023 |
| | significant_coeff_flag[ ] | Table 9-19<br>Table 9-22<br>Table 9-24<br>Table 9-24<br>Table 9-26<br>Table 9-30<br>Table 9-28<br>Table 9-29 | 105-165<br>277-337 | 105-165<br>277-337<br>402-416<br>436-450<br>484-571<br>776-863<br>660-689<br>718-747 | 105-165<br>277-337<br>402-416<br>436-450<br>484-571<br>776-863<br>660-689<br>718-747 | 105-165<br>277-337<br>402-416<br>436-450<br>484-571<br>776-863<br>660-689<br>718-747 |

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| | Syntax element | Table | Slice type | | | |
|---|---|---|---|---|---|---|
| | | | SI | I | P, SP | B |
| | last_significant_coeff_flag[ ] | Table 9-20<br>Table 9-23<br>Table 9-24<br>Table 9-24<br>Table 9-27<br>Table 9-31<br>Table 9-28<br>Table 9-29 | 166-226<br>338-398 | 166-226<br>338-398<br>417-425<br>451-459<br>572-659<br>864-951<br>690-707<br>748-765 | 166-226<br>338-398<br>417-425<br>451-459<br>572-659<br>864-951<br>690-707<br>748-765 | 166-226<br>338-398<br>417-425<br>451-459<br>572-659<br>864-951<br>690-707<br>748-765 |
| | coeff_abs_level_minus1[ ] | Table 9-21<br>Table 9-24<br>Table 9-32<br>Table 9-28<br>Table 9-29 | 227-275 | 227-275<br>426-435<br>952-1011<br>708-717<br>766-775 | 227-275<br>426-435<br>952-1011<br>708-717<br>766-775 | 227-275<br>426-435<br>952-1011<br>708-717<br>766-775 |

NOTE 2 – ctxIdx equal to 276 is associated with the end_of_slice_flag and the bin of mb_type, which specifies the I_PCM macroblock type. The decoding process specified in subclause 9.3.3.2.4 applies to ctxIdx equal to 276. This decoding process, however, may also be implemented by using the decoding process specified in subclause 9.3.3.2.1. In this case, the initial values associated with ctxIdx equal to 276 are specified to be pStateIdx = 63 and valMPS = 0, where pStateIdx = 63 represents a non-adapting probability state.

**Table 9-12 – Values of variables m and n for ctxIdx from 0 to 10**

| Initialisation variables | ctxIdx | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| m | 20 | 2 | 3 | 20 | 2 | 3 | -28 | -23 | -6 | -1 | 7 |
| n | -15 | 54 | 74 | -15 | 54 | 74 | 127 | 104 | 53 | 54 | 51 |

**Table 9-13 – Values of variables m and n for ctxIdx from 11 to 23**

| Value of cabac_init_idc | Initialisation variables | ctxIdx | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 0 | m | 23 | 23 | 21 | 1 | 0 | -37 | 5 | -13 | -11 | 1 | 12 | -4 | 17 |
| | n | 33 | 2 | 0 | 9 | 49 | 118 | 57 | 78 | 65 | 62 | 49 | 73 | 50 |
| 1 | m | 22 | 34 | 16 | -2 | 4 | -29 | 2 | -6 | -13 | 5 | 9 | -3 | 10 |
| | n | 25 | 0 | 0 | 9 | 41 | 118 | 65 | 71 | 79 | 52 | 50 | 70 | 54 |
| 2 | m | 29 | 25 | 14 | -10 | -3 | -27 | 26 | -4 | -24 | 5 | 6 | -17 | 14 |
| | n | 16 | 0 | 0 | 51 | 62 | 99 | 16 | 85 | 102 | 57 | 57 | 73 | 57 |

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**Table 9-14 – Values of variables m and n for ctxIdx from 24 to 39**

| Value of cabac_init_idc | Initialisation variables | ctxIdx | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
| 0 | m | 18 | 9 | 29 | 26 | 16 | 9 | -46 | -20 | 1 | -13 | -11 | 1 | -6 | -17 | -6 | 9 |
| | n | 64 | 43 | 0 | 67 | 90 | 104 | 127 | 104 | 67 | 78 | 65 | 62 | 86 | 95 | 61 | 45 |
| 1 | m | 26 | 19 | 40 | 57 | 41 | 26 | -45 | -15 | -4 | -6 | -13 | 5 | 6 | -13 | 0 | 8 |
| | n | 34 | 22 | 0 | 2 | 36 | 69 | 127 | 101 | 76 | 71 | 79 | 52 | 69 | 90 | 52 | 43 |
| 2 | m | 20 | 20 | 29 | 54 | 37 | 12 | -32 | -22 | -2 | -4 | -24 | 5 | -6 | -14 | -6 | 4 |
| | n | 40 | 10 | 0 | 0 | 42 | 97 | 127 | 117 | 74 | 85 | 102 | 57 | 93 | 88 | 44 | 55 |

**Table 9-15 – Values of variables m and n for ctxIdx from 40 to 53**

| Value of cabac_init_idc | Initialisation variables | ctxIdx | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 |
| 0 | m | -3 | -6 | -11 | 6 | 7 | -5 | 2 | 0 | -3 | -10 | 5 | 4 | -3 | 0 |
| | n | 69 | 81 | 96 | 55 | 67 | 86 | 88 | 58 | 76 | 94 | 54 | 69 | 81 | 88 |
| 1 | m | -2 | -5 | -10 | 2 | 2 | -3 | -3 | 1 | -3 | -6 | 0 | -3 | -7 | -5 |
| | n | 69 | 82 | 96 | 59 | 75 | 87 | 100 | 56 | 74 | 85 | 59 | 81 | 86 | 95 |
| 2 | m | -11 | -15 | -21 | 19 | 20 | 4 | 6 | 1 | -5 | -13 | 5 | 6 | -3 | -1 |
| | n | 89 | 103 | 116 | 57 | 58 | 84 | 96 | 63 | 85 | 106 | 63 | 75 | 90 | 101 |

**Table 9-16 – Values of variables m and n for ctxIdx from 54 to 59, and 399 to 401**

| Value of cabac_init_idc | Initialisation variables | ctxIdx | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 54 | 55 | 56 | 57 | 58 | 59 | 399 | 400 | 401 |
| I slices | m | na | na | na | na | na | na | 31 | 31 | 25 |
| | n | na | na | na | na | na | na | 21 | 31 | 50 |
| 0 | m | -7 | -5 | -4 | -5 | -7 | 1 | 12 | 11 | 14 |
| | n | 67 | 74 | 74 | 80 | 72 | 58 | 40 | 51 | 59 |
| 1 | m | -1 | -1 | 1 | -2 | -5 | 0 | 25 | 21 | 21 |
| | n | 66 | 77 | 70 | 86 | 72 | 61 | 32 | 49 | 54 |
| 2 | m | 3 | -4 | -2 | -12 | -7 | 1 | 21 | 19 | 17 |
| | n | 55 | 79 | 75 | 97 | 50 | 60 | 33 | 50 | 61 |

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**Table 9-17 – Values of variables m and n for ctxIdx from 60 to 69**

| Initialisation variables | ctxIdx | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **60** | **61** | **62** | **63** | **64** | **65** | **66** | **67** | **68** | **69** |
| **m** | 0 | 0 | 0 | 0 | -9 | 4 | 0 | -7 | 13 | 3 |
| **n** | 41 | 63 | 63 | 63 | 83 | 86 | 97 | 72 | 41 | 62 |

**Table 9-18 – Values of variables m and n for ctxIdx from 70 to 104**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | **0** | | **1** | | **2** | | | | | **0** | | **1** | | **2** | |
| | **m** | **n** | **m** | **n** | **m** | **n** | **m** | **n** | | **m** | **n** | **m** | **n** | **m** | **n** | **m** | **n** |
| **70** | 0 | 11 | 0 | 45 | 13 | 15 | 7 | 34 | **88** | -11 | 115 | -13 | 108 | -4 | 92 | 5 | 78 |
| **71** | 1 | 55 | -4 | 78 | 7 | 51 | -9 | 88 | **89** | -12 | 63 | -3 | 46 | 0 | 39 | -6 | 55 |
| **72** | 0 | 69 | -3 | 96 | 2 | 80 | -20 | 127 | **90** | -2 | 68 | -1 | 65 | 0 | 65 | 4 | 61 |
| **73** | -17 | 127 | -27 | 126 | -39 | 127 | -36 | 127 | **91** | -15 | 84 | -1 | 57 | -15 | 84 | -14 | 83 |
| **74** | -13 | 102 | -28 | 98 | -18 | 91 | -17 | 91 | **92** | -13 | 104 | -9 | 93 | -35 | 127 | -37 | 127 |
| **75** | 0 | 82 | -25 | 101 | -17 | 96 | -14 | 95 | **93** | -3 | 70 | -3 | 74 | -2 | 73 | -5 | 79 |
| **76** | -7 | 74 | -23 | 67 | -26 | 81 | -25 | 84 | **94** | -8 | 93 | -9 | 92 | -12 | 104 | -11 | 104 |
| **77** | -21 | 107 | -28 | 82 | -35 | 98 | -25 | 86 | **95** | -10 | 90 | -8 | 87 | -9 | 91 | -11 | 91 |
| **78** | -27 | 127 | -20 | 94 | -24 | 102 | -12 | 89 | **96** | -30 | 127 | -23 | 126 | -31 | 127 | -30 | 127 |
| **79** | -31 | 127 | -16 | 83 | -23 | 97 | -17 | 91 | **97** | -1 | 74 | 5 | 54 | 3 | 55 | 0 | 65 |
| **80** | -24 | 127 | -22 | 110 | -27 | 119 | -31 | 127 | **98** | -6 | 97 | 6 | 60 | 7 | 56 | -2 | 79 |
| **81** | -18 | 95 | -21 | 91 | -24 | 99 | -14 | 76 | **99** | -7 | 91 | 6 | 59 | 7 | 55 | 0 | 72 |
| **82** | -27 | 127 | -18 | 102 | -21 | 110 | -18 | 103 | **100** | -20 | 127 | 6 | 69 | 8 | 61 | -4 | 92 |
| **83** | -21 | 114 | -13 | 93 | -18 | 102 | -13 | 90 | **101** | -4 | 56 | -1 | 48 | -3 | 53 | -6 | 56 |
| **84** | -30 | 127 | -29 | 127 | -36 | 127 | -37 | 127 | **102** | -5 | 82 | 0 | 68 | 0 | 68 | 3 | 68 |
| **85** | -17 | 123 | -7 | 92 | 0 | 80 | 11 | 80 | **103** | -7 | 76 | -4 | 69 | -7 | 74 | -8 | 71 |
| **86** | -12 | 115 | -5 | 89 | -5 | 89 | 5 | 76 | **104** | -22 | 125 | -8 | 88 | -9 | 88 | -13 | 98 |
| **87** | -16 | 122 | -7 | 96 | -7 | 94 | 2 | 84 | | | | | | | | | |

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**Table 9-19 – Values of variables m and n for ctxIdx from 105 to 165**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **105** | -7 | 93 | -2 | 85 | -13 | 103 | -4 | 86 | **136** | -13 | 101 | 5 | 53 | 0 | 58 | -5 | 75 |
| **106** | -11 | 87 | -6 | 78 | -13 | 91 | -12 | 88 | **137** | -13 | 91 | -2 | 61 | -1 | 60 | -8 | 80 |
| **107** | -3 | 77 | -1 | 75 | -9 | 89 | -5 | 82 | **138** | -12 | 94 | 0 | 56 | -3 | 61 | -21 | 83 |
| **108** | -5 | 71 | -7 | 77 | -14 | 92 | -3 | 72 | **139** | -10 | 88 | 0 | 56 | -8 | 67 | -21 | 64 |
| **109** | -4 | 63 | 2 | 54 | -8 | 76 | -4 | 67 | **140** | -16 | 84 | -13 | 63 | -25 | 84 | -13 | 31 |
| **110** | -4 | 68 | 5 | 50 | -12 | 87 | -8 | 72 | **141** | -10 | 86 | -5 | 60 | -14 | 74 | -25 | 64 |
| **111** | -12 | 84 | -3 | 68 | -23 | 110 | -16 | 89 | **142** | -7 | 83 | -1 | 62 | -5 | 65 | -29 | 94 |
| **112** | -7 | 62 | 1 | 50 | -24 | 105 | -9 | 69 | **143** | -13 | 87 | 4 | 57 | 5 | 52 | 9 | 75 |
| **113** | -7 | 65 | 6 | 42 | -10 | 78 | -1 | 59 | **144** | -19 | 94 | -6 | 69 | 2 | 57 | 17 | 63 |
| **114** | 8 | 61 | -4 | 81 | -20 | 112 | 5 | 66 | **145** | 1 | 70 | 4 | 57 | 0 | 61 | -8 | 74 |
| **115** | 5 | 56 | 1 | 63 | -17 | 99 | 4 | 57 | **146** | 0 | 72 | 14 | 39 | -9 | 69 | -5 | 35 |
| **116** | -2 | 66 | -4 | 70 | -78 | 127 | -4 | 71 | **147** | -5 | 74 | 4 | 51 | -11 | 70 | -2 | 27 |
| **117** | 1 | 64 | 0 | 67 | -70 | 127 | -2 | 71 | **148** | 18 | 59 | 13 | 68 | 18 | 55 | 13 | 91 |
| **118** | 0 | 61 | 2 | 57 | -50 | 127 | 2 | 58 | **149** | -8 | 102 | 3 | 64 | -4 | 71 | 3 | 65 |
| **119** | -2 | 78 | -2 | 76 | -46 | 127 | -1 | 74 | **150** | -15 | 100 | 1 | 61 | 0 | 58 | -7 | 69 |
| **120** | 1 | 50 | 11 | 35 | -4 | 66 | -4 | 44 | **151** | 0 | 95 | 9 | 63 | 7 | 61 | 8 | 77 |
| **121** | 7 | 52 | 4 | 64 | -5 | 78 | -1 | 69 | **152** | -4 | 75 | 7 | 50 | 9 | 41 | -10 | 66 |
| **122** | 10 | 35 | 1 | 61 | -4 | 71 | 0 | 62 | **153** | 2 | 72 | 16 | 39 | 18 | 25 | 3 | 62 |
| **123** | 0 | 44 | 11 | 35 | -8 | 72 | -7 | 51 | **154** | -11 | 75 | 5 | 44 | 9 | 32 | -3 | 68 |
| **124** | 11 | 38 | 18 | 25 | -2 | 59 | -4 | 47 | **155** | -3 | 71 | 4 | 52 | 5 | 43 | -20 | 81 |
| **125** | 1 | 45 | 12 | 24 | -1 | 55 | -6 | 42 | **156** | 15 | 46 | 11 | 48 | 9 | 47 | 0 | 30 |
| **126** | 0 | 46 | 13 | 29 | -7 | 70 | -3 | 41 | **157** | -13 | 69 | -5 | 60 | 0 | 44 | 1 | 7 |
| **127** | 5 | 44 | 13 | 36 | -6 | 75 | -6 | 53 | **158** | 0 | 62 | -1 | 59 | 0 | 51 | -3 | 23 |
| **128** | 31 | 17 | -10 | 93 | -8 | 89 | 8 | 76 | **159** | 0 | 65 | 0 | 59 | 2 | 46 | -21 | 74 |
| **129** | 1 | 51 | -7 | 73 | -34 | 119 | -9 | 78 | **160** | 21 | 37 | 22 | 33 | 19 | 38 | 16 | 66 |
| **130** | 7 | 50 | -2 | 73 | -3 | 75 | -11 | 83 | **161** | -15 | 72 | 5 | 44 | -4 | 66 | -23 | 124 |
| **131** | 28 | 19 | 13 | 46 | 32 | 20 | 9 | 52 | **162** | 9 | 57 | 14 | 43 | 15 | 38 | 17 | 37 |
| **132** | 16 | 33 | 9 | 49 | 30 | 22 | 0 | 67 | **163** | 16 | 54 | -1 | 78 | 12 | 42 | 44 | -18 |
| **133** | 14 | 62 | -7 | 100 | -44 | 127 | -5 | 90 | **164** | 0 | 62 | 0 | 60 | 9 | 34 | 50 | -34 |
| **134** | -13 | 108 | 9 | 53 | 0 | 54 | 1 | 67 | **165** | 12 | 72 | 9 | 69 | 0 | 89 | -22 | 127 |
| **135** | -15 | 100 | 2 | 53 | -5 | 61 | -15 | 72 | | | | | | | | | |

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**Table 9-20 – Values of variables m and n for ctxIdx from 166 to 226**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **166** | 24 | 0 | 11 | 28 | 4 | 45 | 4 | 39 | **197** | 26 | -17 | 28 | 3 | 36 | -28 | 28 | -3 |
| **167** | 15 | 9 | 2 | 40 | 10 | 28 | 0 | 42 | **198** | 30 | -25 | 28 | 4 | 38 | -28 | 24 | 10 |
| **168** | 8 | 25 | 3 | 44 | 10 | 31 | 7 | 34 | **199** | 28 | -20 | 32 | 0 | 38 | -27 | 27 | 0 |
| **169** | 13 | 18 | 0 | 49 | 33 | -11 | 11 | 29 | **200** | 33 | -23 | 34 | -1 | 34 | -18 | 34 | -14 |
| **170** | 15 | 9 | 0 | 46 | 52 | -43 | 8 | 31 | **201** | 37 | -27 | 30 | 6 | 35 | -16 | 32 | -44 |
| **171** | 13 | 19 | 2 | 44 | 18 | 15 | 6 | 37 | **202** | 33 | -23 | 30 | 6 | 34 | -14 | 39 | -24 |
| **172** | 10 | 37 | 2 | 51 | 28 | 0 | 7 | 42 | **203** | 40 | -28 | 32 | 9 | 32 | -8 | 19 | 17 |
| **173** | 12 | 18 | 0 | 47 | 35 | -22 | 3 | 40 | **204** | 38 | -17 | 31 | 19 | 37 | -6 | 31 | 25 |
| **174** | 6 | 29 | 4 | 39 | 38 | -25 | 8 | 33 | **205** | 33 | -11 | 26 | 27 | 35 | 0 | 36 | 29 |
| **175** | 20 | 33 | 2 | 62 | 34 | 0 | 13 | 43 | **206** | 40 | -15 | 26 | 30 | 30 | 10 | 24 | 33 |
| **176** | 15 | 30 | 6 | 46 | 39 | -18 | 13 | 36 | **207** | 41 | -6 | 37 | 20 | 28 | 18 | 34 | 15 |
| **177** | 4 | 45 | 0 | 54 | 32 | -12 | 4 | 47 | **208** | 38 | 1 | 28 | 34 | 26 | 25 | 30 | 20 |
| **178** | 1 | 58 | 3 | 54 | 102 | -94 | 3 | 55 | **209** | 41 | 17 | 17 | 70 | 29 | 41 | 22 | 73 |
| **179** | 0 | 62 | 2 | 58 | 0 | 0 | 2 | 58 | **210** | 30 | -6 | 1 | 67 | 0 | 75 | 20 | 34 |
| **180** | 7 | 61 | 4 | 63 | 56 | -15 | 6 | 60 | **211** | 27 | 3 | 5 | 59 | 2 | 72 | 19 | 31 |
| **181** | 12 | 38 | 6 | 51 | 33 | -4 | 8 | 44 | **212** | 26 | 22 | 9 | 67 | 8 | 77 | 27 | 44 |
| **182** | 11 | 45 | 6 | 57 | 29 | 10 | 11 | 44 | **213** | 37 | -16 | 16 | 30 | 14 | 35 | 19 | 16 |
| **183** | 15 | 39 | 7 | 53 | 37 | -5 | 14 | 42 | **214** | 35 | -4 | 18 | 32 | 18 | 31 | 15 | 36 |
| **184** | 11 | 42 | 6 | 52 | 51 | -29 | 7 | 48 | **215** | 38 | -8 | 18 | 35 | 17 | 35 | 15 | 36 |
| **185** | 13 | 44 | 6 | 55 | 39 | -9 | 4 | 56 | **216** | 38 | -3 | 22 | 29 | 21 | 30 | 21 | 28 |
| **186** | 16 | 45 | 11 | 45 | 52 | -34 | 4 | 52 | **217** | 37 | 3 | 24 | 31 | 17 | 45 | 25 | 21 |
| **187** | 12 | 41 | 14 | 36 | 69 | -58 | 13 | 37 | **218** | 38 | 5 | 23 | 38 | 20 | 42 | 30 | 20 |
| **188** | 10 | 49 | 8 | 53 | 67 | -63 | 9 | 49 | **219** | 42 | 0 | 18 | 43 | 18 | 45 | 31 | 12 |
| **189** | 30 | 34 | -1 | 82 | 44 | -5 | 19 | 58 | **220** | 35 | 16 | 20 | 41 | 27 | 26 | 27 | 16 |
| **190** | 18 | 42 | 7 | 55 | 32 | 7 | 10 | 48 | **221** | 39 | 22 | 11 | 63 | 16 | 54 | 24 | 42 |
| **191** | 10 | 55 | -3 | 78 | 55 | -29 | 12 | 45 | **222** | 14 | 48 | 9 | 59 | 7 | 66 | 0 | 93 |
| **192** | 17 | 51 | 15 | 46 | 32 | 1 | 0 | 69 | **223** | 27 | 37 | 9 | 64 | 16 | 56 | 14 | 56 |
| **193** | 17 | 46 | 22 | 31 | 0 | 0 | 20 | 33 | **224** | 21 | 60 | -1 | 94 | 11 | 73 | 15 | 57 |
| **194** | 0 | 89 | -1 | 84 | 27 | 36 | 8 | 63 | **225** | 12 | 68 | -2 | 89 | 10 | 67 | 26 | 38 |
| **195** | 26 | -19 | 25 | 7 | 33 | -25 | 35 | -18 | **226** | 2 | 97 | -9 | 108 | -10 | 116 | -24 | 127 |
| **196** | 22 | -17 | 30 | -7 | 34 | -30 | 33 | -25 | | | | | | | | | |

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**Table 9-21 – Values of variables m and n for ctxIdx from 227 to 275**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **227** | -3 | 71 | -6 | 76 | -23 | 112 | -24 | 115 | **252** | -12 | 73 | -6 | 55 | -16 | 72 | -14 | 75 |
| **228** | -6 | 42 | -2 | 44 | -15 | 71 | -22 | 82 | **253** | -8 | 76 | 0 | 58 | -7 | 69 | -10 | 79 |
| **229** | -5 | 50 | 0 | 45 | -7 | 61 | -9 | 62 | **254** | -7 | 80 | 0 | 64 | -4 | 69 | -9 | 83 |
| **230** | -3 | 54 | 0 | 52 | 0 | 53 | 0 | 53 | **255** | -9 | 88 | -3 | 74 | -5 | 74 | -12 | 92 |
| **231** | -2 | 62 | -3 | 64 | -5 | 66 | 0 | 59 | **256** | -17 | 110 | -10 | 90 | -9 | 86 | -18 | 108 |
| **232** | 0 | 58 | -2 | 59 | -11 | 77 | -14 | 85 | **257** | -11 | 97 | 0 | 70 | 2 | 66 | -4 | 79 |
| **233** | 1 | 63 | -4 | 70 | -9 | 80 | -13 | 89 | **258** | -20 | 84 | -4 | 29 | -9 | 34 | -22 | 69 |
| **234** | -2 | 72 | -4 | 75 | -9 | 84 | -13 | 94 | **259** | -11 | 79 | 5 | 31 | 1 | 32 | -16 | 75 |
| **235** | -1 | 74 | -8 | 82 | -10 | 87 | -11 | 92 | **260** | -6 | 73 | 7 | 42 | 11 | 31 | -2 | 58 |
| **236** | -9 | 91 | -17 | 102 | -34 | 127 | -29 | 127 | **261** | -4 | 74 | 1 | 59 | 5 | 52 | 1 | 58 |
| **237** | -5 | 67 | -9 | 77 | -21 | 101 | -21 | 100 | **262** | -13 | 86 | -2 | 58 | -2 | 55 | -13 | 78 |
| **238** | -5 | 27 | 3 | 24 | -3 | 39 | -14 | 57 | **263** | -13 | 96 | -3 | 72 | -2 | 67 | -9 | 83 |
| **239** | -3 | 39 | 0 | 42 | -5 | 53 | -12 | 67 | **264** | -11 | 97 | -3 | 81 | 0 | 73 | -4 | 81 |
| **240** | -2 | 44 | 0 | 48 | -7 | 61 | -11 | 71 | **265** | -19 | 117 | -11 | 97 | -8 | 89 | -13 | 99 |
| **241** | 0 | 46 | 0 | 55 | -11 | 75 | -10 | 77 | **266** | -8 | 78 | 0 | 58 | 3 | 52 | -13 | 81 |
| **242** | -16 | 64 | -6 | 59 | -15 | 77 | -21 | 85 | **267** | -5 | 33 | 8 | 5 | 7 | 4 | -6 | 38 |
| **243** | -8 | 68 | -7 | 71 | -17 | 91 | -16 | 88 | **268** | -4 | 48 | 10 | 14 | 10 | 8 | -13 | 62 |
| **244** | -10 | 78 | -12 | 83 | -25 | 107 | -23 | 104 | **269** | -2 | 53 | 14 | 18 | 17 | 8 | -6 | 58 |
| **245** | -6 | 77 | -11 | 87 | -25 | 111 | -15 | 98 | **270** | -3 | 62 | 13 | 27 | 16 | 19 | -2 | 59 |
| **246** | -10 | 86 | -30 | 119 | -28 | 122 | -37 | 127 | **271** | -13 | 71 | 2 | 40 | 3 | 37 | -16 | 73 |
| **247** | -12 | 92 | 1 | 58 | -11 | 76 | -10 | 82 | **272** | -10 | 79 | 0 | 58 | -1 | 61 | -10 | 76 |
| **248** | -15 | 55 | -3 | 29 | -10 | 44 | -8 | 48 | **273** | -12 | 86 | -3 | 70 | -5 | 73 | -13 | 86 |
| **249** | -10 | 60 | -1 | 36 | -10 | 52 | -8 | 61 | **274** | -13 | 90 | -6 | 79 | -1 | 70 | -9 | 83 |
| **250** | -6 | 62 | 1 | 38 | -10 | 57 | -8 | 66 | **275** | -14 | 97 | -8 | 85 | -4 | 78 | -10 | 87 |
| **251** | -4 | 65 | 2 | 43 | -9 | 58 | -7 | 70 | | | | | | | | | |

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**Table 9-22 – Values of variables m and n for ctxIdx from 277 to 337**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **277** | -6 | 93 | -13 | 106 | -21 | 126 | -22 | 127 | **308** | -16 | 96 | -1 | 51 | -16 | 77 | -10 | 67 |
| **278** | -6 | 84 | -16 | 106 | -23 | 124 | -25 | 127 | **309** | -7 | 88 | 7 | 49 | -2 | 64 | 1 | 68 |
| **279** | -8 | 79 | -10 | 87 | -20 | 110 | -25 | 120 | **310** | -8 | 85 | 8 | 52 | 2 | 61 | 0 | 77 |
| **280** | 0 | 66 | -21 | 114 | -26 | 126 | -27 | 127 | **311** | -7 | 85 | 9 | 41 | -6 | 67 | 2 | 64 |
| **281** | -1 | 71 | -18 | 110 | -25 | 124 | -19 | 114 | **312** | -9 | 85 | 6 | 47 | -3 | 64 | 0 | 68 |
| **282** | 0 | 62 | -14 | 98 | -17 | 105 | -23 | 117 | **313** | -13 | 88 | 2 | 55 | 2 | 57 | -5 | 78 |
| **283** | -2 | 60 | -22 | 110 | -27 | 121 | -25 | 118 | **314** | 4 | 66 | 13 | 41 | -3 | 65 | 7 | 55 |
| **284** | -2 | 59 | -21 | 106 | -27 | 117 | -26 | 117 | **315** | -3 | 77 | 10 | 44 | -3 | 66 | 5 | 59 |
| **285** | -5 | 75 | -18 | 103 | -17 | 102 | -24 | 113 | **316** | -3 | 76 | 6 | 50 | 0 | 62 | 2 | 65 |
| **286** | -3 | 62 | -21 | 107 | -26 | 117 | -28 | 118 | **317** | -6 | 76 | 5 | 53 | 9 | 51 | 14 | 54 |
| **287** | -4 | 58 | -23 | 108 | -27 | 116 | -31 | 120 | **318** | 10 | 58 | 13 | 49 | -1 | 66 | 15 | 44 |
| **288** | -9 | 66 | -26 | 112 | -33 | 122 | -37 | 124 | **319** | -1 | 76 | 4 | 63 | -2 | 71 | 5 | 60 |
| **289** | -1 | 79 | -10 | 96 | -10 | 95 | -10 | 94 | **320** | -1 | 83 | 6 | 64 | -2 | 75 | 2 | 70 |
| **290** | 0 | 71 | -12 | 95 | -14 | 100 | -15 | 102 | **321** | -7 | 99 | -2 | 69 | -1 | 70 | -2 | 76 |
| **291** | 3 | 68 | -5 | 91 | -8 | 95 | -10 | 99 | **322** | -14 | 95 | -2 | 59 | -9 | 72 | -18 | 86 |
| **292** | 10 | 44 | -9 | 93 | -17 | 111 | -13 | 106 | **323** | 2 | 95 | 6 | 70 | 14 | 60 | 12 | 70 |
| **293** | -7 | 62 | -22 | 94 | -28 | 114 | -50 | 127 | **324** | 0 | 76 | 10 | 44 | 16 | 37 | 5 | 64 |
| **294** | 15 | 36 | -5 | 86 | -6 | 89 | -5 | 92 | **325** | -5 | 74 | 9 | 31 | 0 | 47 | -12 | 70 |
| **295** | 14 | 40 | 9 | 67 | -2 | 80 | 17 | 57 | **326** | 0 | 70 | 12 | 43 | 18 | 35 | 11 | 55 |
| **296** | 16 | 27 | -4 | 80 | -4 | 82 | -5 | 86 | **327** | -11 | 75 | 3 | 53 | 11 | 37 | 5 | 56 |
| **297** | 12 | 29 | -10 | 85 | -9 | 85 | -13 | 94 | **328** | 1 | 68 | 14 | 34 | 12 | 41 | 0 | 69 |
| **298** | 1 | 44 | -1 | 70 | -8 | 81 | -12 | 91 | **329** | 0 | 65 | 10 | 38 | 10 | 41 | 2 | 65 |
| **299** | 20 | 36 | 7 | 60 | -1 | 72 | -2 | 77 | **330** | -14 | 73 | -3 | 52 | 2 | 48 | -6 | 74 |
| **300** | 18 | 32 | 9 | 58 | 5 | 64 | 0 | 71 | **331** | 3 | 62 | 13 | 40 | 12 | 41 | 5 | 54 |
| **301** | 5 | 42 | 5 | 61 | 1 | 67 | -1 | 73 | **332** | 4 | 62 | 17 | 32 | 13 | 41 | 7 | 54 |
| **302** | 1 | 48 | 12 | 50 | 9 | 56 | 4 | 64 | **333** | -1 | 68 | 7 | 44 | 0 | 59 | -6 | 76 |
| **303** | 10 | 62 | 15 | 50 | 0 | 69 | -7 | 81 | **334** | -13 | 75 | 7 | 38 | 3 | 50 | -11 | 82 |
| **304** | 17 | 46 | 18 | 49 | 1 | 69 | 5 | 64 | **335** | 11 | 55 | 13 | 50 | 19 | 40 | -2 | 77 |
| **305** | 9 | 64 | 17 | 54 | 7 | 69 | 15 | 57 | **336** | 5 | 64 | 10 | 57 | 3 | 66 | -2 | 77 |
| **306** | -12 | 104 | 10 | 41 | -7 | 69 | 1 | 67 | **337** | 12 | 70 | 26 | 43 | 18 | 50 | 25 | 42 |
| **307** | -11 | 97 | 7 | 46 | -6 | 67 | 0 | 68 | | | | | | | | | |

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**Table 9-23 – Values of variables m and n for ctxIdx from 338 to 398**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **338** | 15 | 6 | 14 | 11 | 19 | -6 | 17 | -13 | **369** | 32 | -26 | 31 | -4 | 40 | -37 | 37 | -17 |
| **339** | 6 | 19 | 11 | 14 | 18 | -6 | 16 | -9 | **370** | 37 | -30 | 27 | 6 | 38 | -30 | 32 | 1 |
| **340** | 7 | 16 | 9 | 11 | 14 | 0 | 17 | -12 | **371** | 44 | -32 | 34 | 8 | 46 | -33 | 34 | 15 |
| **341** | 12 | 14 | 18 | 11 | 26 | -12 | 27 | -21 | **372** | 34 | -18 | 30 | 10 | 42 | -30 | 29 | 15 |
| **342** | 18 | 13 | 21 | 9 | 31 | -16 | 37 | -30 | **373** | 34 | -15 | 24 | 22 | 40 | -24 | 24 | 25 |
| **343** | 13 | 11 | 23 | -2 | 33 | -25 | 41 | -40 | **374** | 40 | -15 | 33 | 19 | 49 | -29 | 34 | 22 |
| **344** | 13 | 15 | 32 | -15 | 33 | -22 | 42 | -41 | **375** | 33 | -7 | 22 | 32 | 38 | -12 | 31 | 16 |
| **345** | 15 | 16 | 32 | -15 | 37 | -28 | 48 | -47 | **376** | 35 | -5 | 26 | 31 | 40 | -10 | 35 | 18 |
| **346** | 12 | 23 | 34 | -21 | 39 | -30 | 39 | -32 | **377** | 33 | 0 | 21 | 41 | 38 | -3 | 31 | 28 |
| **347** | 13 | 23 | 39 | -23 | 42 | -30 | 46 | -40 | **378** | 38 | 2 | 26 | 44 | 46 | -5 | 33 | 41 |
| **348** | 15 | 20 | 42 | -33 | 47 | -42 | 52 | -51 | **379** | 33 | 13 | 23 | 47 | 31 | 20 | 36 | 28 |
| **349** | 14 | 26 | 41 | -31 | 45 | -36 | 46 | -41 | **380** | 23 | 35 | 16 | 65 | 29 | 30 | 27 | 47 |
| **350** | 14 | 44 | 46 | -28 | 49 | -34 | 52 | -39 | **381** | 13 | 58 | 14 | 71 | 25 | 44 | 21 | 62 |
| **351** | 17 | 40 | 38 | -12 | 41 | -17 | 43 | -19 | **382** | 29 | -3 | 8 | 60 | 12 | 48 | 18 | 31 |
| **352** | 17 | 47 | 21 | 29 | 32 | 9 | 32 | 11 | **383** | 26 | 0 | 6 | 63 | 11 | 49 | 19 | 26 |
| **353** | 24 | 17 | 45 | -24 | 69 | -71 | 61 | -55 | **384** | 22 | 30 | 17 | 65 | 26 | 45 | 36 | 24 |
| **354** | 21 | 21 | 53 | -45 | 63 | -63 | 56 | -46 | **385** | 31 | -7 | 21 | 24 | 22 | 22 | 24 | 23 |
| **355** | 25 | 22 | 48 | -26 | 66 | -64 | 62 | -50 | **386** | 35 | -15 | 23 | 20 | 23 | 22 | 27 | 16 |
| **356** | 31 | 27 | 65 | -43 | 77 | -74 | 81 | -67 | **387** | 34 | -3 | 26 | 23 | 27 | 21 | 24 | 30 |
| **357** | 22 | 29 | 43 | -19 | 54 | -39 | 45 | -20 | **388** | 34 | 3 | 27 | 32 | 33 | 20 | 31 | 29 |
| **358** | 19 | 35 | 39 | -10 | 52 | -35 | 35 | -2 | **389** | 36 | -1 | 28 | 23 | 26 | 28 | 22 | 41 |
| **359** | 14 | 50 | 30 | 9 | 41 | -10 | 28 | 15 | **390** | 34 | 5 | 28 | 24 | 30 | 24 | 22 | 42 |
| **360** | 10 | 57 | 18 | 26 | 36 | 0 | 34 | 1 | **391** | 32 | 11 | 23 | 40 | 27 | 34 | 16 | 60 |
| **361** | 7 | 63 | 20 | 27 | 40 | -1 | 39 | 1 | **392** | 35 | 5 | 24 | 32 | 18 | 42 | 15 | 52 |
| **362** | -2 | 77 | 0 | 57 | 30 | 14 | 30 | 17 | **393** | 34 | 12 | 28 | 29 | 25 | 39 | 14 | 60 |
| **363** | -4 | 82 | -14 | 82 | 28 | 26 | 20 | 38 | **394** | 39 | 11 | 23 | 42 | 18 | 50 | 3 | 78 |
| **364** | -3 | 94 | -5 | 75 | 23 | 37 | 18 | 45 | **395** | 30 | 29 | 19 | 57 | 12 | 70 | -16 | 123 |
| **365** | 9 | 69 | -19 | 97 | 12 | 55 | 15 | 54 | **396** | 34 | 26 | 22 | 53 | 21 | 54 | 21 | 53 |
| **366** | -12 | 109 | -35 | 125 | 11 | 65 | 0 | 79 | **397** | 29 | 39 | 22 | 61 | 14 | 71 | 22 | 56 |
| **367** | 36 | -35 | 27 | 0 | 37 | -33 | 36 | -16 | **398** | 19 | 66 | 11 | 86 | 11 | 83 | 25 | 61 |
| **368** | 36 | -34 | 28 | 0 | 39 | -36 | 37 | -14 | | | | | | | | | |

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**Table 9-24 – Values of variables m and n for ctxIdx from 402 to 459**

| ctxIdx | I slices | | Value of cabac_init_idc | | | | | | ctxIdx | I slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **402** | -17 | 120 | -4 | 79 | -5 | 85 | -3 | 78 | **431** | -2 | 55 | -12 | 56 | -9 | 57 | -12 | 59 |
| **403** | -20 | 112 | -7 | 71 | -6 | 81 | -8 | 74 | **432** | 0 | 61 | -6 | 60 | -6 | 63 | -8 | 63 |
| **404** | -18 | 114 | -5 | 69 | -10 | 77 | -9 | 72 | **433** | 1 | 64 | -5 | 62 | -4 | 65 | -9 | 67 |
| **405** | -11 | 85 | -9 | 70 | -7 | 81 | -10 | 72 | **434** | 0 | 68 | -8 | 66 | -4 | 67 | -6 | 68 |
| **406** | -15 | 92 | -8 | 66 | -17 | 80 | -18 | 75 | **435** | -9 | 92 | -8 | 76 | -7 | 82 | -10 | 79 |
| **407** | -14 | 89 | -10 | 68 | -18 | 73 | -12 | 71 | **436** | -14 | 106 | -5 | 85 | -3 | 81 | -3 | 78 |
| **408** | -26 | 71 | -19 | 73 | -4 | 74 | -11 | 63 | **437** | -13 | 97 | -6 | 81 | -3 | 76 | -8 | 74 |
| **409** | -15 | 81 | -12 | 69 | -10 | 83 | -5 | 70 | **438** | -15 | 90 | -10 | 77 | -7 | 72 | -9 | 72 |
| **410** | -14 | 80 | -16 | 70 | -9 | 71 | -17 | 75 | **439** | -12 | 90 | -7 | 81 | -6 | 78 | -10 | 72 |
| **411** | 0 | 68 | -15 | 67 | -9 | 67 | -14 | 72 | **440** | -18 | 88 | -17 | 80 | -12 | 72 | -18 | 75 |
| **412** | -14 | 70 | -20 | 62 | -1 | 61 | -16 | 67 | **441** | -10 | 73 | -18 | 73 | -14 | 68 | -12 | 71 |
| **413** | -24 | 56 | -19 | 70 | -8 | 66 | -8 | 53 | **442** | -9 | 79 | -4 | 74 | -3 | 70 | -11 | 63 |
| **414** | -23 | 68 | -16 | 66 | -14 | 66 | -14 | 59 | **443** | -14 | 86 | -10 | 83 | -6 | 76 | -5 | 70 |
| **415** | -24 | 50 | -22 | 65 | 0 | 59 | -9 | 52 | **444** | -10 | 73 | -9 | 71 | -5 | 66 | -17 | 75 |
| **416** | -11 | 74 | -20 | 63 | 2 | 59 | -11 | 68 | **445** | -10 | 70 | -9 | 67 | -5 | 62 | -14 | 72 |
| **417** | 23 | -13 | 9 | -2 | 17 | -10 | 9 | -2 | **446** | -10 | 69 | -1 | 61 | 0 | 57 | -16 | 67 |
| **418** | 26 | -13 | 26 | -9 | 32 | -13 | 30 | -10 | **447** | -5 | 66 | -8 | 66 | -4 | 61 | -8 | 53 |
| **419** | 40 | -15 | 33 | -9 | 42 | -9 | 31 | -4 | **448** | -9 | 64 | -14 | 66 | -9 | 60 | -14 | 59 |
| **420** | 49 | -14 | 39 | -7 | 49 | -5 | 33 | -1 | **449** | -5 | 58 | 0 | 59 | 1 | 54 | -9 | 52 |
| **421** | 44 | 3 | 41 | -2 | 53 | 0 | 33 | 7 | **450** | 2 | 59 | 2 | 59 | 2 | 58 | -11 | 68 |
| **422** | 45 | 6 | 45 | 3 | 64 | 3 | 31 | 12 | **451** | 21 | -10 | 21 | -13 | 17 | -10 | 9 | -2 |
| **423** | 44 | 34 | 49 | 9 | 68 | 10 | 37 | 23 | **452** | 24 | -11 | 33 | -14 | 32 | -13 | 30 | -10 |
| **424** | 33 | 54 | 45 | 27 | 66 | 27 | 31 | 38 | **453** | 28 | -8 | 39 | -7 | 42 | -9 | 31 | -4 |
| **425** | 19 | 82 | 36 | 59 | 47 | 57 | 20 | 64 | **454** | 28 | -1 | 46 | -2 | 49 | -5 | 33 | -1 |
| **426** | -3 | 75 | -6 | 66 | -5 | 71 | -9 | 71 | **455** | 29 | 3 | 51 | 2 | 53 | 0 | 33 | 7 |
| **427** | -1 | 23 | -7 | 35 | 0 | 24 | -7 | 37 | **456** | 29 | 9 | 60 | 6 | 64 | 3 | 31 | 12 |
| **428** | 1 | 34 | -7 | 42 | -1 | 36 | -8 | 44 | **457** | 35 | 20 | 61 | 17 | 68 | 10 | 37 | 23 |
| **429** | 1 | 43 | -8 | 45 | -2 | 42 | -11 | 49 | **458** | 29 | 36 | 55 | 34 | 66 | 27 | 31 | 38 |
| **430** | 0 | 54 | -5 | 48 | -2 | 52 | -10 | 56 | **459** | 14 | 67 | 42 | 62 | 47 | 57 | 20 | 64 |

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**Table 9-25 – Values of variables m and n for ctxIdx from 460 to 483**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **460** | -17 | 123 | -7 | 92 | 0 | 80 | 11 | 80 | **472** | -17 | 123 | -7 | 92 | 0 | 80 | 11 | 80 |
| **461** | -12 | 115 | -5 | 89 | -5 | 89 | 5 | 76 | **473** | -12 | 115 | -5 | 89 | -5 | 89 | 5 | 76 |
| **462** | -16 | 122 | -7 | 96 | -7 | 94 | 2 | 84 | **474** | -16 | 122 | -7 | 96 | -7 | 94 | 2 | 84 |
| **463** | -11 | 115 | -13 | 108 | -4 | 92 | 5 | 78 | **475** | -11 | 115 | -13 | 108 | -4 | 92 | 5 | 78 |
| **464** | -12 | 63 | -3 | 46 | 0 | 39 | -6 | 55 | **476** | -12 | 63 | -3 | 46 | 0 | 39 | -6 | 55 |
| **465** | -2 | 68 | -1 | 65 | 0 | 65 | 4 | 61 | **477** | -2 | 68 | -1 | 65 | 0 | 65 | 4 | 61 |
| **466** | -15 | 84 | -1 | 57 | -15 | 84 | -14 | 83 | **478** | -15 | 84 | -1 | 57 | -15 | 84 | -14 | 83 |
| **467** | -13 | 104 | -9 | 93 | -35 | 127 | -37 | 127 | **479** | -13 | 104 | -9 | 93 | -35 | 127 | -37 | 127 |
| **468** | -3 | 70 | -3 | 74 | -2 | 73 | -5 | 79 | **480** | -3 | 70 | -3 | 74 | -2 | 73 | -5 | 79 |
| **469** | -8 | 93 | -9 | 92 | -12 | 104 | -11 | 104 | **481** | -8 | 93 | -9 | 92 | -12 | 104 | -11 | 104 |
| **470** | -10 | 90 | -8 | 87 | -9 | 91 | -11 | 91 | **482** | -10 | 90 | -8 | 87 | -9 | 91 | -11 | 91 |
| **471** | -30 | 127 | -23 | 126 | -31 | 127 | -30 | 127 | **483** | -30 | 127 | -23 | 126 | -31 | 127 | -30 | 127 |

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**Table 9-26 – Values of variables m and n for ctxIdx from 484 to 571**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **484** | -7 | 93 | -2 | 85 | -13 | 103 | -4 | 86 | **528** | -7 | 93 | -2 | 85 | -13 | 103 | -4 | 86 |
| **485** | -11 | 87 | -6 | 78 | -13 | 91 | -12 | 88 | **529** | -11 | 87 | -6 | 78 | -13 | 91 | -12 | 88 |
| **486** | -3 | 77 | -1 | 75 | -9 | 89 | -5 | 82 | **530** | -3 | 77 | -1 | 75 | -9 | 89 | -5 | 82 |
| **487** | -5 | 71 | -7 | 77 | -14 | 92 | -3 | 72 | **531** | -5 | 71 | -7 | 77 | -14 | 92 | -3 | 72 |
| **488** | -4 | 63 | 2 | 54 | -8 | 76 | -4 | 67 | **532** | -4 | 63 | 2 | 54 | -8 | 76 | -4 | 67 |
| **489** | -4 | 68 | 5 | 50 | -12 | 87 | -8 | 72 | **533** | -4 | 68 | 5 | 50 | -12 | 87 | -8 | 72 |
| **490** | -12 | 84 | -3 | 68 | -23 | 110 | -16 | 89 | **534** | -12 | 84 | -3 | 68 | -23 | 110 | -16 | 89 |
| **491** | -7 | 62 | 1 | 50 | -24 | 105 | -9 | 69 | **535** | -7 | 62 | 1 | 50 | -24 | 105 | -9 | 69 |
| **492** | -7 | 65 | 6 | 42 | -10 | 78 | -1 | 59 | **536** | -7 | 65 | 6 | 42 | -10 | 78 | -1 | 59 |
| **493** | 8 | 61 | -4 | 81 | -20 | 112 | 5 | 66 | **537** | 8 | 61 | -4 | 81 | -20 | 112 | 5 | 66 |
| **494** | 5 | 56 | 1 | 63 | -17 | 99 | 4 | 57 | **538** | 5 | 56 | 1 | 63 | -17 | 99 | 4 | 57 |
| **495** | -2 | 66 | -4 | 70 | -78 | 127 | -4 | 71 | **539** | -2 | 66 | -4 | 70 | -78 | 127 | -4 | 71 |
| **496** | 1 | 64 | 0 | 67 | -70 | 127 | -2 | 71 | **540** | 1 | 64 | 0 | 67 | -70 | 127 | -2 | 71 |
| **497** | 0 | 61 | 2 | 57 | -50 | 127 | 2 | 58 | **641** | 0 | 61 | 2 | 57 | -50 | 127 | 2 | 58 |
| **498** | -2 | 78 | -2 | 76 | -46 | 127 | -1 | 74 | **542** | -2 | 78 | -2 | 76 | -46 | 127 | -1 | 74 |
| **499** | 1 | 50 | 11 | 35 | -4 | 66 | -4 | 44 | **543** | 1 | 50 | 11 | 35 | -4 | 66 | -4 | 44 |
| **500** | 7 | 52 | 4 | 64 | -5 | 78 | -1 | 69 | **544** | 7 | 52 | 4 | 64 | -5 | 78 | -1 | 69 |
| **501** | 10 | 35 | 1 | 61 | -4 | 71 | 0 | 62 | **545** | 10 | 35 | 1 | 61 | -4 | 71 | 0 | 62 |
| **502** | 0 | 44 | 11 | 35 | -8 | 72 | -7 | 51 | **546** | 0 | 44 | 11 | 35 | -8 | 72 | -7 | 51 |
| **503** | 11 | 38 | 18 | 25 | 2 | 59 | -4 | 47 | **547** | 11 | 38 | 18 | 25 | 2 | 59 | -4 | 47 |
| **504** | 1 | 45 | 12 | 24 | -1 | 55 | -6 | 42 | **548** | 1 | 45 | 12 | 24 | -1 | 55 | -6 | 42 |
| **505** | 0 | 46 | 13 | 29 | -7 | 70 | -3 | 41 | **549** | 0 | 46 | 13 | 29 | -7 | 70 | -3 | 41 |
| **506** | 5 | 44 | 13 | 36 | -6 | 75 | -6 | 53 | **550** | 5 | 44 | 13 | 36 | -6 | 75 | -6 | 53 |
| **507** | 31 | 17 | -10 | 93 | -8 | 89 | 8 | 76 | **551** | 31 | 17 | -10 | 93 | -8 | 89 | 8 | 76 |
| **508** | 1 | 51 | -7 | 73 | -34 | 119 | -9 | 78 | **552** | 1 | 51 | -7 | 73 | -34 | 119 | -9 | 78 |
| **509** | 7 | 50 | -2 | 73 | -3 | 75 | -11 | 83 | **553** | 7 | 50 | -2 | 73 | -3 | 75 | -11 | 83 |
| **510** | 28 | 19 | 13 | 46 | 32 | 20 | 9 | 52 | **554** | 28 | 19 | 13 | 46 | 32 | 20 | 9 | 52 |
| **511** | 16 | 33 | 9 | 49 | 30 | 22 | 0 | 67 | **555** | 16 | 33 | 9 | 49 | 30 | 22 | 0 | 67 |
| **512** | 14 | 62 | -7 | 100 | -44 | 127 | -5 | 90 | **556** | 14 | 62 | -7 | 100 | -44 | 127 | -5 | 90 |
| **513** | -13 | 108 | 9 | 53 | 0 | 54 | 1 | 67 | **557** | -13 | 108 | 9 | 53 | 0 | 54 | 1 | 67 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **514** | -15 | 100 | 2 | 53 | -5 | 61 | -15 | 72 | **558** | -15 | 100 | 2 | 53 | -5 | 61 | -15 | 72 |
| **515** | -13 | 101 | 5 | 53 | 0 | 58 | -5 | 75 | **559** | -13 | 101 | 5 | 53 | 0 | 58 | -5 | 75 |
| **516** | -13 | 91 | -2 | 61 | -1 | 60 | -8 | 80 | **560** | -13 | 91 | -2 | 61 | -1 | 60 | -8 | 80 |
| **517** | -12 | 94 | 0 | 56 | -3 | 61 | -21 | 83 | **561** | -12 | 94 | 0 | 56 | -3 | 61 | -21 | 83 |
| **518** | -10 | 88 | 0 | 56 | -8 | 67 | -21 | 64 | **562** | -10 | 88 | 0 | 56 | -8 | 67 | -21 | 64 |
| **519** | -16 | 84 | -13 | 63 | -25 | 84 | -13 | 31 | **563** | -16 | 84 | -13 | 63 | -25 | 84 | -13 | 31 |
| **520** | -10 | 86 | -5 | 60 | -14 | 74 | -25 | 64 | **564** | -10 | 86 | -5 | 60 | -14 | 74 | -25 | 64 |
| **521** | -7 | 83 | -1 | 62 | -5 | 65 | -29 | 94 | **565** | -7 | 83 | -1 | 62 | -5 | 65 | -29 | 94 |
| **522** | -13 | 87 | 4 | 57 | 5 | 52 | 9 | 75 | **566** | -13 | 87 | 4 | 57 | 5 | 52 | 9 | 75 |
| **523** | -19 | 94 | -6 | 69 | 2 | 57 | 17 | 63 | **567** | -19 | 94 | -6 | 69 | 2 | 57 | 17 | 63 |
| **524** | 1 | 70 | 4 | 57 | 0 | 61 | -8 | 74 | **568** | 1 | 70 | 4 | 57 | 0 | 61 | -8 | 74 |
| **525** | 0 | 72 | 14 | 39 | -9 | 69 | -5 | 35 | **569** | 0 | 72 | 14 | 39 | -9 | 69 | -5 | 35 |
| **526** | -5 | 74 | 4 | 51 | -11 | 70 | -2 | 27 | **570** | -5 | 74 | 4 | 51 | -11 | 70 | -2 | 27 |
| **527** | 18 | 59 | 13 | 68 | 18 | 55 | 13 | 91 | **571** | 18 | 59 | 13 | 68 | 18 | 55 | 13 | 91 |

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**Table 9-27 – Values of variables m and n for ctxIdx from 572 to 659**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **572** | 24 | 0 | 11 | 28 | 4 | 45 | 4 | 39 | **616** | 24 | 0 | 11 | 28 | 4 | 45 | 4 | 39 |
| **573** | 15 | 9 | 2 | 40 | 10 | 28 | 0 | 42 | **617** | 15 | 9 | 2 | 40 | 10 | 28 | 0 | 42 |
| **574** | 8 | 25 | 3 | 44 | 10 | 31 | 7 | 34 | **618** | 8 | 25 | 3 | 44 | 10 | 31 | 7 | 34 |
| **575** | 13 | 18 | 0 | 49 | 33 | -11 | 11 | 29 | **619** | 13 | 18 | 0 | 49 | 33 | -11 | 11 | 29 |
| **576** | 15 | 9 | 0 | 46 | 52 | -43 | 8 | 31 | **620** | 15 | 9 | 0 | 46 | 52 | -43 | 8 | 31 |
| **577** | 13 | 19 | 2 | 44 | 18 | 15 | 6 | 37 | **621** | 13 | 19 | 2 | 44 | 18 | 15 | 6 | 37 |
| **578** | 10 | 37 | 2 | 51 | 28 | 0 | 7 | 42 | **622** | 10 | 37 | 2 | 51 | 28 | 0 | 7 | 42 |
| **579** | 12 | 18 | 0 | 47 | 35 | -22 | 3 | 40 | **623** | 12 | 18 | 0 | 47 | 35 | -22 | 3 | 40 |
| **580** | 6 | 29 | 4 | 39 | 38 | -25 | 8 | 33 | **624** | 6 | 29 | 4 | 39 | 38 | -25 | 8 | 33 |
| **581** | 20 | 33 | 2 | 62 | 34 | 0 | 13 | 43 | **625** | 20 | 33 | 2 | 62 | 34 | 0 | 13 | 43 |
| **582** | 15 | 30 | 6 | 46 | 39 | -18 | 13 | 36 | **626** | 15 | 30 | 6 | 46 | 39 | -18 | 13 | 36 |
| **583** | 4 | 45 | 0 | 54 | 32 | -12 | 4 | 47 | **627** | 4 | 45 | 0 | 54 | 32 | -12 | 4 | 47 |
| **584** | 1 | 58 | 3 | 54 | 102 | -94 | 3 | 55 | **628** | 1 | 58 | 3 | 54 | 102 | -94 | 3 | 55 |
| **585** | 0 | 62 | 2 | 58 | 0 | 0 | 2 | 58 | **629** | 0 | 62 | 2 | 58 | 0 | 0 | 2 | 58 |
| **586** | 7 | 61 | 4 | 63 | 56 | -15 | 6 | 60 | **630** | 7 | 61 | 4 | 63 | 56 | -15 | 6 | 60 |
| **587** | 12 | 38 | 6 | 51 | 33 | -4 | 8 | 44 | **631** | 12 | 38 | 6 | 51 | 33 | -4 | 8 | 44 |
| **588** | 11 | 45 | 6 | 57 | 29 | 10 | 11 | 44 | **632** | 11 | 45 | 6 | 57 | 29 | 10 | 11 | 44 |
| **589** | 15 | 39 | 7 | 53 | 37 | -5 | 14 | 42 | **633** | 15 | 39 | 7 | 53 | 37 | -5 | 14 | 42 |
| **590** | 11 | 42 | 6 | 52 | 51 | -29 | 7 | 48 | **634** | 11 | 42 | 6 | 52 | 51 | -29 | 7 | 48 |
| **591** | 13 | 44 | 6 | 55 | 39 | -9 | 4 | 56 | **635** | 13 | 44 | 6 | 55 | 39 | -9 | 4 | 56 |
| **592** | 16 | 45 | 11 | 45 | 52 | -34 | 4 | 52 | **636** | 16 | 45 | 11 | 45 | 52 | -34 | 4 | 52 |
| **593** | 12 | 41 | 14 | 36 | 69 | -58 | 13 | 37 | **637** | 12 | 41 | 14 | 36 | 69 | -58 | 13 | 37 |
| **594** | 10 | 49 | 8 | 53 | 67 | -63 | 9 | 49 | **638** | 10 | 49 | 8 | 53 | 67 | -63 | 9 | 49 |
| **595** | 30 | 34 | -1 | 82 | 44 | -5 | 19 | 58 | **639** | 30 | 34 | -1 | 82 | 44 | -5 | 19 | 58 |
| **596** | 18 | 42 | 7 | 55 | 32 | 7 | 10 | 48 | **640** | 18 | 42 | 7 | 55 | 32 | 7 | 10 | 48 |
| **597** | 10 | 55 | -3 | 78 | 55 | -29 | 12 | 45 | **641** | 10 | 55 | -3 | 78 | 55 | -29 | 12 | 45 |
| **598** | 17 | 51 | 15 | 46 | 32 | 1 | 0 | 69 | **642** | 17 | 51 | 15 | 46 | 32 | 1 | 0 | 69 |
| **599** | 17 | 46 | 22 | 31 | 0 | 0 | 20 | 33 | **643** | 17 | 46 | 22 | 31 | 0 | 0 | 20 | 33 |
| **600** | 0 | 89 | -1 | 84 | 27 | 36 | 8 | 63 | **644** | 0 | 89 | -1 | 84 | 27 | 36 | 8 | 63 |
| **601** | 26 | -19 | 25 | 7 | 33 | -25 | 35 | -18 | **645** | 26 | -19 | 25 | 7 | 33 | -25 | 35 | -18 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **602** | 22 | -17 | 30 | -7 | 34 | -30 | 33 | -25 | **646** | 22 | -17 | 30 | -7 | 34 | -30 | 33 | -25 |
| **603** | 26 | -17 | 28 | 3 | 36 | -28 | 28 | -3 | **647** | 26 | -17 | 28 | 3 | 36 | -28 | 28 | -3 |
| **604** | 30 | -25 | 28 | 4 | 38 | -28 | 24 | 10 | **648** | 30 | -25 | 28 | 4 | 38 | -28 | 24 | 10 |
| **605** | 28 | -20 | 32 | 0 | 38 | -27 | 27 | 0 | **649** | 28 | -20 | 32 | 0 | 38 | -27 | 27 | 0 |
| **606** | 33 | -23 | 34 | -1 | 34 | -18 | 34 | -14 | **650** | 33 | -23 | 34 | -1 | 34 | -18 | 34 | -14 |
| **607** | 37 | -27 | 30 | 6 | 35 | -16 | 52 | -44 | **651** | 37 | -27 | 30 | 6 | 35 | -16 | 52 | -44 |
| **608** | 33 | -23 | 30 | 6 | 34 | -14 | 39 | -24 | **652** | 33 | -23 | 30 | 6 | 34 | -14 | 39 | -24 |
| **609** | 40 | -28 | 32 | 9 | 32 | -8 | 19 | 17 | **653** | 40 | -28 | 32 | 9 | 32 | -8 | 19 | 17 |
| **610** | 38 | -17 | 31 | 19 | 37 | -6 | 31 | 25 | **654** | 38 | -17 | 31 | 19 | 37 | -6 | 31 | 25 |
| **611** | 33 | -11 | 26 | 27 | 35 | 0 | 36 | 29 | **655** | 33 | -11 | 26 | 27 | 35 | 0 | 36 | 29 |
| **612** | 40 | -15 | 26 | 30 | 30 | 10 | 24 | 33 | **656** | 40 | -15 | 26 | 30 | 30 | 10 | 24 | 33 |
| **613** | 41 | -6 | 37 | 20 | 28 | 18 | 34 | 15 | **657** | 41 | -6 | 37 | 20 | 28 | 18 | 34 | 15 |
| **614** | 38 | 1 | 28 | 34 | 26 | 25 | 30 | 20 | **658** | 38 | 1 | 28 | 34 | 26 | 25 | 30 | 20 |
| **615** | 41 | 17 | 17 | 70 | 29 | 41 | 22 | 73 | **659** | 41 | 17 | 17 | 70 | 29 | 41 | 22 | 73 |

**Table 9-28– Values of variables m and n for ctxIdx from 660 to 717**

| ctxIdx | I slices | | Value of cabac_init_idc | | | | | | ctxIdx | I slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **660** | -17 | 120 | -4 | 79 | -5 | 85 | -13 | 78 | **689** | 2 | 59 | 2 | 59 | 2 | 58 | -11 | 68 |
| **661** | -20 | 112 | -7 | 71 | -6 | 81 | -8 | 74 | **690** | 23 | -13 | 9 | -2 | 17 | -10 | 9 | -2 |
| **662** | -18 | 114 | -5 | 69 | -10 | 77 | -9 | 72 | **691** | 26 | -13 | 26 | -9 | 32 | -13 | 30 | -10 |
| **663** | -11 | 85 | -9 | 70 | -7 | 81 | -10 | 72 | **692** | 40 | -15 | 33 | -9 | 42 | -9 | 31 | -4 |
| **664** | -15 | 92 | -8 | 66 | -17 | 80 | -18 | 75 | **693** | 49 | -14 | 39 | -7 | 49 | -5 | 33 | -1 |
| **665** | -14 | 89 | -10 | 68 | -18 | 73 | -12 | 71 | **694** | 44 | 3 | 41 | -2 | 53 | 0 | 33 | 7 |
| **666** | -26 | 71 | -19 | 73 | -4 | 74 | -11 | 63 | **695** | 45 | 6 | 45 | 3 | 64 | 3 | 31 | 12 |
| **667** | -15 | 81 | -12 | 69 | -10 | 83 | -5 | 70 | **696** | 44 | 34 | 49 | 9 | 68 | 10 | 37 | 23 |
| **668** | -14 | 80 | -16 | 70 | -9 | 71 | -17 | 75 | **697** | 33 | 54 | 45 | 27 | 66 | 27 | 31 | 38 |
| **669** | 0 | 68 | -15 | 67 | -9 | 67 | -14 | 72 | **698** | 19 | 82 | 36 | 59 | 47 | 57 | 20 | 64 |
| **670** | -14 | 70 | -20 | 62 | -1 | 61 | -16 | 67 | **699** | 21 | -10 | 21 | -13 | 17 | -10 | 9 | -2 |
| **671** | -24 | 56 | -19 | 70 | -8 | 66 | -8 | 53 | **700** | 24 | -11 | 33 | -14 | 32 | -13 | 30 | -10 |
| **672** | -23 | 68 | -16 | 66 | -14 | 66 | -14 | 59 | **701** | 28 | -8 | 39 | -7 | 42 | -9 | 31 | -4 |
| **673** | -24 | 50 | -22 | 65 | 0 | 59 | -9 | 52 | **702** | 28 | -1 | 46 | -2 | 49 | -5 | 33 | -1 |
| **674** | -11 | 74 | -20 | 63 | 2 | 59 | -11 | 68 | **703** | 29 | 3 | 51 | 2 | 53 | 0 | 33 | 7 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **675** | -14 | 106 | -5 | 85 | -3 | 81 | -3 | 78 | **704** | 29 | 9 | 60 | 6 | 64 | 3 | 31 | 12 |
| **676** | -13 | 97 | -6 | 81 | -3 | 76 | -8 | 74 | **705** | 35 | 20 | 61 | 17 | 68 | 10 | 37 | 23 |
| **677** | -15 | 90 | -10 | 77 | -7 | 72 | -9 | 72 | **706** | 29 | 36 | 55 | 34 | 66 | 27 | 31 | 38 |
| **678** | -12 | 90 | -7 | 81 | -6 | 78 | -10 | 72 | **707** | 14 | 67 | 42 | 62 | 47 | 57 | 20 | 64 |
| **679** | -18 | 88 | -17 | 80 | -12 | 72 | -18 | 75 | **708** | -3 | 75 | -6 | 66 | -5 | 71 | -9 | 71 |
| **680** | -10 | 73 | -18 | 73 | -14 | 68 | -12 | 71 | **709** | -1 | 23 | -7 | 35 | 0 | 24 | -7 | 37 |
| **681** | -9 | 79 | -4 | 74 | -3 | 70 | -11 | 63 | **710** | 1 | 34 | -7 | 42 | -1 | 36 | -8 | 44 |
| **682** | -14 | 86 | -10 | 83 | -6 | 76 | -5 | 70 | **711** | 1 | 43 | -8 | 45 | -2 | 42 | -11 | 49 |
| **683** | -10 | 73 | -9 | 71 | -5 | 66 | -17 | 75 | **712** | 0 | 54 | -5 | 48 | -2 | 52 | -10 | 56 |
| **684** | -10 | 70 | -9 | 67 | -5 | 62 | -14 | 72 | **713** | -2 | 55 | -12 | 56 | -9 | 57 | -12 | 59 |
| **685** | -10 | 69 | -1 | 61 | 0 | 57 | -16 | 67 | **714** | 0 | 61 | -6 | 60 | -6 | 63 | -8 | 63 |
| **686** | -5 | 66 | -8 | 66 | -4 | 61 | -8 | 53 | **715** | 1 | 64 | -5 | 62 | -4 | 65 | -9 | 67 |
| **687** | -9 | 64 | -14 | 66 | -9 | 60 | -14 | 59 | **716** | 0 | 68 | -8 | 66 | -4 | 67 | -6 | 68 |
| **688** | -5 | 58 | 0 | 59 | 1 | 54 | -9 | 52 | **717** | -9 | 92 | -8 | 76 | -7 | 82 | -10 | 79 |

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**Table 9-29– Values of variables m and n for ctxIdx from 718 to 775**

| ctxIdx | I slices | | Value of cabac_init_idc | | | | | | ctxIdx | I slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **718** | -17 | 120 | -4 | 79 | -5 | 85 | -3 | 78 | **747** | 2 | 59 | 2 | 59 | 2 | 58 | -11 | 68 |
| **719** | -20 | 112 | -7 | 71 | -6 | 81 | -8 | 74 | **748** | 23 | -13 | 9 | -2 | 17 | -10 | 9 | -2 |
| **720** | -18 | 114 | -5 | 69 | -10 | 77 | -9 | 72 | **749** | 26 | -13 | 26 | -9 | 32 | -13 | 30 | -10 |
| **721** | -11 | 85 | -9 | 70 | -7 | 81 | -10 | 72 | **750** | 40 | -15 | 33 | -9 | 42 | -9 | 31 | -4 |
| **722** | -15 | 92 | -8 | 66 | -17 | 80 | -18 | 75 | **751** | 49 | -14 | 39 | -7 | 49 | -5 | 33 | -1 |
| **723** | -14 | 89 | -10 | 68 | -18 | 73 | -12 | 71 | **752** | 44 | 3 | 41 | -2 | 53 | 0 | 33 | 7 |
| **724** | -26 | 71 | -19 | 73 | -4 | 74 | -11 | 63 | **753** | 45 | 6 | 45 | 3 | 64 | 3 | 31 | 12 |
| **725** | -15 | 81 | -12 | 69 | -10 | 83 | -5 | 70 | **754** | 44 | 34 | 49 | 9 | 68 | 10 | 37 | 23 |
| **726** | -14 | 80 | -16 | 70 | -9 | 71 | -17 | 75 | **755** | 33 | 54 | 45 | 27 | 66 | 27 | 31 | 38 |
| **727** | 0 | 68 | -15 | 67 | -9 | 67 | -14 | 72 | **756** | 19 | 82 | 36 | 59 | 47 | 57 | 20 | 64 |
| **728** | -14 | 70 | -20 | 62 | -1 | 61 | -16 | 67 | **757** | 21 | 10 | 21 | -13 | 17 | -10 | 9 | -2 |
| **729** | -24 | 56 | -19 | 70 | -8 | 66 | -8 | 53 | **758** | 24 | -11 | 33 | -14 | 32 | -13 | 30 | -10 |
| **730** | -23 | 68 | -16 | 66 | -14 | 66 | -14 | 59 | **759** | 28 | -8 | 39 | -7 | 42 | -9 | 31 | -4 |
| **731** | -24 | 50 | -22 | 65 | 0 | 59 | -9 | 52 | **760** | 28 | -1 | 46 | -2 | 49 | -5 | 33 | -1 |
| **732** | -11 | 74 | -20 | 63 | 2 | 59 | -11 | 68 | **761** | 29 | 3 | 51 | 2 | 53 | 0 | 33 | 7 |
| **733** | -14 | 106 | -5 | 85 | -3 | 81 | -3 | 78 | **762** | 29 | 9 | 60 | 6 | 64 | 3 | 31 | 12 |
| **734** | -13 | 97 | -6 | 81 | -3 | 76 | -8 | 74 | **763** | 35 | 20 | 61 | 17 | 68 | 10 | 37 | 23 |
| **735** | -15 | 90 | -10 | 77 | -7 | 72 | -9 | 72 | **764** | 29 | 36 | 55 | 34 | 66 | 27 | 31 | 38 |
| **736** | -12 | 90 | -7 | 81 | -6 | 78 | -10 | 72 | **765** | 14 | 67 | 42 | 62 | 47 | 57 | 20 | 64 |
| **737** | -18 | 88 | -17 | 80 | -12 | 72 | -18 | 75 | **766** | -3 | 75 | -6 | 66 | -5 | 71 | -9 | 71 |
| **738** | -10 | 73 | -18 | 73 | -14 | 68 | -12 | 71 | **767** | -1 | 23 | -7 | 35 | 0 | 24 | -7 | 37 |
| **739** | -9 | 79 | -4 | 74 | -3 | 70 | -11 | 63 | **768** | 1 | 34 | -7 | 42 | -1 | 36 | -8 | 44 |
| **740** | -14 | 86 | -10 | 83 | -6 | 76 | -5 | 70 | **769** | 1 | 43 | -8 | 45 | -2 | 42 | -11 | 49 |
| **741** | -10 | 73 | -9 | 71 | -5 | 66 | -17 | 75 | **770** | 0 | 54 | -5 | 48 | -2 | 52 | -10 | 56 |
| **742** | -10 | 70 | -9 | 67 | -5 | 62 | -14 | 72 | **771** | -2 | 55 | -12 | 56 | -9 | 57 | -12 | 59 |
| **743** | -10 | 69 | -1 | 61 | 0 | 57 | -16 | 67 | **772** | 0 | 61 | -6 | 60 | -6 | 63 | -8 | 63 |
| **744** | -5 | 66 | -8 | 66 | -4 | 61 | -8 | 53 | **773** | 1 | 64 | -5 | 62 | -4 | 65 | -9 | 67 |
| **745** | -9 | 64 | -14 | 66 | -9 | 60 | -14 | 59 | **774** | 0 | 68 | -8 | 66 | -4 | 67 | -6 | 68 |
| **746** | -5 | 58 | 0 | 59 | 1 | 54 | -9 | 52 | **775** | -9 | 92 | -8 | 76 | -7 | 82 | -10 | 79 |

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**Table 9-30 – Values of variables m and n for ctxIdx from 776 to 863**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **776** | -6 | 93 | -13 | 106 | -21 | 126 | -22 | 127 | **820** | -6 | 93 | -13 | 106 | -21 | 126 | -22 | 127 |
| **777** | -6 | 84 | -16 | 106 | -23 | 124 | -25 | 127 | **821** | -6 | 84 | -16 | 106 | -23 | 124 | -25 | 127 |
| **778** | -8 | 79 | -10 | 87 | -20 | 110 | -25 | 120 | **822** | -8 | 79 | -10 | 87 | -20 | 110 | -25 | 120 |
| **779** | 0 | 66 | -21 | 114 | -26 | 126 | -27 | 127 | **823** | 0 | 66 | -21 | 114 | -26 | 126 | -27 | 127 |
| **780** | -1 | 71 | -18 | 110 | -25 | 124 | -19 | 114 | **824** | -1 | 71 | -18 | 110 | -25 | 124 | -19 | 114 |
| **781** | 0 | 62 | -14 | 98 | -17 | 105 | -23 | 117 | **825** | 0 | 62 | -14 | 98 | -17 | 105 | -23 | 117 |
| **782** | -2 | 60 | -22 | 110 | -27 | 121 | -25 | 118 | **826** | -2 | 60 | -22 | 110 | -27 | 121 | -25 | 118 |
| **783** | -2 | 59 | -21 | 106 | -27 | 117 | -26 | 117 | **827** | -2 | 59 | -21 | 106 | -27 | 117 | -26 | 117 |
| **784** | -5 | 75 | -18 | 103 | -17 | 102 | -24 | 113 | **828** | -5 | 75 | -18 | 103 | -17 | 102 | -24 | 113 |
| **785** | -3 | 62 | -21 | 107 | -26 | 117 | -28 | 118 | **829** | -3 | 62 | -21 | 107 | -26 | 117 | -28 | 118 |
| **786** | -4 | 58 | -23 | 108 | -27 | 116 | -31 | 120 | **830** | -4 | 58 | -23 | 108 | -27 | 116 | -31 | 120 |
| **787** | -9 | 66 | -26 | 112 | -33 | 122 | -37 | 124 | **831** | -9 | 66 | -26 | 112 | -33 | 122 | -37 | 124 |
| **788** | -1 | 79 | -10 | 96 | -10 | 95 | -10 | 94 | **832** | -1 | 79 | -10 | 96 | -10 | 95 | -10 | 94 |
| **789** | 0 | 71 | -12 | 95 | -14 | 100 | -15 | 102 | **833** | 0 | 71 | -12 | 95 | -14 | 100 | -15 | 102 |
| **790** | 3 | 68 | -5 | 91 | -8 | 95 | -10 | 99 | **834** | 3 | 68 | -5 | 91 | -8 | 95 | -10 | 99 |
| **791** | 10 | 44 | -9 | 93 | -17 | 111 | -13 | 106 | **835** | 10 | 44 | -9 | 93 | -17 | 111 | -13 | 106 |
| **792** | -7 | 62 | -22 | 94 | -28 | 114 | -50 | 127 | **836** | -7 | 62 | -22 | 94 | -28 | 114 | -50 | 127 |
| **793** | 15 | 36 | -5 | 86 | -6 | 89 | -5 | 92 | **837** | 15 | 36 | -5 | 86 | -6 | 89 | -5 | 92 |
| **794** | 14 | 40 | 9 | 67 | -2 | 80 | 17 | 57 | **838** | 14 | 40 | 9 | 67 | -2 | 80 | 17 | 57 |
| **795** | 16 | 27 | -4 | 80 | -4 | 82 | -5 | 86 | **839** | 16 | 27 | -4 | 80 | -4 | 82 | -5 | 86 |
| **796** | 12 | 29 | -10 | 85 | -9 | 85 | -13 | 94 | **840** | 12 | 29 | -10 | 85 | -9 | 85 | -13 | 94 |
| **797** | 1 | 44 | -1 | 70 | -8 | 81 | -12 | 91 | **841** | 1 | 44 | -1 | 70 | -8 | 81 | -12 | 91 |
| **798** | 20 | 36 | 7 | 60 | -1 | 72 | -2 | 77 | **842** | 20 | 36 | 7 | 60 | -1 | 72 | -2 | 77 |
| **799** | 18 | 32 | 9 | 58 | 5 | 64 | 0 | 71 | **843** | 18 | 32 | 9 | 58 | 5 | 64 | 0 | 71 |
| **800** | 5 | 42 | 5 | 61 | 1 | 67 | -1 | 73 | **844** | 5 | 42 | 5 | 61 | 1 | 67 | -1 | 73 |
| **801** | 1 | 48 | 12 | 50 | 9 | 56 | 4 | 64 | **845** | 1 | 48 | 12 | 50 | 9 | 56 | 4 | 64 |
| **802** | 10 | 62 | 15 | 50 | 0 | 69 | -7 | 81 | **846** | 10 | 62 | 15 | 50 | 0 | 69 | -7 | 81 |
| **803** | 17 | 46 | 18 | 49 | 1 | 69 | 5 | 64 | **847** | 17 | 46 | 18 | 49 | 1 | 69 | 5 | 64 |
| **804** | 9 | 64 | 17 | 54 | 7 | 69 | 15 | 57 | **848** | 9 | 64 | 17 | 54 | 7 | 69 | 15 | 57 |
| **805** | -12 | 104 | 10 | 41 | -7 | 69 | 1 | 67 | **849** | -12 | 104 | 10 | 41 | -7 | 69 | 1 | 67 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **806** | -11 | 97 | 7 | 46 | -6 | 67 | 0 | 68 | **850** | -11 | 97 | 7 | 46 | -6 | 67 | 0 | 68 |
| **807** | -16 | 96 | -1 | 51 | -16 | 77 | -10 | 67 | **851** | -16 | 96 | -1 | 51 | -16 | 77 | -10 | 67 |
| **808** | -7 | 88 | 7 | 49 | -2 | 64 | 1 | 68 | **852** | -7 | 88 | 7 | 49 | -2 | 64 | 1 | 68 |
| **809** | -8 | 85 | 8 | 52 | 2 | 61 | 0 | 77 | **853** | -8 | 85 | 8 | 52 | 2 | 61 | 0 | 77 |
| **810** | -7 | 85 | 9 | 41 | -6 | 67 | 2 | 64 | **854** | -7 | 85 | 9 | 41 | -6 | 67 | 2 | 64 |
| **811** | -9 | 85 | 6 | 47 | -3 | 64 | 0 | 68 | **855** | -9 | 85 | 6 | 47 | -3 | 64 | 0 | 68 |
| **812** | -13 | 88 | 2 | 55 | 2 | 57 | -5 | 78 | **856** | -13 | 88 | 2 | 55 | 2 | 57 | -5 | 78 |
| **813** | 4 | 66 | 13 | 41 | -3 | 65 | 7 | 55 | **857** | 4 | 66 | 13 | 41 | -3 | 65 | 7 | 55 |
| **814** | -3 | 77 | 10 | 44 | -3 | 66 | 5 | 59 | **858** | -3 | 77 | 10 | 44 | -3 | 66 | 5 | 59 |
| **815** | -3 | 76 | 6 | 50 | 0 | 62 | 2 | 65 | **859** | -3 | 76 | 6 | 50 | 0 | 62 | 2 | 65 |
| **816** | -6 | 76 | 5 | 53 | 9 | 51 | 14 | 54 | **860** | -6 | 76 | 5 | 53 | 9 | 51 | 14 | 54 |
| **817** | 10 | 58 | 13 | 49 | -1 | 66 | 15 | 44 | **861** | 10 | 58 | 13 | 49 | -1 | 66 | 15 | 44 |
| **818** | -1 | 76 | 4 | 63 | -2 | 71 | 5 | 60 | **862** | -1 | 76 | 4 | 63 | -2 | 71 | 5 | 60 |
| **819** | -1 | 83 | 6 | 64 | -2 | 75 | 2 | 70 | **863** | -1 | 83 | 6 | 64 | -2 | 75 | 2 | 70 |

**Table 9-31 – Values of variables m and n for ctxIdx from 864 to 951**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **864** | 15 | 6 | 14 | 11 | 19 | -6 | 17 | -13 | **908** | 15 | 6 | 14 | 11 | 19 | -6 | 17 | -13 |
| **865** | 6 | 19 | 11 | 14 | 18 | -6 | 16 | -9 | **909** | 6 | 19 | 11 | 14 | 18 | -6 | 16 | -9 |
| **866** | 7 | 16 | 9 | 11 | 14 | 0 | 17 | -12 | **910** | 7 | 16 | 9 | 11 | 14 | 0 | 17 | -12 |
| **867** | 12 | 14 | 18 | 11 | 26 | -12 | 27 | -21 | **911** | 12 | 14 | 18 | 11 | 26 | -12 | 27 | -21 |
| **868** | 18 | 13 | 21 | 9 | 31 | -16 | 37 | -30 | **912** | 18 | 13 | 21 | 9 | 31 | -16 | 37 | -30 |
| **869** | 13 | 11 | 23 | -2 | 33 | -25 | 41 | -40 | **913** | 13 | 11 | 23 | -2 | 33 | -25 | 41 | -40 |
| **870** | 13 | 15 | 32 | -15 | 33 | -22 | 42 | -41 | **914** | 13 | 15 | 32 | -15 | 33 | -22 | 42 | -41 |
| **871** | 15 | 16 | 32 | -15 | 37 | -28 | 48 | -47 | **915** | 15 | 16 | 32 | -15 | 37 | -28 | 48 | -47 |
| **872** | 12 | 23 | 34 | -21 | 39 | -30 | 39 | -32 | **916** | 12 | 23 | 34 | -21 | 39 | -30 | 39 | -32 |
| **873** | 13 | 23 | 39 | -23 | 42 | -30 | 46 | -40 | **917** | 13 | 23 | 39 | -23 | 42 | -30 | 46 | -40 |
| **874** | 15 | 20 | 42 | -33 | 47 | -42 | 52 | -51 | **918** | 15 | 20 | 42 | -33 | 47 | -42 | 52 | -51 |
| **875** | 14 | 26 | 41 | -31 | 45 | -36 | 46 | -41 | **919** | 14 | 26 | 41 | -31 | 45 | -36 | 46 | -41 |
| **876** | 14 | 44 | 46 | -28 | 49 | -34 | 52 | -39 | **920** | 14 | 44 | 46 | -28 | 49 | -34 | 52 | -39 |
| **877** | 17 | 40 | 38 | -12 | 41 | -17 | 43 | -19 | **921** | 17 | 40 | 38 | -12 | 41 | -17 | 43 | -19 |
| **878** | 17 | 47 | 21 | 29 | 32 | 9 | 32 | 11 | **922** | 17 | 47 | 21 | 29 | 32 | 9 | 32 | 11 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **879** | 24 | 17 | 45 | -24 | 69 | -71 | 61 | -55 | **923** | 24 | 17 | 45 | -24 | 69 | -71 | 61 | -55 |
| **880** | 21 | 21 | 53 | -45 | 63 | -63 | 56 | -46 | **924** | 21 | 21 | 53 | -45 | 63 | -63 | 56 | -46 |
| **881** | 25 | 22 | 48 | -26 | 66 | -64 | 62 | -50 | **925** | 25 | 22 | 48 | -26 | 66 | -64 | 62 | -50 |
| **882** | 31 | 27 | 65 | -43 | 77 | -74 | 81 | -67 | **926** | 31 | 27 | 65 | -43 | 77 | -74 | 81 | -67 |
| **883** | 22 | 29 | 43 | -19 | 54 | -39 | 45 | -20 | **927** | 22 | 29 | 43 | -19 | 54 | -39 | 45 | -20 |
| **884** | 19 | 35 | 39 | -10 | 52 | -35 | 35 | -2 | **928** | 19 | 35 | 39 | -10 | 52 | -35 | 35 | -2 |
| **885** | 14 | 50 | 30 | 9 | 41 | -10 | 28 | 15 | **929** | 14 | 50 | 30 | 9 | 41 | -10 | 28 | 15 |
| **886** | 10 | 57 | 18 | 26 | 36 | 0 | 34 | 1 | **930** | 10 | 57 | 18 | 26 | 36 | 0 | 34 | 1 |
| **887** | 7 | 63 | 20 | 27 | 40 | -1 | 39 | 1 | **931** | 7 | 63 | 20 | 27 | 40 | -1 | 39 | 1 |
| **888** | -2 | 77 | 0 | 57 | 30 | 14 | 30 | 17 | **932** | -2 | 77 | 0 | 57 | 30 | 14 | 30 | 17 |
| **889** | -4 | 82 | -14 | 82 | 28 | 26 | 20 | 38 | **933** | -4 | 82 | -14 | 82 | 28 | 26 | 20 | 38 |
| **890** | -3 | 94 | -5 | 75 | 23 | 37 | 18 | 45 | **934** | -3 | 94 | -5 | 75 | 23 | 37 | 18 | 45 |
| **891** | 9 | 69 | -19 | 97 | 12 | 55 | 15 | 54 | **935** | 9 | 69 | -19 | 97 | 12 | 55 | 15 | 54 |
| **892** | -12 | 109 | -35 | 125 | 11 | 65 | 0 | 79 | **936** | -12 | 109 | -35 | 125 | 11 | 65 | 0 | 79 |
| **893** | 36 | -35 | 27 | 0 | 37 | -33 | 36 | -16 | **937** | 36 | -35 | 27 | 0 | 37 | -33 | 36 | -16 |
| **894** | 36 | -34 | 28 | 0 | 39 | -36 | 37 | -14 | **938** | 36 | -34 | 28 | 0 | 39 | -36 | 37 | -14 |
| **895** | 32 | -26 | 31 | -4 | 40 | -37 | 37 | -17 | **939** | 32 | -26 | 31 | -4 | 40 | -37 | 37 | -17 |
| **896** | 37 | -30 | 27 | 6 | 38 | -30 | 32 | 1 | **940** | 37 | -30 | 27 | 6 | 38 | -30 | 32 | 1 |
| **897** | 44 | -32 | 34 | 8 | 46 | -33 | 34 | 15 | **941** | 44 | -32 | 34 | 8 | 46 | -33 | 34 | 15 |
| **898** | 34 | -18 | 30 | 10 | 42 | -30 | 29 | 15 | **942** | 34 | -18 | 30 | 10 | 42 | -30 | 29 | 15 |
| **899** | 34 | -15 | 24 | 22 | 40 | -24 | 24 | 25 | **943** | 34 | -15 | 24 | 22 | 40 | -24 | 24 | 25 |
| **900** | 40 | -15 | 33 | 19 | 49 | -29 | 34 | 22 | **944** | 40 | -15 | 33 | 19 | 49 | -29 | 34 | 22 |
| **901** | 33 | -7 | 22 | 32 | 38 | -12 | 31 | 16 | **945** | 33 | -7 | 22 | 32 | 38 | -12 | 31 | 16 |
| **902** | 35 | -5 | 26 | 31 | 40 | -10 | 35 | 18 | **946** | 35 | -5 | 26 | 31 | 40 | -10 | 35 | 18 |
| **903** | 33 | 0 | 21 | 41 | 38 | -3 | 31 | 28 | **947** | 33 | 0 | 21 | 41 | 38 | -3 | 31 | 28 |
| **904** | 38 | 2 | 26 | 44 | 46 | -5 | 33 | 41 | **948** | 38 | 2 | 26 | 44 | 46 | -5 | 33 | 41 |
| **905** | 33 | 13 | 23 | 47 | 31 | 20 | 36 | 28 | **949** | 33 | 13 | 23 | 47 | 31 | 20 | 36 | 28 |
| **906** | 23 | 35 | 16 | 65 | 29 | 30 | 27 | 47 | **950** | 23 | 35 | 16 | 65 | 29 | 30 | 27 | 47 |
| **907** | 13 | 58 | 14 | 71 | 25 | 44 | 21 | 62 | **951** | 13 | 58 | 14 | 71 | 25 | 44 | 21 | 62 |

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**Table 9-32 – Values of variables m and n for ctxIdx from 952 to 1011**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | n | m | n |
| **952** | -3 | 71 | -6 | 76 | -23 | 112 | -24 | 115 | **982** | -3 | 71 | -6 | 76 | -23 | 112 | -24 | 115 |
| **953** | -6 | 42 | -2 | 44 | -15 | 71 | -22 | 82 | **983** | -6 | 42 | -2 | 44 | -15 | 71 | -22 | 82 |
| **954** | -5 | 50 | 0 | 45 | -7 | 61 | -9 | 62 | **984** | -5 | 50 | 0 | 45 | -7 | 61 | -9 | 62 |
| **955** | -3 | 54 | 0 | 52 | 0 | 53 | 0 | 53 | **985** | -3 | 54 | 0 | 52 | 0 | 53 | 0 | 53 |
| **956** | -2 | 62 | -3 | 64 | -5 | 66 | 0 | 59 | **986** | -2 | 62 | -3 | 64 | -5 | 66 | 0 | 59 |
| **957** | 0 | 58 | -2 | 59 | -11 | 77 | -14 | 85 | **987** | 0 | 58 | -2 | 59 | -11 | 77 | -14 | 85 |
| **958** | 1 | 63 | -4 | 70 | -9 | 80 | -13 | 89 | **988** | 1 | 63 | -4 | 70 | -9 | 80 | -13 | 89 |
| **959** | -2 | 72 | -4 | 75 | -9 | 84 | -13 | 94 | **989** | -2 | 72 | -4 | 75 | -9 | 84 | -13 | 94 |
| **960** | -1 | 74 | -8 | 82 | -10 | 87 | -11 | 92 | **990** | -1 | 74 | -8 | 82 | -10 | 87 | -11 | 92 |
| **961** | -9 | 91 | -17 | 102 | -34 | 127 | -29 | 127 | **991** | -9 | 91 | -17 | 102 | -34 | 127 | -29 | 127 |
| **962** | -5 | 67 | -9 | 77 | -21 | 101 | -21 | 100 | **992** | -5 | 67 | -9 | 77 | -21 | 101 | -21 | 100 |
| **963** | -5 | 27 | 3 | 24 | -3 | 39 | -14 | 57 | **993** | -5 | 27 | 3 | 24 | -3 | 39 | -14 | 57 |
| **964** | -3 | 39 | 0 | 42 | -5 | 53 | -12 | 67 | **994** | -3 | 39 | 0 | 42 | -5 | 53 | -12 | 67 |
| **965** | -2 | 44 | 0 | 48 | -7 | 61 | -11 | 71 | **995** | -2 | 44 | 0 | 48 | -7 | 61 | -11 | 71 |
| **966** | 0 | 46 | 0 | 55 | -11 | 75 | -10 | 77 | **996** | 0 | 46 | 0 | 55 | -11 | 75 | -10 | 77 |
| **967** | -16 | 64 | -6 | 59 | -15 | 77 | -21 | 85 | **997** | -16 | 64 | -6 | 59 | -15 | 77 | -21 | 85 |
| **968** | -8 | 68 | -7 | 71 | -17 | 91 | -16 | 88 | **998** | -8 | 68 | -7 | 71 | -17 | 91 | -16 | 88 |
| **969** | -10 | 78 | -12 | 83 | -25 | 107 | -23 | 104 | **999** | -10 | 78 | -12 | 83 | -25 | 107 | -23 | 104 |
| **970** | -6 | 77 | -11 | 87 | -25 | 111 | -15 | 98 | **1000** | -6 | 77 | -11 | 87 | -25 | 111 | -15 | 98 |
| **971** | -10 | 86 | -30 | 119 | -28 | 122 | -37 | 127 | **1001** | -10 | 86 | -30 | 119 | -28 | 122 | -37 | 127 |
| **972** | -12 | 92 | 1 | 58 | -11 | 76 | -10 | 82 | **1002** | -12 | 92 | 1 | 58 | -11 | 76 | -10 | 82 |
| **973** | -15 | 55 | -3 | 29 | -10 | 44 | -8 | 48 | **1003** | -15 | 55 | -3 | 29 | -10 | 44 | -8 | 48 |
| **974** | -10 | 60 | -1 | 36 | -10 | 52 | -8 | 61 | **1004** | -10 | 60 | -1 | 36 | -10 | 52 | -8 | 61 |
| **975** | -6 | 62 | 1 | 38 | -10 | 57 | -8 | 66 | **1005** | -6 | 62 | 1 | 38 | -10 | 57 | -8 | 66 |
| **976** | -4 | 65 | 2 | 43 | -9 | 58 | -7 | 70 | **1006** | -4 | 65 | 2 | 43 | -9 | 58 | -7 | 70 |
| **977** | -12 | 73 | -6 | 55 | -16 | 72 | -14 | 75 | **1007** | -12 | 73 | -6 | 55 | -16 | 72 | -14 | 75 |
| **978** | -8 | 76 | 0 | 58 | -7 | 69 | -10 | 79 | **1008** | -8 | 76 | 0 | 58 | -7 | 69 | -10 | 79 |
| **979** | -7 | 80 | 0 | 64 | -4 | 69 | -9 | 83 | **1009** | -7 | 80 | 0 | 64 | -4 | 69 | -9 | 83 |
| **980** | -9 | 88 | -3 | 74 | -5 | 74 | -12 | 92 | **1010** | -9 | 88 | -3 | 74 | -5 | 74 | -12 | 92 |
| **981** | -17 | 110 | -10 | 90 | -9 | 86 | -18 | 108 | **1011** | -17 | 110 | -10 | 90 | -9 | 86 | -18 | 108 |

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**Table 9-33 – Values of variables m and n for ctxIdx from 1012 to 1023**

| ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | | ctxIdx | I and SI slices | | Value of cabac_init_idc | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | | 1 | | 2 | | | | | 0 | | 1 | | 2 | |
| | m | n | m | n | m | n | m | n | | m | n | m | n | m | N | m | n |
| **1012** | -3 | 70 | -3 | 74 | -2 | 73 | -5 | 79 | **1018** | -10 | 90 | -8 | 87 | -9 | 91 | -11 | 91 |
| **1013** | -8 | 93 | -9 | 92 | -12 | 104 | -11 | 104 | **1019** | -30 | 127 | -23 | 126 | -31 | 127 | -30 | 127 |
| **1014** | -10 | 90 | -8 | 87 | -9 | 91 | -11 | 91 | **1020** | -3 | 70 | -3 | 74 | -2 | 73 | -5 | 79 |
| **1015** | -30 | 127 | -23 | 126 | -31 | 127 | -30 | 127 | **1021** | -8 | 93 | -9 | 92 | -12 | 104 | -11 | 104 |
| **1016** | -3 | 70 | -3 | 74 | -2 | 73 | -5 | 79 | **1022** | -10 | 90 | -8 | 87 | -9 | 91 | -11 | 91 |
| **1017** | -8 | 93 | -9 | 92 | -12 | 104 | -11 | 104 | **1023** | -30 | 127 | -23 | 126 | -31 | 127 | -30 | 127 |

#### 9.3.1.2 Initialisation process for the arithmetic decoding engine

This process is invoked before decoding the first macroblock of a slice or after the decoding of any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data for a macroblock of type I_PCM.

Outputs of this process are the initialised decoding engine registers codIRange and codIOffset both in 16 bit register precision.

The status of the arithmetic decoding engine is represented by the variables codIRange and codIOffset. In the initialisation procedure of the arithmetic decoding process, codIRange is set equal to 0x01FE and codIOffset is set equal to the value returned from read_bits( 9 ) interpreted as a 9 bit binary representation of an unsigned integer with most significant bit written first.

The bitstream shall not contain data that results in a value of codIOffset being equal to 0x01FE or 0x01FF.

NOTE – The description of the arithmetic decoding engine in this International Standard utilizes 16 bit register precision. However, the minimum register precision for the variables codIRange and codIOffset is 9 bits.

### 9.3.2 Binarization process

Input to this process is a request for a syntax element.

Output of this process is the binarization of the syntax element, maxBinIdxCtx, ctxIdxOffset, and bypassFlag.

Table 9-34 specifies the type of binarization process, maxBinIdxCtx, and ctxIdxOffset associated with each syntax element.

The specification of the unary (U) binarization process, the truncated unary (TU) binarization process, the concatenated unary / k-th order Exp-Golomb (UEGk) binarization process, and the fixed-length (FL) binarization process are given in subclauses 9.3.2.1 to 9.3.2.4, respectively. Other binarizations are specified in subclauses 9.3.2.5 to 9.3.2.7.

Except for I slices, the binarizations for the syntax element mb_type as specified in subclause 9.3.2.5 consist of bin strings given by a concatenation of prefix and suffix bit strings. The UEGk binarization as specified in 9.3.2.3, which is used for the binarization of the syntax elements mvd_lX (X = 0, 1) and coeff_abs_level_minus1, and the binarization of the coded_block_pattern also consist of a concatenation of prefix and suffix bit strings. For these binarization processes, the prefix and the suffix bit string are separately indexed using the binIdx variable as specified further in subclause 9.3.3. The two sets of prefix bit strings and suffix bit strings are referred to as the binarization prefix part and the binarization suffix part, respectively.

Associated with each binarization or binarization part of a syntax element is a specific value of the context index offset (ctxIdxOffset) variable and a specific value of the maxBinIdxCtx variable as given in Table 9-34. When two values for each of these variables are specified for one syntax element in Table 9-34, the value in the upper row is related to the prefix part while the value in the lower row is related to the suffix part of the binarization of the corresponding syntax element.

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The use of the DecodeBypass process and the variable bypassFlag is derived as follows.

– If no value is assigned to ctxIdxOffset for the corresponding binarization or binarization part in Table 9-34 labelled as "na", all bins of the bit strings of the corresponding binarization or of the binarization prefix/suffix part are decoded by invoking the DecodeBypass process as specified in subclause 9.3.3.2.3. In such a case, bypassFlag is set equal to 1, where bypassFlag is used to indicate that for parsing the value of the bin from the bitstream the DecodeBypass process is applied.

– Otherwise, for each possible value of binIdx up to the specified value of maxBinIdxCtx given in Table 9-34, a specific value of the variable ctxIdx is further specified in subclause 9.3.3. bypassFlag is set equal to 0.

The possible values of the context index ctxIdx are in the range 0 to 1023, inclusive. The value assigned to ctxIdxOffset specifies the lower value of the range of ctxIdx assigned to the corresponding binarization or binarization part of a syntax element.

ctxIdx = ctxIdxOffset = 276 is assigned to the syntax element end_of_slice_flag and the bin of mb_type, which specifies the I_PCM macroblock type as further specified in subclause 9.3.3.1. For parsing the value of the corresponding bin from the bitstream, the arithmetic decoding process for decisions before termination (DecodeTerminate) as specified in subclause 9.3.3.2.4 is applied.

NOTE – The bins of mb_type in I slices and the bins of the suffix for mb_type in SI slices that correspond to the same value of binIdx share the same ctxIdx. The last bin of the prefix of mb_type and the first bin of the suffix of mb_type in P, SP, and B slices may share the same ctxIdx.

**Table 9-34 – Syntax elements and associated types of binarization, maxBinIdxCtx, and ctxIdxOffset**

| Syntax element | Type of binarization | maxBinIdxCtx | ctxIdxOffset |
|---|---|---|---|
| mb_type<br>(SI slices only) | prefix and suffix<br>as specified in subclause 9.3.2.5 | prefix: 0<br>suffix: 6 | prefix: 0<br>suffix: 3 |
| mb_type (I slices only) | as specified in subclause 9.3.2.5 | 6 | 3 |
| mb_skip_flag<br>(P, SP slices only) | FL, cMax=1 | 0 | 11 |
| mb_type (P, SP slices only) | prefix and suffix<br>as specified in subclause 9.3.2.5 | prefix: 2<br>suffix: 5 | prefix: 14<br>suffix: 17 |
| sub_mb_type<br>(P, SP slices only) | as specified in subclause 9.3.2.5 | 2 | 21 |
| mb_skip_flag<br>(B slices only) | FL, cMax=1 | 0 | 24 |
| mb_type (B slices only) | prefix and suffix<br>as specified in subclause 9.3.2.5 | prefix: 3<br>suffix: 5 | prefix: 27<br>suffix: 32 |
| sub_mb_type (B slices only) | as specified in subclause 9.3.2.5 | 3 | 36 |
| mvd_l0[ ][ ][ 0 ], mvd_l1[ ][ ][ 0 ] | prefix and suffix as given by UEG3 with signedValFlag=1, uCoff=9 | prefix: 4<br>suffix: na | prefix: 40<br>suffix: na (uses DecodeBypass) |
| mvd_l0[ ][ ][ 1 ], mvd_l1[ ][ ][ 1 ] | | prefix: 4<br>suffix: na | prefix: 47<br>suffix: na (uses DecodeBypass) |
| ref_idx_l0, ref_idx_l1 | U | 2 | 54 |
| mb_qp_delta | as specified in subclause 9.3.2.7 | 2 | 60 |
| intra_chroma_pred_mode | TU, cMax=3 | 1 | 64 |
| prev_intra4x4_pred_mode_flag,<br>prev_intra8x8_pred_mode_flag | FL, cMax=1 | 0 | 68 |
| rem_intra4x4_pred_mode,<br>rem_intra8x8_pred_mode | FL, cMax=7 | 0 | 69 |

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| Syntax element | Type of binarization | maxBinIdxCtx | ctxIdxOffset |
|---|---|---|---|
| mb_field_decoding_flag | FL, cMax=1 | 0 | 70 |
| coded_block_pattern | prefix and suffix<br>as specified in subclause 9.3.2.6 | prefix: 3<br>suffix: 1 | prefix: 73<br>suffix: 77 |
| coded_block_flag | FL, cMax=1 | 0 | 85 |
| significant_coeff_flag<br>(frame coded blocks with ctxBlockCat < 5) | FL, cMax=1 | 0 | 105 |
| last_significant_coeff_flag<br>(frame coded blocks with ctxBlockCat < 5) | FL, cMax=1 | 0 | 166 |
| coeff_abs_level_minus1<br>(blocks with ctxBlockCat < 5) | prefix and suffix as given by UEG0<br>with signedValFlag=0, uCoff=14 | prefix: 1<br>suffix: na | prefix: 227<br>suffix: na, (uses DecodeBypass) |
| coeff_sign_flag | FL, cMax=1 | 0 | na, (uses DecodeBypass) |
| end_of_slice_flag | FL, cMax=1 | 0 | 276 |
| significant_coeff_flag<br>(field coded blocks with ctxBlockCat < 5) | FL, cMax=1 | 0 | 277 |
| last_significant_coeff_flag<br>(field coded blocks with ctxBlockCat < 5) | FL, cMax=1 | 0 | 338 |
| transform_size_8x8_flag | FL, cMax=1 | 0 | 399 |
| significant_coeff_flag<br>(frame coded blocks with ctxBlockCat == 5) | FL, cMax=1 | 0 | 402 |
| last_significant_coeff_flag<br>(frame coded blocks with ctxBlockCat == 5) | FL, cMax=1 | 0 | 417 |
| coeff_abs_level_minus1<br>(blocks with ctxBlockCat == 5) | prefix and suffix as given by UEG0<br>with signedValFlag=0, uCoff=14 | prefix: 1<br>suffix: na | prefix: 426<br>suffix: na, (uses DecodeBypass) |
| significant_coeff_flag<br>(field coded blocks with ctxBlockCat == 5) | FL, cMax=1 | 0 | 436 |
| last_significant_coeff_flag<br>(field coded blocks with ctxBlockCat == 5) | FL, cMax=1 | 0 | 451 |
| coded_block_flag<br>(5 < ctxBlockCat < 9) | FL, cMax=1 | 0 | 460 |
| coded_block_flag<br>(9 < ctxBlockCat < 13) | FL, cMax=1 | 0 | 472 |
| coded_block_flag<br>(ctxBlockCat == 5, 9, or 13) | FL, cMax=1 | 0 | 1012 |
| significant_coeff_flag<br>(frame coded blocks<br>with 5 < ctxBlockCat < 9) | FL, cMax=1 | 0 | 484 |
| significant_coeff_flag<br>(frame coded blocks with<br>9 < ctxBlockCat < 13) | FL, cMax=1 | 0 | 528 |
| last_significant_coeff_flag<br>(frame coded blocks with<br>5 < ctxBlockCat < 9) | FL, cMax=1 | 0 | 572 |

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| Syntax element | Type of binarization | maxBinIdxCtx | ctxIdxOffset |
|---|---|---|---|
| last_significant_coeff_flag (frame coded blocks with 9 < ctxBlockCat < 13) | FL, cMax=1 | 0 | 616 |
| coeff_abs_level_minus1 (blocks with 5 < ctxBlockCat < 9) | prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14 | prefix: 1<br>suffix: na | prefix: 952<br>suffix: na, (uses DecodeBypass) |
| coeff_abs_level_minus1 (blocks with 9 < ctxBlockCat < 13) | prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14 | prefix: 1<br>suffix: na | prefix: 982<br>suffix: na, (uses DecodeBypass) |
| significant_coeff_flag (field coded blocks with 5 < ctxBlockCat < 9) | FL, cMax=1 | 0 | 776 |
| significant_coeff_flag (field coded blocks with 9 < ctxBlockCat < 13) | FL, cMax=1 | 0 | 820 |
| last_significant_coeff_flag (field coded blocks with 5 < ctxBlockCat < 9) | FL, cMax=1 | 0 | 864 |
| last_significant_coeff_flag (field coded blocks with 9 < ctxBlockCat < 13) | FL, cMax=1 | 0 | 908 |
| significant_coeff_flag (frame coded blocks with ctxBlockCat == 9) | FL, cMax=1 | 0 | 660 |
| significant_coeff_flag (frame coded blocks with ctxBlockCat == 13) | FL, cMax=1 | 0 | 718 |
| last_significant_coeff_flag (frame coded blocks with ctxBlockCat == 9) | FL, cMax=1 | 0 | 690 |
| last_significant_coeff_flag (frame coded blocks with ctxBlockCat == 13) | FL, cMax=1 | 0 | 748 |
| coeff_abs_level_minus1 (blocks with ctxBlockCat == 9) | prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14 | prefix: 1<br>suffix: na | prefix: 708<br>suffix: na, (uses DecodeBypass) |
| coeff_abs_level_minus1 (blocks with ctxBlockCat == 13) | prefix and suffix as given by UEG0 with signedValFlag=0, uCoff=14 | prefix: 1<br>suffix: na | prefix: 766<br>suffix: na, (uses DecodeBypass) |
| significant_coeff_flag (field coded blocks with ctxBlockCat == 9) | FL, cMax=1 | 0 | 675 |
| significant_coeff_flag (field coded blocks with ctxBlockCat == 13) | FL, cMax=1 | 0 | 733 |
| last_significant_coeff_flag (field coded blocks with ctxBlockCat == 9) | FL, cMax=1 | 0 | 699 |
| last_significant_coeff_flag (field coded blocks with ctxBlockCat == 13) | FL, cMax=1 | 0 | 757 |

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#### 9.3.2.1 Unary (U) binarization process

Input to this process is a request for a U binarization for a syntax element.

Output of this process is the U binarization of the syntax element.

The bin string of a syntax element having (unsigned integer) value synElVal is a bit string of length synElVal + 1 indexed by BinIdx. The bins for binIdx less than synElVal are equal to 1. The bin with binIdx equal to synElVal is equal to 0.

Table 9-35 illustrates the bin strings of the unary binarization for a syntax element.

**Table 9-35 – Bin string of the unary binarization (informative)**

| Value of syntax element | Bin string | | | | | |
|---|---|---|---|---|---|---|
| 0 (I_NxN) | 0 | | | | | |
| 1 | 1 | 0 | | | | |
| 2 | 1 | 1 | 0 | | | |
| 3 | 1 | 1 | 1 | 0 | | |
| 4 | 1 | 1 | 1 | 1 | 0 | |
| 5 | 1 | 1 | 1 | 1 | 1 | 0 |
| … | | | | | | |
| binIdx | 0 | 1 | 2 | 3 | 4 | 5 |

#### 9.3.2.2 Truncated unary (TU) binarization process

Input to this process is a request for a TU binarization for a syntax element and cMax.

Output of this process is the TU binarization of the syntax element.

For syntax element (unsigned integer) values less than cMax, the U binarization process as specified in subclause 9.3.2.1 is invoked. For the syntax element value equal to cMax the bin string is a bit string of length cMax with all bins being equal to 1.

NOTE – TU binarization is always invoked with a cMax value equal to the largest possible value of the syntax element being decoded.

#### 9.3.2.3 Concatenated unary/ k-th order Exp-Golomb (UEGk) binarization process

Input to this process is a request for a UEGk binarization for a syntax element, signedValFlag and uCoff.

Output of this process is the UEGk binarization of the syntax element.

A UEGk bin string is a concatenation of a prefix bit string and a suffix bit string. The prefix of the binarization is specified by invoking the TU binarization process for the prefix part Min( uCoff, Abs( synElVal ) ) of a syntax element value synElVal as specified in subclause 9.3.2.2 with cMax = uCoff, where uCoff > 0.

The UEGk bin string is derived as follows.

- If one of the following is true, the bin string of a syntax element having value synElVal consists only of a prefix bit string,
    - signedValFlag is equal to 0 and the prefix bit string is not equal to the bit string of length uCoff with all bits equal to 1.
    - signedValFlag is equal to 1 and the prefix bit string is equal to the bit string that consists of a single bit with value equal to 0.

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- Otherwise, the bin string of the UEGk suffix part of a syntax element value synElVal is specified by a process equivalent to the following pseudo-code:

```
if( Abs( synElVal ) >= uCoff ) {
    sufS = Abs( synElVal ) − uCoff
    stopLoop = 0
    do {
        if( sufS >= ( 1 << k ) ) {
            put( 1 )
            sufS = sufS − ( 1<<k )
            k++
        } else {
            put( 0 )
            while( k− − )
                put( ( sufS >> k ) & 0x01 )
            stopLoop = 1
        }
    } while( !stopLoop )
}
if( signedValFlag && synElVal != 0)
    if( synElVal > 0 )
        put( 0 )
    else
        put( 1 )
```

NOTE – The specification for the k-th order Exp-Golomb (EGk) code uses 1's and 0's in reverse meaning for the unary part of the Exp-Golomb code of 0-th order as specified in subclause 9.1.

#### 9.3.2.4 Fixed-length (FL) binarization process

Input to this process is a request for a FL binarization for a syntax element and cMax.

Output of this process is the FL binarization of the syntax element.

FL binarization is constructed by using an fixedLength-bit unsigned integer bin string of the syntax element value, where fixedLength = Ceil( Log2( cMax + 1 ) ). The indexing of bins for the FL binarization is such that the binIdx = 0 relates to the least significant bit with increasing values of binIdx towards the most significant bit.

#### 9.3.2.5 Binarization process for macroblock type and sub-macroblock type

Input to this process is a request for a binarization for syntax elements mb_type or sub_mb_type.

Output of this process is the binarization of the syntax element.

The binarization scheme for decoding of macroblock type in I slices is specified in Table 9-36.

For macroblock types in SI slices, the binarization consists of bin strings specified as a concatenation of a prefix and a suffix bit string as follows.

The prefix bit string consists of a single bit, which is specified by $b_0$ = ((mb_type == SI) ? 0 : 1 ). For the syntax element value for which $b_0$ is equal to 0, the bin string only consists of the prefix bit string. For the syntax element value for which $b_0$ is equal to 1, the binarization is given by concatenating the prefix $b_0$ and the suffix bit string as specified in Table 9-36 for macroblock type in I slices indexed by subtracting 1 from the value of mb_type in SI slices.

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**Table 9-36 – Binarization for macroblock types in I slices**

| Value (name) of mb_type | Bin string | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 (I_4x4) | 0 | | | | | | |
| 1 (I_16x16_0_0_0) | 1 | 0 | 0 | 0 | 0 | 0 | |
| 2 (I_16x16_1_0_0) | 1 | 0 | 0 | 0 | 0 | 1 | |
| 3 (I_16x16_2_0_0) | 1 | 0 | 0 | 0 | 1 | 0 | |
| 4 (I_16x16_3_0_0) | 1 | 0 | 0 | 0 | 1 | 1 | |
| 5 (I_16x16_0_1_0) | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 6 (I_16x16_1_1_0) | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| 7 (I_16x16_2_1_0) | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 8 (I_16x16_3_1_0) | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 9 (I_16x16_0_2_0) | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 10 (I_16x16_1_2_0) | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 11 (I_16x16_2_2_0) | 1 | 0 | 0 | 1 | 1 | 1 | 0 |
| 12 (I_16x16_3_2_0) | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| 13 (I_16x16_0_0_1) | 1 | 0 | 1 | 0 | 0 | 0 | |
| 14 (I_16x16_1_0_1) | 1 | 0 | 1 | 0 | 0 | 1 | |
| 15 (I_16x16_2_0_1) | 1 | 0 | 1 | 0 | 1 | 0 | |
| 16 (I_16x16_3_0_1) | 1 | 0 | 1 | 0 | 1 | 1 | |
| 17 (I_16x16_0_1_1) | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| 18 (I_16x16_1_1_1) | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| 19 (I_16x16_2_1_1) | 1 | 0 | 1 | 1 | 0 | 1 | 0 |
| 20 (I_16x16_3_1_1) | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| 21 (I_16x16_0_2_1) | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| 22 (I_16x16_1_2_1) | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| 23 (I_16x16_2_2_1) | 1 | 0 | 1 | 1 | 1 | 1 | 0 |
| 24 (I_16x16_3_2_1) | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| 25 (I_PCM) | 1 | 1 | | | | | |
| binIdx | 0 | 1 | 2 | 3 | 4 | 5 | 6 |

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The binarization schemes for P macroblock types in P and SP slices and for B macroblocks in B slices are specified in Table 9-37.

The bin string for I macroblock types in P and SP slices corresponding to mb_type values 5 to 30 consists of a concatenation of a prefix, which consists of a single bit with value equal to 1 as specified in Table 9-37 and a suffix as specified in Table 9-36, indexed by subtracting 5 from the value of mb_type.

mb_type equal to 4 (P_8x8ref0) is not allowed.

For I macroblock types in B slices (mb_type values 23 to 48) the binarization consists of bin strings specified as a concatenation of a prefix bit string as specified in Table 9-37 and suffix bit strings as specified in Table 9-36, indexed by subtracting 23 from the value of mb_type.

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**Table 9-37 – Binarization for macroblock types in P, SP, and B slices**

| Slice type | Value (name) of mb_type | Bin string | | | | | | |
|---|---|---|---|---|---|---|---|---|
| P, SP slice | 0 (P_L0_16x16) | 0 | 0 | 0 | | | | |
| | 1 (P_L0_L0_16x8) | 0 | 1 | 1 | | | | |
| | 2 (P_L0_L0_8x16) | 0 | 1 | 0 | | | | |
| | 3 (P_8x8) | 0 | 0 | 1 | | | | |
| | 4 (P_8x8ref0) | na | | | | | | |
| | 5 to 30 (Intra, prefix only) | 1 | | | | | | |
| B slice | 0 (B_Direct_16x16) | 0 | | | | | | |
| | 1 (B_L0_16x16) | 1 | 0 | 0 | | | | |
| | 2 (B_L1_16x16) | 1 | 0 | 1 | | | | |
| | 3 (B_Bi_16x16) | 1 | 1 | 0 | 0 | 0 | 0 | |
| | 4 (B_L0_L0_16x8) | 1 | 1 | 0 | 0 | 0 | 1 | |
| | 5 (B_L0_L0_8x16) | 1 | 1 | 0 | 0 | 1 | 0 | |
| | 6 (B_L1_L1_16x8) | 1 | 1 | 0 | 0 | 1 | 1 | |
| | 7 (B_L1_L1_8x16) | 1 | 1 | 0 | 1 | 0 | 0 | |
| | 8 (B_L0_L1_16x8) | 1 | 1 | 0 | 1 | 0 | 1 | |
| | 9 (B_L0_L1_8x16) | 1 | 1 | 0 | 1 | 1 | 0 | |
| | 10 (B_L1_L0_16x8) | 1 | 1 | 0 | 1 | 1 | 1 | |
| | 11 (B_L1_L0_8x16) | 1 | 1 | 1 | 1 | 1 | 0 | |
| | 12 (B_L0_Bi_16x8) | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| | 13 (B_L0_Bi_8x16) | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| | 14 (B_L1_Bi_16x8) | 1 | 1 | 1 | 0 | 0 | 1 | 0 |
| | 15 (B_L1_Bi_8x16) | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| | 16 (B_Bi_L0_16x8) | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| | 17 (B_Bi_L0_8x16) | 1 | 1 | 1 | 0 | 1 | 0 | 1 |
| | 18 (B_Bi_L1_16x8) | 1 | 1 | 1 | 0 | 1 | 1 | 0 |
| | 19 (B_Bi_L1_8x16) | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| | 20 (B_Bi_Bi_16x8) | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| | 21 (B_Bi_Bi_8x16) | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| | 22 (B_8x8) | 1 | 1 | 1 | 1 | 1 | 1 | |
| | 23 to 48 (Intra, prefix only) | 1 | 1 | 1 | 1 | 0 | 1 | |
| binIdx | | 0 | 1 | 2 | 3 | 4 | 5 | 6 |

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For P, SP, and B slices the specification of the binarization for sub_mb_type is given in Table 9-38.


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**Table 9-38 – Binarization for sub-macroblock types in P, SP, and B slices**

| Slice type | Value (name) of sub_mb_type | Bin string | | | | | |
|---|---|---|---|---|---|---|---|
| P, SP slice | 0 (P_L0_8x8) | 1 | | | | | |
| | 1 (P_L0_8x4) | 0 | 0 | | | | |
| | 2 (P_L0_4x8) | 0 | 1 | 1 | | | |
| | 3 (P_L0_4x4) | 0 | 1 | 0 | | | |
| B slice | 0 (B_Direct_8x8) | 0 | | | | | |
| | 1 (B_L0_8x8) | 1 | 0 | 0 | | | |
| | 2 (B_L1_8x8) | 1 | 0 | 1 | | | |
| | 3 (B_Bi_8x8) | 1 | 1 | 0 | 0 | 0 | |
| | 4 (B_L0_8x4) | 1 | 1 | 0 | 0 | 1 | |
| | 5 (B_L0_4x8) | 1 | 1 | 0 | 1 | 0 | |
| | 6 (B_L1_8x4) | 1 | 1 | 0 | 1 | 1 | |
| | 7 (B_L1_4x8) | 1 | 1 | 1 | 0 | 0 | 0 |
| | 8 (B_Bi_8x4) | 1 | 1 | 1 | 0 | 0 | 1 |
| | 9 (B_Bi_4x8) | 1 | 1 | 1 | 0 | 1 | 0 |
| | 10 (B_L0_4x4) | 1 | 1 | 1 | 0 | 1 | 1 |
| | 11 (B_L1_4x4) | 1 | 1 | 1 | 1 | 0 | |
| | 12 (B_Bi_4x4) | 1 | 1 | 1 | 1 | 1 | |
| binIdx | | 0 | 1 | 2 | 3 | 4 | 5 |

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#### 9.3.2.6 Binarization process for coded block pattern

Input to this process is a request for a binarization for the syntax element coded_block_pattern.

Output of this process is the binarization of the syntax element.

The binarization of coded_block_pattern consists of a prefix part and (when present) a suffix part. The prefix part of the binarization is given by the FL binarization of CodedBlockPatternLuma with cMax = 15. When ChromaArrayType is not equal to 0 or 3, the suffix part is present and consists of the TU binarization of CodedBlockPatternChroma with cMax = 2. The relationship between the value of the syntax element coded_block_pattern and the values of CodedBlockPatternLuma and CodedBlockPatternChroma is given as specified in subclause 7.4.5.

#### 9.3.2.7 Binarization process for mb_qp_delta

Input to this process is a request for a binarization for the syntax element mb_qp_delta.

Output of this process is the binarization of the syntax element.

The bin string of mb_qp_delta is derived by the U binarization of the mapped value of the syntax element mb_qp_delta, where the assignment rule between the signed value of mb_qp_delta and its mapped value is given as specified in Table 9-3.

### 9.3.3 Decoding process flow

Input to this process is a binarization of the requested syntax element, maxBinIdxCtx, bypassFlag and ctxIdxOffset as specified in subclause 9.3.2.

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Output of this process is the value of the syntax element.

This process specifies how each bit of a bit string is parsed for each syntax element.

After parsing each bit, the resulting bit string is compared to all bin strings of the binarization of the syntax element and the following applies.

– If the bit string is equal to one of the bin strings, the corresponding value of the syntax element is the output.

– Otherwise (the bit string is not equal to one of the bin strings), the next bit is parsed.

While parsing each bin, the variable binIdx is incremented by 1 starting with binIdx being set equal to 0 for the first bin.

When the binarization of the corresponding syntax element consists of a prefix and a suffix binarization part, the variable binIdx is set equal to 0 for the first bin of each part of the bin string (prefix part or suffix part). In this case, after parsing the prefix bit string, the parsing process of the suffix bit string related to the binarizations specified in subclauses 9.3.2.3 and 9.3.2.5 is invoked depending on the resulting prefix bit string as specified in subclauses 9.3.2.3 and 9.3.2.5. Note that for the binarization of the syntax element coded_block_pattern, the suffix bit string is present regardless of the prefix bit string of length 4 as specified in subclause 9.3.2.6.

Depending on the variable bypassFlag, the following applies.

– If bypassFlag is equal to 1, the bypass decoding process as specified in subclause 9.3.3.2.3 is applied for parsing the value of the bins from the bitstream.

– Otherwise (bypassFlag is equal to 0), the parsing of each bin is specified by the following two ordered steps:

1. Given binIdx, maxBinIdxCtx and ctxIdxOffset, ctxIdx is derived as specified in subclause 9.3.3.1.
2. Given ctxIdx, the value of the bin from the bitstream as specified in subclause 9.3.3.2 is decoded.

#### 9.3.3.1 Derivation process for ctxIdx

Inputs to this process are binIdx, maxBinIdxCtx and ctxIdxOffset.

Output of this process is ctxIdx.

Table 9-39 shows the assignment of ctxIdx increments (ctxIdxInc) to binIdx for all ctxIdxOffset values except those related to the syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1.

The ctxIdx to be used with a specific binIdx is specified by first determining the ctxIdxOffset associated with the given bin string or part thereof. The ctxIdx is determined as follows.

– If the ctxIdxOffset is listed in Table 9-39, the ctxIdx for a binIdx is the sum of ctxIdxOffset and ctxIdxInc, which is found in Table 9-39. When more than one value is listed in Table 9-39 for a binIdx, the assignment process for ctxIdxInc for that binIdx is further specified in the subclauses given in parenthesis of the corresponding table entry.

– Otherwise (ctxIdxOffset is not listed in Table 9-39), the ctxIdx is specified to be the sum of the following terms: ctxIdxOffset and ctxIdxBlockCatOffset(ctxBlockCat) as specified in Table 9-40 and ctxIdxInc(ctxBlockCat). Subclause 9.3.3.1.3 specifies which ctxBlockCat is used. Subclause 9.3.3.1.1.9 specifies the assignment of ctxIdxInc(ctxBlockCat) for coded_block_flag, and subclause 9.3.3.1.3 specifies the assignment of ctxIdxInc(ctxBlockCat) for significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1.

All bins with binIdx greater than maxBinIdxCtx are parsed using the value of ctxIdx being assigned to binIdx equal to maxBinIdxCtx.

All entries in Table 9-39 labelled with “na” correspond to values of binIdx that do not occur for the corresponding ctxIdxOffset.

ctxIdx = 276 is assigned to the binIdx of mb_type indicating the I_PCM mode. For parsing the value of the corresponding bins from the bitstream, the arithmetic decoding process for decisions before termination as specified in subclause 9.3.3.2.4 is applied.

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**Table 9-39 – Assignment of ctxIdxInc to binIdx for all ctxIdxOffset values except those related to the syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1**

| ctxIdxOffset | binIdx | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | >= 6 |
| 0 | 0,1,2 (subclause 9.3.3.1.1.3) | na | na | na | na | na | na |
| 3 | 0,1,2 (subclause 9.3.3.1.1.3) | ctxIdx=276 | 3 | 4 | 5,6 (subclause 9.3.3.1.2) | 6,7 (subclause 9.3.3.1.2) | 7 |
| 11 | 0,1,2 (subclause 9.3.3.1.1.1) | na | na | na | na | na | na |
| 14 | 0 | 1 | 2,3 (subclause 9.3.3.1.2) | na | na | na | na |
| 17 | 0 | ctxIdx=276 | 1 | 2 | 2,3 (subclause 9.3.3.1.2) | 3 | 3 |
| 21 | 0 | 1 | 2 | na | na | na | na |
| 24 | 0,1,2 (subclause 9.3.3.1.1.1) | na | na | na | na | na | na |
| 27 | 0,1,2 (subclause 9.3.3.1.1.3) | 3 | 4,5 (subclause 9.3.3.1.2) | 5 | 5 | 5 | 5 |
| 32 | 0 | ctxIdx=276 | 1 | 2 | 2,3 (subclause 9.3.3.1.2) | 3 | 3 |
| 36 | 0 | 1 | 2,3 (subclause 9.3.3.1.2) | 3 | 3 | 3 | na |
| 40 | 0,1,2 (subclause 9.3.3.1.1.7) | 3 | 4 | 5 | 6 | 6 | 6 |
| 47 | 0,1,2 (subclause 9.3.3.1.1.7) | 3 | 4 | 5 | 6 | 6 | 6 |
| 54 | 0,1,2,3 (subclause 9.3.3.1.1.6) | 4 | 5 | 5 | 5 | 5 | 5 |
| 60 | 0,1 (subclause 9.3.3.1.1.5) | 2 | 3 | 3 | 3 | 3 | 3 |
| 64 | 0,1,2 (subclause 9.3.3.1.1.8) | 3 | 3 | na | na | na | na |
| 68 | 0 | na | na | na | na | na | na |
| 69 | 0 | 0 | 0 | na | na | na | na |
| 70 | 0,1,2 (subclause 9.3.3.1.1.2) | na | na | na | na | na | na |
| 73 | 0,1,2,3 (subclause 9.3.3.1.1.4) | 0,1,2,3 (subclause 9.3.3.1.1.4) | 0,1,2,3 (subclause 9.3.3.1.1.4) | 0,1,2,3 (subclause 9.3.3.1.1.4) | na | na | na |
| 77 | 0,1,2,3 (subclause 9.3.3.1.1.4) | 4,5,6,7 (subclause 9.3.3.1.1.4) | na | na | na | na | na |
| 276 | 0 | na | na | na | na | na | na |
| 399 | 0,1,2 (subclause 9.3.3.1.1.10) | na | na | na | na | na | na |

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Table 9-40 shows the values of ctxIdxBlockCatOffset depending on ctxBlockCat for the syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1. The specification of ctxBlockCat is given in Table 9-42.

**Table 9-40 – Assignment of ctxIdxBlockCatOffset to ctxBlockCat for syntax elements coded_block_flag, significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1**

| Syntax element | ctxBlockCat (as specified in Table 9-42) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** |
| coded_block_flag | 0 | 4 | 8 | 12 | 16 | 0 | 0 | 4 | 8 | 4 | 0 | 4 | 8 | 8 |
| significant_coeff_flag | 0 | 15 | 29 | 44 | 47 | 0 | 0 | 15 | 29 | 0 | 0 | 15 | 29 | 0 |
| last_significant_coeff_flag | 0 | 15 | 29 | 44 | 47 | 0 | 0 | 15 | 29 | 0 | 0 | 15 | 29 | 0 |
| coeff_abs_level_minus1 | 0 | 10 | 20 | 30 | 39 | 0 | 0 | 10 | 20 | 0 | 0 | 10 | 20 | 0 |

#### 9.3.3.1.1 Assignment process of ctxIdxInc using neighbouring syntax elements

Subclause 9.3.3.1.1.1 specifies the derivation process of ctxIdxInc for the syntax element mb_skip_flag.

Subclause 9.3.3.1.1.2 specifies the derivation process of ctxIdxInc for the syntax element mb_field_decoding_flag.

Subclause 9.3.3.1.1.3 specifies the derivation process of ctxIdxInc for the syntax element mb_type.

Subclause 9.3.3.1.1.4 specifies the derivation process of ctxIdxInc for the syntax element coded_block_pattern.

Subclause 9.3.3.1.1.5 specifies the derivation process of ctxIdxInc for the syntax element mb_qp_delta.

Subclause 9.3.3.1.1.6 specifies the derivation process of ctxIdxInc for the syntax elements ref_idx_l0 and ref_idx_l1.

Subclause 9.3.3.1.1.7 specifies the derivation process of ctxIdxInc for the syntax elements mvd_l0 and mvd_l1.

Subclause 9.3.3.1.1.8 specifies the derivation process of ctxIdxInc for the syntax element intra_chroma_pred_mode.

Subclause 9.3.3.1.1.9 specifies the derivation process of ctxIdxInc for the syntax element coded_block_flag.

Subclause 9.3.3.1.1.10 specifies the derivation process of ctxIdxInc for the syntax element transform_size_8x8_flag.

##### 9.3.3.1.1.1 Derivation process of ctxIdxInc for the syntax element mb_skip_flag

Output of this process is ctxIdxInc.

When MbaffFrameFlag is equal to 1 and mb_field_decoding_flag has not been decoded (yet) for the current macroblock pair with top macroblock address 2 * ( CurrMbAddr / 2 ), the inference rule for the syntax element mb_field_decoding_flag as specified in subclause 7.4.4 is applied.

The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If mbAddrN is not available or mb_skip_flag for the macroblock mbAddrN is equal to 1, condTermFlagN is set equal to 0.

– Otherwise (mbAddrN is available and mb_skip_flag for the macroblock mbAddrN is equal to 0), condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

$$ctxIdxInc = condTermFlagA + condTermFlagB \quad (9\text{-}1)$$

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#### 9.3.3.1.1.2 Derivation process of ctxIdxInc for the syntax element mb_field_decoding_flag

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblock addresses and their availability in MBAFF frames as specified in subclause 6.4.9 is invoked and the output is assigned to mbAddrA and mbAddrB.

When both macroblocks mbAddrN and mbAddrN + 1 have mb_type equal to P_Skip or B_Skip, the inference rule for the syntax element mb_field_decoding_flag as specified in subclause 7.4.4 is applied for the macroblock mbAddrN.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0,
  – mbAddrN is not available
  – the macroblock mbAddrN is a frame macroblock.
– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

$$ctxIdxInc = condTermFlagA + condTermFlagB \quad (9\text{-}2)$$

#### 9.3.3.1.1.3 Derivation process of ctxIdxInc for the syntax element mb_type

Input to this process is ctxIdxOffset.

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0
  – mbAddrN is not available
  – ctxIdxOffset is equal to 0 and mb_type for the macroblock mbAddrN is equal to SI
  – ctxIdxOffset is equal to 3 and mb_type for the macroblock mbAddrN is equal to I_NxN
  – ctxIdxOffset is equal to 27 and mb_type for the macroblock mbAddrN is equal to P_Skip, B_Skip, or B_Direct_16x16
– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived as

$$ctxIdxInc = condTermFlagA + condTermFlagB \quad (9\text{-}3)$$

#### 9.3.3.1.1.4 Derivation process of ctxIdxInc for the syntax element coded_block_pattern

Inputs to this process are ctxIdxOffset and binIdx.

Output of this process is ctxIdxInc.

Depending on the value of the variable ctxIdxOffset, the following applies.

– If ctxIdxOffset is equal to 73, the following applies
  – The derivation process for neighbouring 8x8 luma blocks specified in subclause 6.4.10.2 is invoked with luma8x8BlkIdx = binIdx as input and the output is assigned to mbAddrA, mbAddrB, luma8x8BlkIdxA, and luma8x8BlkIdxB.
  – Let the variable condTermFlagN (with N being either A or B) be derived as follows.
    – If any of the following conditions are true, condTermFlagN is set equal to 0

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- mbAddrN is not available
- mb_type for the macroblock mbAddrN is equal to I_PCM
- the macroblock mbAddrN is not the current macroblock CurrMbAddr and the macroblock mbAddrN does not have mb_type equal to P_Skip or B_Skip, and ( ( CodedBlockPatternLuma >> luma8x8BlkIdxN ) & 1 ) is not equal to 0 for the value of CodedBlockPatternLuma for the macroblock mbAddrN
- the macroblock mbAddrN is the current macroblock CurrMbAddr and the prior decoded bin value $b_k$ of coded_block_pattern with k = luma8x8BlkIdxN is not equal to 0.

– Otherwise, condTermFlagN is set equal to 1.

– The variable ctxIdxInc is derived as

$$ctxIdxInc = condTermFlagA + 2 * condTermFlagB \quad (9\text{-}4)$$

– Otherwise (ctxIdxOffset is equal to 77), the following applies.

– The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

– Let the variable condTermFlagN (with N being either A or B) be derived as follows.

– If mbAddrN is available and mb_type for the macroblock mbAddrN is equal to I_PCM, condTermFlagN is set equal to 1

– Otherwise, if any of the following conditions is true, condTermFlagN is set equal to 0

– mbAddrN is not available or the macroblock mbAddrN has mb_type equal to P_Skip or B_Skip

– binIdx is equal to 0 and CodedBlockPatternChroma for the macroblock mbAddrN is equal to 0

– binIdx is equal to 1 and CodedBlockPatternChroma for the macroblock mbAddrN is not equal to 2

– Otherwise, condTermFlagN is set equal to 1.

– The variable ctxIdxInc is derived as

$$ctxIdxInc = condTermFlagA + 2 * condTermFlagB + ( ( binIdx == 1 ) ? 4 : 0 ) \quad (9\text{-}5)$$

NOTE – When a macroblock uses an Intra_16x16 prediction mode, the values of CodedBlockPatternLuma and CodedBlockPatternChroma for the macroblock are derived from mb_type as specified in Table 7-11.

#### 9.3.3.1.1.5 Derivation process of ctxIdxInc for the syntax element mb_qp_delta

Output of this process is ctxIdxInc.

Let prevMbAddr be the macroblock address of the macroblock that precedes the current macroblock in decoding order. When the current macroblock is the first macroblock of a slice, prevMbAddr is marked as not available.

Let the variable ctxIdxInc be derived as follows.

– If any of the following conditions is true, ctxIdxInc is set equal to 0

– prevMbAddr is not available or the macroblock prevMbAddr has mb_type equal to P_Skip or B_Skip

– mb_type of the macroblock prevMbAddr is equal to I_PCM

– The macroblock prevMbAddr is not coded in Intra_16x16 prediction mode and both CodedBlockPatternLuma and CodedBlockPatternChroma for the macroblock prevMbAddr are equal to 0

– mb_qp_delta for the macroblock prevMbAddr is equal to 0

– Otherwise, ctxIdxInc is set equal to 1.

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#### 9.3.3.1.1.6 Derivation process of ctxIdxInc for the syntax elements ref_idx_l0 and ref_idx_l1

Input to this process is mbPartIdx.

Output of this process is ctxIdxInc.

The interpretation of ref_idx_lX and Pred_LX within this subclause is specified as follows.

- If this process is invoked for the derivation of ref_idx_l0, ref_idx_lX is interpreted as ref_idx_l0 and Pred_LX is interpreted as Pred_L0.
- Otherwise (this process is invoked for the derivation of ref_idx_l1), ref_idx_lX is interpreted as ref_idx_l1 and Pred_LX is interpreted as Pred_L1.

The derivation process for neighbouring partitions specified in subclause 6.4.10.7 is invoked with mbPartIdx, currSubMbType, and subMbPartIdx = 0 as input and the output is assigned to mbAddrA\mbPartIdxA and mbAddrB\mbPartIdxB.

With ref_idx_lX[ mbPartIdxN ] (with N being either A or B) specifying the syntax element for the macroblock mbAddrN, let the variable refIdxZeroFlagN be derived as follows.

- If MbaffFrameFlag is equal to 1, the current macroblock is a frame macroblock, and the macroblock mbAddrN is a field macroblock

$$refIdxZeroFlagN = ( ( ref_idx_lX[ mbPartIdxN ] > 1 ) ? 0 : 1 ) \quad (9\text{-}6)$$

- Otherwise,

$$refIdxZeroFlagN = ( ( ref_idx_lX[ mbPartIdxN ] > 0 ) ? 0 : 1 ) \quad (9\text{-}7)$$

Let the variable predModeEqualFlagN be specified as follows.

- If the macroblock mbAddrN has mb_type equal to P_8x8 or B_8x8, the following applies.
  - If SubMbPredMode( sub_mb_type[ mbPartIdxN ] ) is not equal to Pred_LX and not equal to BiPred, predModeEqualFlagN is set equal to 0, where sub_mb_type specifies the syntax element for the macroblock mbAddrN.
  - Otherwise, predModeEqualFlagN is set equal to 1.
- Otherwise, the following applies.
  - If MbPartPredMode( mb_type, mbPartIdxN ) is not equal to Pred_LX and not equal to BiPred, predModeEqualFlagN is set equal to 0, where mb_type specifies the syntax element for the macroblock mbAddrN.
  - Otherwise, predModeEqualFlagN is set equal to 1.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

- If any of the following conditions is true, condTermFlagN is set equal to 0
  - mbAddrN is not available
  - the macroblock mbAddrN has mb_type equal to P_Skip or B_Skip
  - the macroblock mbAddrN is coded in Intra prediction mode
  - predModeEqualFlagN is equal to 0
  - refIdxZeroFlagN is equal to 1
- Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived as

$$ctxIdxInc = condTermFlagA + 2 * condTermFlagB \quad (9\text{-}8)$$

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#### 9.3.3.1.1.7 Derivation process of ctxIdxInc for the syntax elements mvd_l0 and mvd_l1

Inputs to this process are mbPartIdx, subMbPartIdx, and ctxIdxOffset.

Output of this process is ctxIdxInc.

The interpretation of mvd_lX and Pred_LX within this subclause is specified as follows.

- If this process is invoked for the derivation of mvd_l0, mvd_lX is interpreted as mvd_l0 and Pred_LX is interpreted as Pred_L0.
- Otherwise (this process is invoked for the derivation of mvd_l1), mvd_lX is interpreted as mvd_l1 and Pred_LX is interpreted as Pred_L1.

Let currSubMbType be set equal to sub_mb_type[ mbPartIdx ].

The derivation process for neighbouring partitions specified in subclause 6.4.10.7 is invoked with mbPartIdx, currSubMbType, and subMbPartIdx as input and the output is assigned to mbAddrA\mbPartIdxA\subMbPartIdxA and mbAddrB\mbPartIdxB\subMbPartIdxB.

Let the variable compIdx be derived as follows.

- If ctxIdxOffset is equal to 40, compIdx is set equal to 0.
- Otherwise (ctxIdxOffset is equal to 47), compIdx is set equal to 1.

Let the variable predModeEqualFlagN be specified as follows.

- If the macroblock mbAddrN has mb_type equal to P_8x8 or B_8x8, the following applies.
  - If SubMbPredMode( sub_mb_type[ mbPartIdxN ] ) is not equal to Pred_LX and not equal to BiPred, predModeEqualFlagN is set equal to 0, where sub_mb_type specifies the syntax element for the macroblock mbAddrN.
  - Otherwise, predModeEqualFlagN is set equal to 1.
- Otherwise, the following applies.
  - If MbPartPredMode( mb_type, mbPartIdxN ) is not equal to Pred_LX and not equal to BiPred, predModeEqualFlagN is set equal to 0, where mb_type specifies the syntax element for the macroblock mbAddrN.
  - Otherwise, predModeEqualFlagN is set equal to 1.

Let the variable absMvdCompN (with N being either A or B) be derived as follows.

- If any of the following conditions is true, absMvdCompN is set equal to 0
  - mbAddrN is not available
  - the macroblock mbAddrN has mb_type equal to P_Skip or B_Skip
  - the macroblock mbAddrN is coded in an Intra prediction mode
  - predModeEqualFlagN is equal to 0
- Otherwise, the following applies
  - If compIdx is equal to 1, MbaffFrameFlag is equal to 1, the current macroblock is a frame macroblock, and the macroblock mbAddrN is a field macroblock

$$absMvdCompN = Abs( mvd_lX[ mbPartIdxN ][ subMbPartIdxN ][ compIdx ] ) * 2 \quad (9\text{-}9)$$

  - Otherwise, if compIdx is equal to 1, MbaffFrameFlag is equal to 1, the current macroblock is a field macroblock, and the macroblock mbAddrN is a frame macroblock

$$absMvdCompN = Abs( mvd_lX[ mbPartIdxN ][ subMbPartIdxN ][ compIdx ] ) / 2 \quad (9\text{-}10)$$

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– Otherwise,

$$absMvdCompN = Abs( mvd_lX[ mbPartIdxN ][ subMbPartIdxN ][ compIdx ] ) \quad (9\text{-}11)$$

The variable ctxIdxInc is derived as follows

– If ( absMvdCompA + absMvdCompB ) is less than 3, ctxIdxInc is set equal to 0.

– Otherwise, if ( absMvdCompA + absMvdCompB ) is greater than 32, ctxIdxInc is set equal to 2.

– Otherwise ( ( absMvdCompA + absMvdCompB ) is in the range of 3 to 32, inclusive), ctxIdxInc is set equal to 1.

#### 9.3.3.1.1.8 Derivation process of ctxIdxInc for the syntax element intra_chroma_pred_mode

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being replaced by either A or B) be derived as follows.

– If any of the following conditions is true, condTermFlagN is set equal to 0

  – mbAddrN is not available

  – The macroblock mbAddrN is coded in Inter prediction mode

  – mb_type for the macroblock mbAddrN is equal to I_PCM

  – intra_chroma_pred_mode for the macroblock mbAddrN is equal to 0

– Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

$$ctxIdxInc = condTermFlagA + condTermFlagB \quad (9\text{-}12)$$

#### 9.3.3.1.1.9 Derivation process of ctxIdxInc for the syntax element coded_block_flag

Input to this process is ctxBlockCat and additional input is specified as follows.

– If ctxBlockCat is equal to 0, 6, or 10, no additional input

– Otherwise, if ctxBlockCat is equal to 1 or 2, luma4x4BlkIdx

– Otherwise, if ctxBlockCat is equal to 3, the chroma component index iCbCr

– Otherwise, if ctxBlockCat is equal to 4, chroma4x4BlkIdx and the chroma component index iCbCr

– Otherwise, if ctxBlockCat is equal to 5, luma8x8BlkIdx

– Otherwise, if ctxBlockCat is equal to 7 or 8, cb4x4BlkIdx

– Otherwise, if ctxBlockCat is equal to 9, cb8x8BlkIdx

– Otherwise, if ctxBlockCat is equal to 11 or 12, cr4x4BlkIdx

– Otherwise (ctxBlockCat is equal to 13), cr8x8BlkIdx

Output of this process is ctxIdxInc( ctxBlockCat ).

Let the variable transBlockN (with N being either A or B) be derived as follows.

– If ctxBlockCat is equal to 0, 6, or 10, the following applies.

  – The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrN (with N being either A or B).

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- The variable transBlockN is derived as follows.
- If mbAddrN is available and the macroblock mbAddrN is coded in Intra_16x16 prediction mode, the following applies.
  - If ctxBlockCat is equal to 0, the luma DC block of macroblock mbAddrN is assigned to transBlockN
  - Otherwise, if ctxBlockCat is equal to 6, the Cb DC block of macroblock mbAddrN is assigned to transBlockN
  - Otherwise (ctxBlockCat is equal to 10), the Cr DC block of macroblock mbAddrN is assigned to transBlockN
- Otherwise, transBlockN is marked as not available.

- Otherwise, if ctxBlockCat is equal to 1 or 2, the following applies.
  - The derivation process for neighbouring 4x4 luma blocks specified in subclause 6.4.10.4 is invoked with luma4x4BlkIdx as input and the output is assigned to mbAddrN, luma4x4BlkIdxN (with N being either A or B).
  - The variable transBlockN is derived as follows.
    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ( ( CodedBlockPatternLuma >> ( luma4x4BlkIdxN >>2 ) ) & 1 ) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 0 for the macroblock mbAddrN, the 4x4 luma block with index luma4x4BlkIdxN of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, if mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip or B_Skip, ( ( CodedBlockPatternLuma >> ( luma4x4BlkIdxN >>2 ) ) & 1 ) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 luma block with index ( luma4x4BlkIdxN >> 2 ) of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, transBlockN is marked as not available.
- Otherwise, if ctxBlockCat is equal to 3, the following applies.
  - The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrN (with N being either A or B).
  - The variable transBlockN is derived as follows.
    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, and CodedBlockPatternChroma is not equal to 0 for the macroblock mbAddrN, the chroma DC block of chroma component iCbCr of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, transBlockN is marked as not available.
- Otherwise, if ctxBlockCat is equal to 4, the following applies.
  - The derivation process for neighbouring 4x4 chroma blocks specified in subclause 6.4.10.5 is invoked with chroma4x4BlkIdx as input and the output is assigned to mbAddrN, chroma4x4BlkIdxN (with N being either A or B).
  - The variable transBlockN is derived as follows.
    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, and CodedBlockPatternChroma is equal to 2 for the macroblock mbAddrN, the 4x4 chroma block with chroma4x4BlkIdxN of the chroma component iCbCr of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, transBlockN is marked as not available.
- Otherwise, if ctxBlockCat is equal to 5, the following applies.
  - The derivation process for neighbouring 8x8 luma blocks specified in subclause 6.4.8.2 is invoked with luma8x8BlkIdx as input and the output is assigned to mbAddrN, luma8x8BlkIdxN (with N being either A or B).

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- The variable transBlockN is derived as follows.
  - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ( ( CodedBlockPatternLuma >>luma8x8BlkIdx) & 1 ) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 luma block with index luma8x8BlkIdxN of macroblock mbAddrN is assigned to transBlockN.
  - Otherwise, transBlockN is marked as not available.
- Otherwise, if ctxBlockCat is equal to7 or 8, the following applies.
  - The derivation process for neighbouring 4x4 Cb blocks specified in subclause 6.4.8.4.1 is invoked with cb4x4BlkIdx as input and the output is assigned to mbAddrN, cb4x4BlkIdxN (with N being either A or B).
  - The variable transBlockN is derived as follows.
    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, (( CodedBlockPatternLuma >> ( cb4x4BlkIdxN >>2 ) ) & 1 ) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 0 for the macroblock mbAddrN, the 4x4 Cb block with index cb4x4BlkIdxN of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, if mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip or B_Skip, ( ( CodedBlockPatternLuma >> ( cb4x4BlkIdxN >>2 ) ) & 1 ) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 Cb block with index ( cb4x4BlkIdxN >> 2 ) of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, transBlockN is marked as not available.
- Otherwise, if ctxBlockCat is equal to 9, the following applies.
  - The derivation process for neighbouring 8x8 Cb blocks specified in subclause 6.4.8.2.1 is invoked with cb8x8BlkIdx as input and the output is assigned to mbAddrN, cb8x8BlkIdxN (with N being either A or B).
  - The variable transBlockN is derived as follows.
    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ( ( CodedBlockPatternLuma >>cb8x8BlkIdx) & 1 ) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 Cb block with index cb8x8BlkIdxN of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, transBlockN is marked as not available.
- Otherwise, if ctxBlockCat is equal to 11 or 12, the following applies.
  - The derivation process for neighbouring 4x4 Cr blocks specified in subclause 6.4.8.4.1 is invoked with cr4x4BlkIdx as input and the output is assigned to mbAddrN, cr4x4BlkIdxN (with N being either A or B).
  - The variable transBlockN is derived as follows.
    - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM, ( ( CodedBlockPatternLuma >> ( cr4x4BlkIdxN >>2 ) ) & 1 ) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 0 for the macroblock mbAddrN, the 4x4 Cr block with index cr4x4BlkIdxN of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, if mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip or B_Skip, ( ( CodedBlockPatternLuma >> ( cr4x4BlkIdxN >>2 ) ) & 1 ) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 Cr block with index ( cr4x4BlkIdxN >> 2 ) of macroblock mbAddrN is assigned to transBlockN.
    - Otherwise, transBlockN is marked as not available.
- Otherwise (ctxBlockCat is equal to 13), the following applies.
  - The derivation process for neighbouring 8x8 Cr blocks specified in subclause 6.4.8.2.1 is invoked with cr8x8BlkIdx as input and the output is assigned to mbAddrN, cr8x8BlkIdxN (with N being either A or B).

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- The variable transBlockN is derived as follows.
  - If mbAddrN is available, the macroblock mbAddrN does not have mb_type equal to P_Skip, B_Skip, or I_PCM,, ( ( CodedBlockPatternLuma >>cr8x8BlkIdx) & 1 ) is not equal to 0 for the macroblock mbAddrN, and transform_size_8x8_flag is equal to 1 for the macroblock mbAddrN, the 8x8 Cr block with index cr8x8BlkIdxN of macroblock mbAddrN is assigned to transBlockN.
  - Otherwise, transBlockN is marked as not available.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

- If any of the following conditions is true, condTermFlagN is set equal to 0
  - mbAddrN is not available and the current macroblock is coded in Inter prediction mode
  - mbAddrN is available and transBlockN is not available and mb_type for the macroblock mbAddrN is not equal to I_PCM
  - The current macroblock is coded in Intra prediction mode, constrained_intra_pred_flag is equal to 1, the macroblock mbAddrN is available and coded in Inter prediction mode, and slice data partitioning is in use (nal_unit_type is in the range of 2 through 4, inclusive).
- Otherwise, if any of the following conditions is true, condTermFlagN is set equal to 1
  - mbAddrN is not available and the current macroblock is coded in Intra prediction mode
  - mb_type for the macroblock mbAddrN is equal to I_PCM
- Otherwise, condTermFlagN is set equal to the value of the coded_block_flag of the transform block transBlockN that was decoded for the macroblock mbAddrN.

The variable ctxIdxInc( ctxBlockCat ) is derived by

$$\text{ctxIdxInc( ctxBlockCat )} = \text{condTermFlagA} + 2 * \text{condTermFlagB} \quad (9\text{-}13)$$

#### 9.3.3.1.1.10 Derivation process of ctxIdxInc for the syntax element transform_size_8x8_flag

Output of this process is ctxIdxInc.

The derivation process for neighbouring macroblocks specified in subclause 6.4.10.1 is invoked and the output is assigned to mbAddrA and mbAddrB.

Let the variable condTermFlagN (with N being either A or B) be derived as follows.

- If any of the following conditions is true, condTermFlagN is set equal to 0.
  - mbAddrN is not available
  - transform_size_8x8_flag for the macroblock mbAddrN is equal to 0
- Otherwise, condTermFlagN is set equal to 1.

The variable ctxIdxInc is derived by

$$\text{ctxIdxInc} = \text{condTermFlagA} + \text{condTermFlagB} \quad (9\text{-}14)$$

#### 9.3.3.1.2 Assignment process of ctxIdxInc using prior decoded bin values

Inputs to this process are ctxIdxOffset and binIdx.

Output of this process is ctxIdxInc.

Table 9-41 contains the specification of ctxIdxInc for the given values of ctxIdxOffset and binIdx.

For each value of ctxIdxOffset and binIdx, ctxIdxInc is derived by using some of the values of prior decoded bin values ( $b_0$, $b_1$, $b_2$,…, $b_k$ ), where the value of the index k is less than the value of binIdx.

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**Table 9-41 – Specification of ctxIdxInc for specific values of ctxIdxOffset and binIdx**

| Value (name) of ctxIdxOffset | binIdx | ctxIdxInc |
|---|---|---|
| 3 | 4 | ($b_3$ != 0) ? 5: 6 |
| | 5 | ($b_3$ != 0) ? 6: 7 |
| 14 | 2 | ($b_1$ != 1) ? 2: 3 |
| 17 | 4 | ($b_3$ != 0) ? 2: 3 |
| 27 | 2 | ($b_1$ != 0) ? 4: 5 |
| 32 | 4 | ($b_3$ != 0) ? 2: 3 |
| 36 | 2 | ($b_1$ != 0) ? 2: 3 |

#### 9.3.3.1.3 Assignment process of ctxIdxInc for syntax elements significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1

Inputs to this process are ctxIdxOffset and binIdx.

Output of this process is ctxIdxInc.

The assignment process of ctxIdxInc for syntax elements significant_coeff_flag, last_significant_coeff_flag, and coeff_abs_level_minus1 as well as for coded_block_flag depends on categories of different blocks denoted by the variable ctxBlockCat. The specification of these block categories is given in Table 9-42.

**Table 9-42 – Specification of ctxBlockCat for the different blocks**

| Block description | maxNumCoeff | ctxBlockCat |
|---|---|---|
| block of luma DC transform coefficient levels (i.e., list Intra16x16DCLevel as described in subclause 7.4.5.3) | 16 | 0 |
| block of luma AC transform coefficient levels (i.e., list Intra16x16ACLevel[ i ] as described in subclause 7.4.5.3) | 15 | 1 |
| block of 16 luma transform coefficient levels (i.e., list LumaLevel[ i ] as described in subclause 7.4.5.3) | 16 | 2 |
| block of chroma DC transform coefficient levels when ChromaArrayType is equal to 1 or 2 (i.e., list ChromaDCLevel as described in subclause 7.4.5.3) | 4 * NumC8x8 | 3 |
| block of chroma AC transform coefficient levels when ChromaArrayType is equal to 1 or 2 (i.e., list ChromaACLevel as described in subclause 7.4.5.3) | 15 | 4 |
| block of 64 luma transform coefficient levels (i.e., list LumaLevel8x8[ i ] as described in subclause 7.4.5.3) | 64 | 5 |
| block of Cb DC transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CbIntra16x16DCLevel as described in subclause 7.4.5.3) | 16 | 6 |
| block of Cb AC transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CbIntra16x16ACLevel[ i ] as described in subclause 7.4.5.3) | 15 | 7 |
| block of 16 Cb transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CbLevel[ i ] as described in subclause 7.4.5.3) | 16 | 8 |
| block of 64 Cb transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CbLevel8x8[ i ] as described in subclause 7.4.5.3) | 64 | 9 |
| block of Cr DC transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CrIntra16x16DCLevel as described in subclause 7.4.5.3) | 16 | 10 |
| block of Cr AC transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CrIntra16x16ACLevel[ i ] as described in subclause 7.4.5.3) | 15 | 11 |
| block of 16 Cr transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CrLevel[ i ] as described in subclause 7.4.5.3) | 16 | 12 |
| block of 64 Cr transform coefficient levels when ChromaArrayType is equal to 3 (i.e., list CrLevel8x8[ i ] as described in subclause 7.4.5.3) | 64 | 13 |

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Let the variable levelListIdx be set equal to the index of the list of transform coefficient levels as specified in subclause 7.4.5.3.

For the syntax elements significant_coeff_flag and last_significant_coeff_flag in blocks with ctxBlockCat not equal to 3, 5, 9, and 13, the variable ctxIdxInc is derived by

$$ctxIdxInc = levelListIdx \tag{9-15}$$

where levelListIdx ranges from 0 to maxNumCoeff – 2, inclusive.

For the syntax elements significant_coeff_flag and last_significant_coeff_flag in blocks with ctxBlockCat == 3, the variable ctxIdxInc is derived by

$$ctxIdxInc = Min( levelListIdx / NumC8x8, 2 ) \tag{9-16}$$

where levelListIdx ranges from 0 to 4 * NumC8x8 – 2, inclusive.

For the syntax elements significant_coeff_flag and last_significant_coeff_flag in 8x8 luma, Cb, or Cr blocks with ctxBlockCat == 5, 9, or 13, Table 9-43 contains the specification of ctxIdxInc for the given values of levelListIdx, where levelListIdx ranges from 0 to 62, inclusive.

**Table 9-43 – Mapping of scanning position to ctxIdxInc for ctxBlockCat == 5, 9, or 13**

| levelListIdx | ctxIdxInc for significant_coeff_flag (frame coded macroblocks) | ctxIdxInc for significant_coeff_flag (field coded macroblocks) | ctxIdxInc for last_significant_coeff_flag | levelListIdx | ctxIdxInc for significant_coeff_flag (frame coded macroblocks) | ctxIdxInc for significant_coeff_flag (field coded macroblocks) | ctxIdxInc for last_significant_coeff_flag |
|---|---|---|---|---|---|---|---|
| **0** | 0 | 0 | 0 | **32** | 7 | 9 | 3 |
| **1** | 1 | 1 | 1 | **33** | 6 | 9 | 3 |
| **2** | 2 | 1 | 1 | **34** | 11 | 10 | 3 |
| **3** | 3 | 2 | 1 | **35** | 12 | 10 | 3 |
| **4** | 4 | 2 | 1 | **36** | 13 | 8 | 3 |
| **5** | 5 | 3 | 1 | **37** | 11 | 11 | 3 |
| **6** | 5 | 3 | 1 | **38** | 6 | 12 | 3 |
| **7** | 4 | 4 | 1 | **39** | 7 | 11 | 3 |
| **8** | 4 | 5 | 1 | **40** | 8 | 9 | 4 |
| **9** | 3 | 6 | 1 | **41** | 9 | 9 | 4 |
| **10** | 3 | 7 | 1 | **42** | 14 | 10 | 4 |
| **11** | 4 | 7 | 1 | **43** | 10 | 10 | 4 |
| **12** | 4 | 7 | 1 | **44** | 9 | 8 | 4 |
| **13** | 4 | 8 | 1 | **45** | 8 | 13 | 4 |
| **14** | 5 | 4 | 1 | **46** | 6 | 13 | 4 |

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| levelListIdx | ctxIdxInc for significant_coeff_flag (frame coded macroblocks) | ctxIdxInc for significant_coeff_flag (field coded macroblocks) | ctxIdxInc for last_significant_coeff_flag | levelListIdx | ctxIdxInc for significant_coeff_flag (frame coded macroblocks) | ctxIdxInc for significant_coeff_flag (field coded macroblocks) | ctxIdxInc for last_significant_coeff_flag |
|---|---|---|---|---|---|---|---|
| **15** | 5 | 5 | 1 | **47** | 11 | 9 | 4 |
| **16** | 4 | 6 | 2 | **48** | 12 | 9 | 5 |
| **17** | 4 | 9 | 2 | **49** | 13 | 10 | 5 |
| **18** | 4 | 10 | 2 | **50** | 11 | 10 | 5 |
| **19** | 4 | 10 | 2 | **51** | 6 | 8 | 5 |
| **20** | 3 | 8 | 2 | **52** | 9 | 13 | 6 |
| **21** | 3 | 11 | 2 | **53** | 14 | 13 | 6 |
| **22** | 6 | 12 | 2 | **54** | 10 | 9 | 6 |
| **23** | 7 | 11 | 2 | **55** | 9 | 9 | 6 |
| **24** | 7 | 9 | 2 | **56** | 11 | 10 | 7 |
| **25** | 7 | 9 | 2 | **57** | 12 | 10 | 7 |
| **26** | 8 | 10 | 2 | **58** | 13 | 14 | 7 |
| **27** | 9 | 10 | 2 | **59** | 11 | 14 | 7 |
| **28** | 10 | 8 | 2 | **60** | 14 | 14 | 8 |
| **29** | 9 | 11 | 2 | **61** | 10 | 14 | 8 |
| **30** | 8 | 12 | 2 | **62** | 12 | 14 | 8 |
| **31** | 7 | 11 | 2 | | | | |

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Let numDecodAbsLevelEq1 denotes the accumulated number of decoded transform coefficient levels with absolute value equal to 1, and let numDecodAbsLevelGt1 denotes the accumulated number of decoded transform coefficient levels with absolute value greater than 1. Both numbers are related to the same transform coefficient block, where the current decoding process takes place. Then, for decoding of coeff_abs_level_minus1, ctxIdxInc for coeff_abs_level_minus1 is specified depending on binIdx as follows.

– If binIdx is equal to 0, ctxIdxInc is derived by

$$ctxIdxInc = ( ( numDecodAbsLevelGt1 \; != \; 0 ) \; ? \; 0 : Min( 4, 1 + numDecodAbsLevelEq1 ) ) \quad (9\text{-}17)$$

– Otherwise (binIdx is greater than 0), ctxIdxInc is derived by

$$ctxIdxInc = 5 + Min( 4 - ( ctxBlockCat \; == \; 3 ), numDecodAbsLevelGt1 ) \quad (9\text{-}18)$$

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#### 9.3.3.2 Arithmetic decoding process

Inputs to this process are the bypassFlag, ctxIdx as derived in subclause 9.3.3.1, and the state variables codIRange and codIOffset of the arithmetic decoding engine.

Output of this process is the value of the bin.

Figure 9-2 illustrates the whole arithmetic decoding process for a single bin. For decoding the value of a bin, the context index ctxIdx is passed to the arithmetic decoding process DecodeBin(ctxIdx), which is specified as follows.

– If bypassFlag is equal to 1, DecodeBypass( ) as specified in subclause 9.3.3.2.3 is invoked.

– Otherwise, if bypassFlag is equal to 0 and ctxIdx is equal to 276, DecodeTerminate( ) as specified in subclause 9.3.3.2.4 is invoked.

– Otherwise (bypassFlag is equal to 0 and ctxIdx is not equal to 276), DecodeDecision( ) as specified in subclause 9.3.3.2.1 is applied.

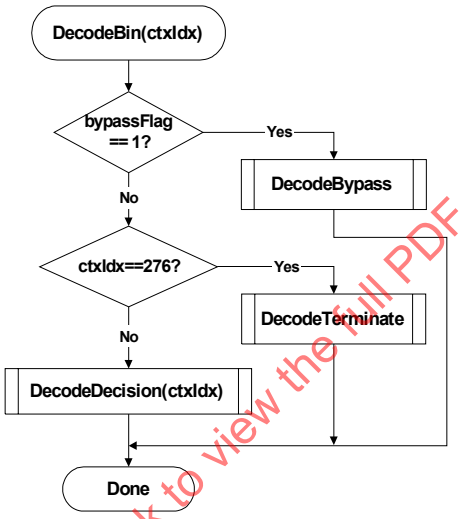


**Figure 9-2 – Overview of the arithmetic decoding process for a single bin (informative)**

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NOTE – Arithmetic coding is based on the principle of recursive interval subdivision. Given a probability estimation p( 0 ) and p( 1 ) = 1 – p( 0 ) of a binary decision ( 0, 1 ), an initially given code sub-interval with the range codIRange will be subdivided into two sub-intervals having range p( 0 ) * codIRange and codIRange – p( 0 ) * codIRange, respectively. Depending on the decision, which has been observed, the corresponding sub-interval will be chosen as the new code interval, and a binary code string pointing into that interval will represent the sequence of observed binary decisions. It is useful to distinguish between the most probable symbol (MPS) and the least probable symbol (LPS), so that binary decisions have to be identified as either MPS or LPS, rather than 0 or 1. Given this terminology, each context is specified by the probability $p_{LPS}$ of the LPS and the value of MPS (valMPS), which is either 0 or 1.

The arithmetic core engine in this International Standard has three distinct properties:

– The probability estimation is performed by means of a finite-state machine with a table-based transition process between 64 different representative probability states $\{ p_{LPS}(pStateIdx) \mid 0 <= pStateIdx < 64 \}$ for the LPS probability $p_{LPS}$. The numbering of the states is arranged in such a way that the probability state with index pStateIdx = 0 corresponds to an LPS probability value of 0.5, with decreasing LPS probability towards higher state indices.

– The range codIRange representing the state of the coding engine is quantised to a small set $\{Q_1,\ldots,Q_4\}$ of pre-set quantisation values prior to the calculation of the new interval range. Storing a table containing all 64x4 pre-computed product values of $Q_i * p_{LPS}(pStateIdx)$ allows a multiplication-free approximation of the product codIRange * $p_{LPS}(pStateIdx)$.

– For syntax elements or parts thereof for which an approximately uniform probability distribution is assumed to be given a separate simplified encoding and decoding bypass process is used.


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#### 9.3.3.2.1 Arithmetic decoding process for a binary decision

Inputs to this process are ctxIdx, codIRange, and codIOffset.

Outputs of this process are the decoded value binVal, and the updated variables codIRange and codIOffset.

Figure 9-3 shows the flowchart for decoding a single decision (DecodeDecision).

1. The value of the variable codIRangeLPS is derived as follows.

– Given the current value of codIRange, the variable qCodIRangeIdx is derived by

$$qCodIRangeIdx = ( codIRange >> 6 ) \& 0x03 \quad (9\text{-}19)$$

– Given qCodIRangeIdx and pStateIdx associated with ctxIdx, the value of the variable rangeTabLPS as specified in Table 9-44 is assigned to codIRangeLPS:

$$codIRangeLPS = rangeTabLPS[ pStateIdx ][ qCodIRangeIdx ] \quad (9\text{-}20)$$

2. The variable codIRange is set equal to codIRange – codIRangeLPS and the following applies.

– If codIOffset is greater than or equal to codIRange, the variable binVal is set equal to 1 - valMPS, codIOffset is decremented by codIRange, and codIRange is set equal to codIRangeLPS.

– Otherwise, the variable binVal is set equal to valMPS.

Given the value of binVal, the state transition is performed as specified in subclause 9.3.3.2.1.1. Depending on the current value of codIRange, renormalization is performed as specified in subclause 9.3.3.2.2.

##### 9.3.3.2.1.1 State transition process

Inputs to this process are the current pStateIdx, the decoded value binVal and valMPS values of the context variable associated with ctxIdx.

Outputs of this process are the updated pStateIdx and valMPS of the context variable associated with ctxIdx.

Depending on the decoded value binVal, the update of the two variables pStateIdx and valMPS associated with ctxIdx is derived as follows:

```
if( binVal == valMPS )
    pStateIdx = transIdxMPS( pStateIdx )
else {                                                    (9-21)
    if( pStateIdx == 0 )
        valMPS = 1 – valMPS
    pStateIdx = transIdxLPS( pStateIdx )
}
```

Table 9-45 specifies the transition rules transIdxMPS( ) and transIdxLPS( ) after decoding the value of valMPS and 1 – valMPS, respectively.

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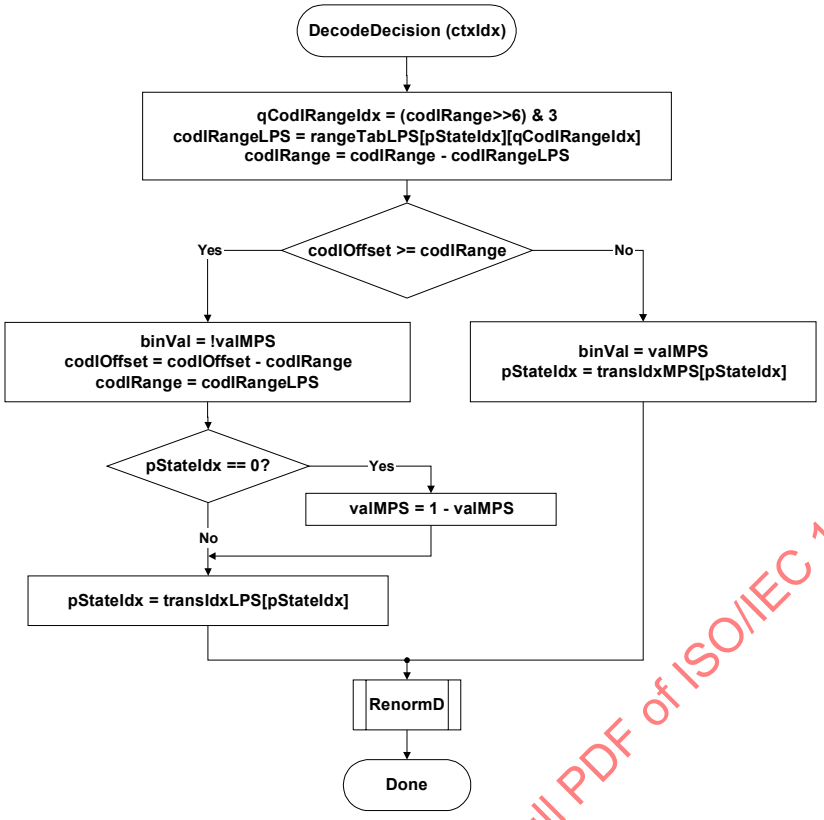


**Figure 9-3 – Flowchart for decoding a decision**

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**Table 9-44 – Specification of rangeTabLPS depending on pStateIdx and qCodIRangeIdx**

| pStateIdx | qCodIRangeIdx | | | | pStateIdx | qCodIRangeIdx | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | | 0 | 1 | 2 | 3 |
| **0** | 128 | 176 | 208 | 240 | **32** | 27 | 33 | 39 | 45 |
| **1** | 128 | 167 | 197 | 227 | **33** | 26 | 31 | 37 | 43 |
| **2** | 128 | 158 | 187 | 216 | **34** | 24 | 30 | 35 | 41 |
| **3** | 123 | 150 | 178 | 205 | **35** | 23 | 28 | 33 | 39 |
| **4** | 116 | 142 | 169 | 195 | **36** | 22 | 27 | 32 | 37 |
| **5** | 111 | 135 | 160 | 185 | **37** | 21 | 26 | 30 | 35 |
| **6** | 105 | 128 | 152 | 175 | **38** | 20 | 24 | 29 | 33 |
| **7** | 100 | 122 | 144 | 166 | **39** | 19 | 23 | 27 | 31 |
| **8** | 95 | 116 | 137 | 158 | **40** | 18 | 22 | 26 | 30 |
| **9** | 90 | 110 | 130 | 150 | **41** | 17 | 21 | 25 | 28 |
| **10** | 85 | 104 | 123 | 142 | **42** | 16 | 20 | 23 | 27 |
| **11** | 81 | 99 | 117 | 135 | **43** | 15 | 19 | 22 | 25 |
| **12** | 77 | 94 | 111 | 128 | **44** | 14 | 18 | 21 | 24 |
| **13** | 73 | 89 | 105 | 122 | **45** | 14 | 17 | 20 | 23 |
| **14** | 69 | 85 | 100 | 116 | **46** | 13 | 16 | 19 | 22 |
| **15** | 66 | 80 | 95 | 110 | **47** | 12 | 15 | 18 | 21 |
| **16** | 62 | 76 | 90 | 104 | **48** | 12 | 14 | 17 | 20 |
| **17** | 59 | 72 | 86 | 99 | **49** | 11 | 14 | 16 | 19 |
| **18** | 56 | 69 | 81 | 94 | **50** | 11 | 13 | 15 | 18 |
| **19** | 53 | 65 | 77 | 89 | **51** | 10 | 12 | 15 | 17 |
| **20** | 51 | 62 | 73 | 85 | **52** | 10 | 12 | 14 | 16 |
| **21** | 48 | 59 | 69 | 80 | **53** | 9 | 11 | 13 | 15 |
| **22** | 46 | 56 | 66 | 76 | **54** | 9 | 11 | 12 | 14 |
| **23** | 43 | 53 | 63 | 72 | **55** | 8 | 10 | 12 | 14 |
| **24** | 41 | 50 | 59 | 69 | **56** | 8 | 9 | 11 | 13 |
| **25** | 39 | 48 | 56 | 65 | **57** | 7 | 9 | 11 | 12 |
| **26** | 37 | 45 | 54 | 62 | **58** | 7 | 9 | 10 | 12 |
| **27** | 35 | 43 | 51 | 59 | **59** | 7 | 8 | 10 | 11 |
| **28** | 33 | 41 | 48 | 56 | **60** | 6 | 8 | 9 | 11 |
| **29** | 32 | 39 | 46 | 53 | **61** | 6 | 7 | 9 | 10 |
| **30** | 30 | 37 | 43 | 50 | **62** | 6 | 7 | 8 | 9 |
| **31** | 29 | 35 | 41 | 48 | **63** | 2 | 2 | 2 | 2 |

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**Table 9-45 – State transition table**

| **pStateIdx** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **transIdxLPS** | 0 | 0 | 1 | 2 | 2 | 4 | 4 | 5 | 6 | 7 | 8 | 9 | 9 | 11 | 11 | 12 |
| **transIdxMPS** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| **pStateIdx** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** | **31** |
| **transIdxLPS** | 13 | 13 | 15 | 15 | 16 | 16 | 18 | 18 | 19 | 19 | 21 | 21 | 22 | 22 | 23 | 24 |
| **transIdxMPS** | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| **pStateIdx** | **32** | **33** | **34** | **35** | **36** | **37** | **38** | **39** | **40** | **41** | **42** | **43** | **44** | **45** | **46** | **47** |
| **transIdxLPS** | 24 | 25 | 26 | 26 | 27 | 27 | 28 | 29 | 29 | 30 | 30 | 30 | 31 | 32 | 32 | 33 |
| **transIdxMPS** | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 |
| **pStateIdx** | **48** | **49** | **50** | **51** | **52** | **53** | **54** | **55** | **56** | **57** | **58** | **59** | **60** | **61** | **62** | **63** |
| **transIdxLPS** | 33 | 33 | 34 | 34 | 35 | 35 | 35 | 36 | 36 | 36 | 37 | 37 | 37 | 38 | 38 | 63 |
| **transIdxMPS** | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 62 | 63 |

#### 9.3.3.2.2 Renormalization process in the arithmetic decoding engine

Inputs to this process are bits from slice data and the variables codIRange and codIOffset.

Outputs of this process are the updated variables codIRange and codIOffset.

A flowchart of the renormalization is shown in Figure 9-4. The current value of codIRange is first compared to 0x0100 and further steps are specified as follows.

– If codIRange is greater than or equal to 0x0100, no renormalization is needed and the RenormD process is finished;

– Otherwise (codIRange is less than 0x0100), the renormalization loop is entered. Within this loop, the value of codIRange is doubled, i.e., left-shifted by 1 and a single bit is shifted into codIOffset by using read_bits( 1 ).

The bitstream shall not contain data that results in a value of codIOffset being greater than or equal to codIRange upon completion of this process.

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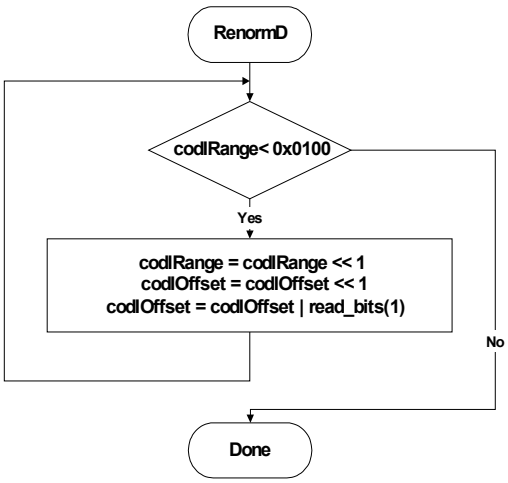


**Figure 9-4 – Flowchart of renormalization**


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#### 9.3.3.2.3 Bypass decoding process for binary decisions

Inputs to this process are bits from slice data and the variables codIRange and codIOffset.

Outputs of this process are the updated variable codIOffset and the decoded value binVal.

The bypass decoding process is invoked when bypassFlag is equal to 1. Figure 9-5 shows a flowchart of the corresponding process.

First, the value of codIOffset is doubled, i.e., left-shifted by 1 and a single bit is shifted into codIOffset by using read_bits( 1 ). Then, the value of codIOffset is compared to the value of codIRange and further steps are specified as follows.

– If codIOffset is greater than or equal to codIRange, the variable binVal is set equal to 1 and codIOffset is decremented by codIRange.

– Otherwise (codIOffset is less than codIRange), the variable binVal is set equal to 0.

The bitstream shall not contain data that results in a value of codIOffset being greater than or equal to codIRange upon completion of this process.

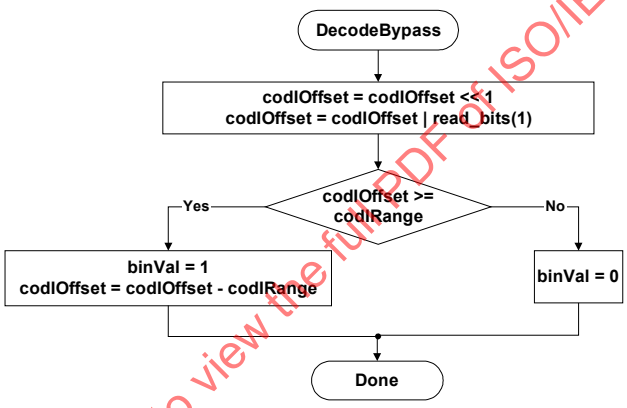


**Figure 9-5 – Flowchart of bypass decoding process**

#### 9.3.3.2.4 Decoding process for binary decisions before termination

Inputs to this process are bits from slice data and the variables codIRange and codIOffset.

Outputs of this process are the updated variables codIRange and codIOffset, and the decoded value binVal.

This special decoding routine applies to decoding of end_of_slice_flag and of the bin indicating the I_PCM mode corresponding to ctxIdx equal to 276. Figure 9-6 shows the flowchart of the corresponding decoding process, which is specified as follows.

First, the value of codIRange is decremented by 2. Then, the value of codIOffset is compared to the value of codIRange and further steps are specified as follows.

– If codIOffset is greater than or equal to codIRange, the variable binVal is set equal to 1, no renormalization is carried out, and CABAC decoding is terminated. The last bit inserted in register codIOffset is equal to 1. When decoding end_of_slice_flag, this last bit inserted in register codIOffset is interpreted as rbsp_stop_one_bit.

– Otherwise (codIOffset is less than codIRange), the variable binVal is set equal to 0 and renormalization is performed as specified in subclause 9.3.3.2.2.

NOTE – This procedure may also be implemented using DecodeDecision(ctxIdx) with ctxIdx = 276. In the case where the decoded value is equal to 1, seven more bits would be read by DecodeDecision(ctxIdx) and a decoding process would have to adjust its bitstream pointer accordingly to properly decode following syntax elements.

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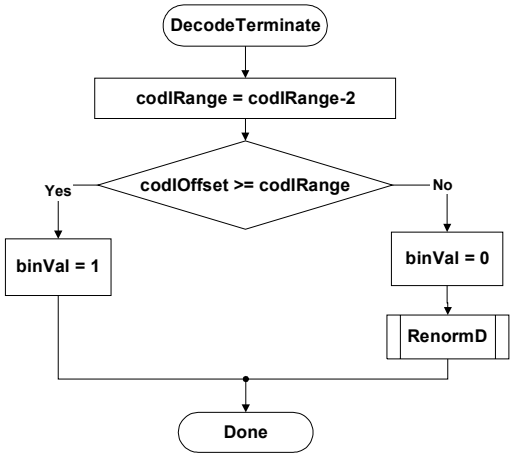


**Figure 9-6 – Flowchart of decoding a decision before termination**

### 9.3.4 Arithmetic encoding process (informative)

This subclause does not form an integral part of this International Standard.

Inputs to this process are decisions that are to be encoded and written.

Outputs of this process are bits that are written to the RBSP.

This informative subclause describes an arithmetic encoding engine that matches the arithmetic decoding engine described in subclause 9.3.3.2. The encoding engine is essentially symmetric with the decoding engine, i.e., procedures are called in the same order. The following procedures are described in this section: InitEncoder, EncodeDecision, EncodeBypass, EncodeTerminate, which correspond to InitDecoder, DecodeDecision, DecodeBypass, and DecodeTerminate, respectively. The state of the arithmetic encoding engine is represented by a value of the variable codILow pointing to the lower end of a sub-interval and a value of the variable codIRange specifying the corresponding range of that sub-interval.

#### 9.3.4.1 Initialisation process for the arithmetic encoding engine (informative)

This subclause does not form an integral part of this International Standard.

This process is invoked before encoding the first macroblock of a slice, and after encoding any pcm_alignment_zero_bit and all pcm_sample_luma and pcm_sample_chroma data for a macroblock of type I_PCM.

Outputs of this process are the values codILow, codIRange, firstBitFlag, bitsOutstanding, and symCnt of the arithmetic encoding engine.

In the initialisation procedure of the encoder, codILow is set equal to 0, and codIRange is set equal to 0x01FE. Furthermore, a firstBitFlag is set equal to 1, and bitsOutstanding and symCnt counters are set equal to 0.

NOTE – The minimum register precision required for codILow is 10 bits and for CodIRange is 9 bits. The precision required for the counters bitsOutstanding and symCnt should be sufficiently large to prevent overflow of the related registers. When MaxBinCountInSlice denotes the maximum total number of binary decisions to encode in one slice, the minimum register precision required for the variables bitsOutstanding and symCnt is given by Ceil( Log2( MaxBinCountInSlice + 1 ) ).

#### 9.3.4.2 Encoding process for a binary decision (informative)

This subclause does not form an integral part of this International Standard.

Inputs to this process are the context index ctxIdx, the value of binVal to be encoded, and the variables codIRange, codILow and symCnt.

Outputs of this process are the variables codIRange, codILow, and symCnt.

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Figure 9-7 shows the flowchart for encoding a single decision. In a first step, the variable codIRangeLPS is derived as follows.

Given the current value of codIRange, codIRange is mapped to the index qCodIRangeIdx of a quantised value of codIRange by using Equation 9-19. The value of qCodIRangeIdx and the value of pStateIdx associated with ctxIdx are used to determine the value of the variable rangeTabLPS as specified in Table 9-44, which is assigned to codIRangeLPS. The value of codIRange – codIRangeLPS is assigned to codIRange.

In a second step, the value of binVal is compared to valMPS associated with ctxIdx. When binVal is different from valMPS, codIRange is added to codILow and codIRange is set equal to the value codIRangeLPS. Given the encoded decision, the state transition is performed as specified in subclause 9.3.3.2.1.1. Depending on the current value of codIRange, renormalization is performed as specified in subclause 9.3.4.3. Finally, the variable symCnt is incremented by 1.

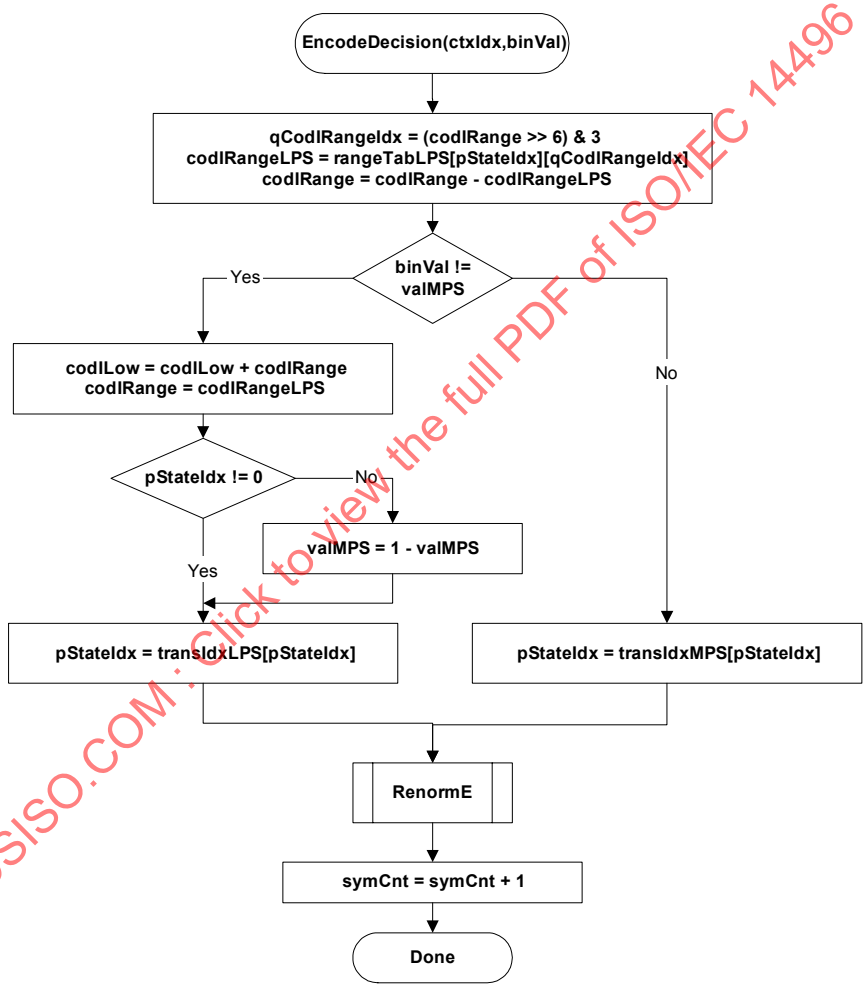


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**Figure 9-7 – Flowchart for encoding a decision**

### 9.3.4.3 Renormalization process in the arithmetic encoding engine (informative)

This subclause does not form an integral part of this International Standard.

Inputs to this process are the variables codIRange, codILow, firstBitFlag, and bitsOutstanding.

Outputs of this process are zero or more bits written to the RBSP and the updated variables codIRange, codILow, firstBitFlag, and bitsOutstanding.

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Renormalization is illustrated in Figure 9-8.

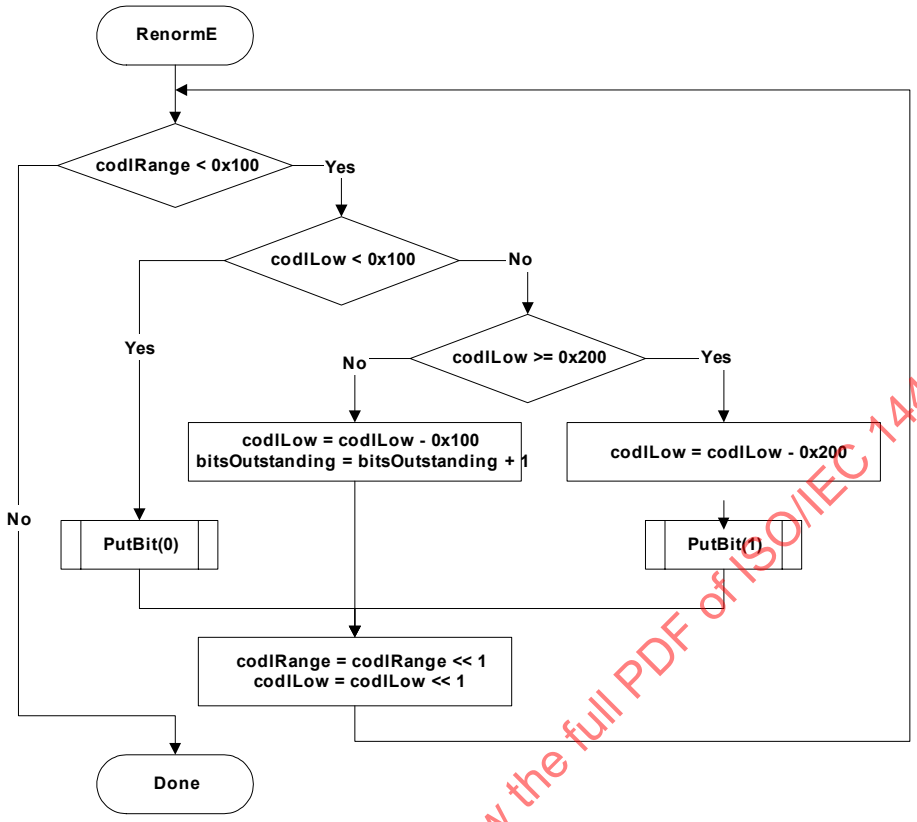


**Figure 9-8 – Flowchart of renormalization in the encoder**

The PutBit( ) procedure described in Figure 9-9 provides carry over control. It uses the function WriteBits( B, N ) that writes N bits with value B to the bitstream and advances the bitstream pointer by N bit positions. This function assumes the existence of a bitstream pointer with an indication of the position of the next bit to be written to the bitstream by the encoding process.

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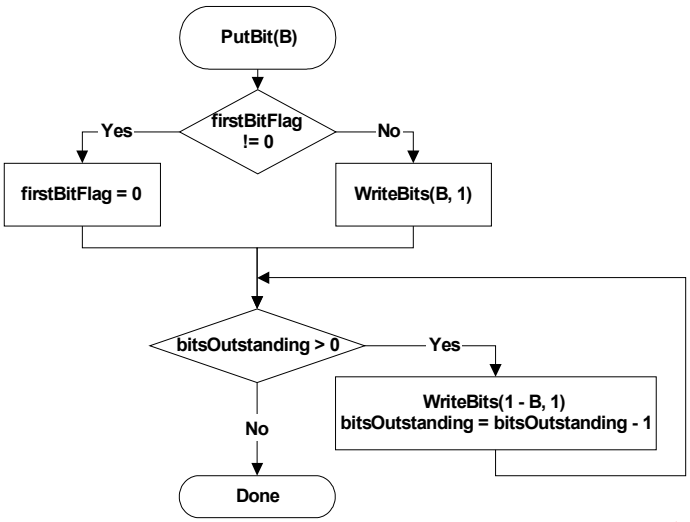


**Figure 9-9 – Flowchart of PutBit(B)**

#### 9.3.4.4 Bypass encoding process for binary decisions (informative)

This subclause does not form an integral part of this International Standard.

Inputs to this process are the variables binVal, codILow, codIRange, bitsOutstanding, and symCnt.

Output of this process is a bit written to the RBSP and the updated variables codILow, bitsOutstanding, and symCnt.

This encoding process applies to all binary decisions with bypassFlag equal to 1. Renormalization is included in the specification of this process as given in Figure 9-10.

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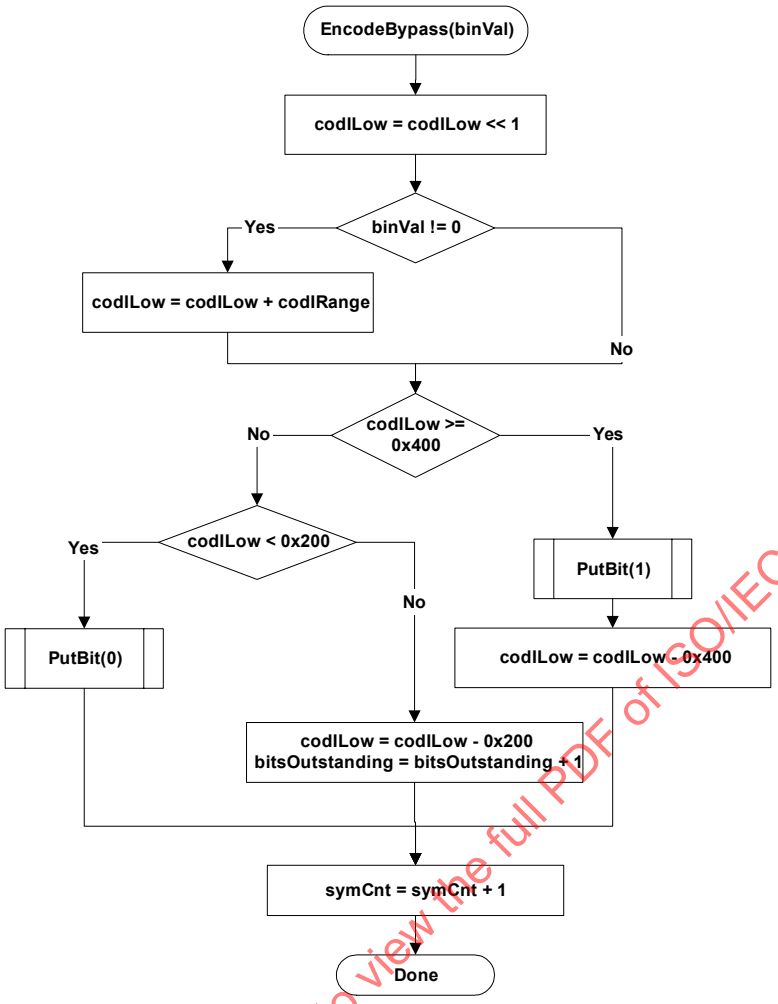


**Figure 9-10 – Flowchart of encoding bypass**

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#### 9.3.4.5 Encoding process for a binary decision before termination (informative)

This subclause does not form an integral part of this International Standard.

Inputs to this process are the variables binVal, codIRange, codILow, bitsOutstanding, and symCnt.

Outputs of this process are zero or more bits written to the RBSP and the updated variables codILow, codIRange, bitsOutstanding, and symCnt.

This encoding routine shown in Figure 9-11 applies to encoding of the end_of_slice_flag and of the bin indicating the I_PCM mb_type both associated with ctxIdx equal to 276.


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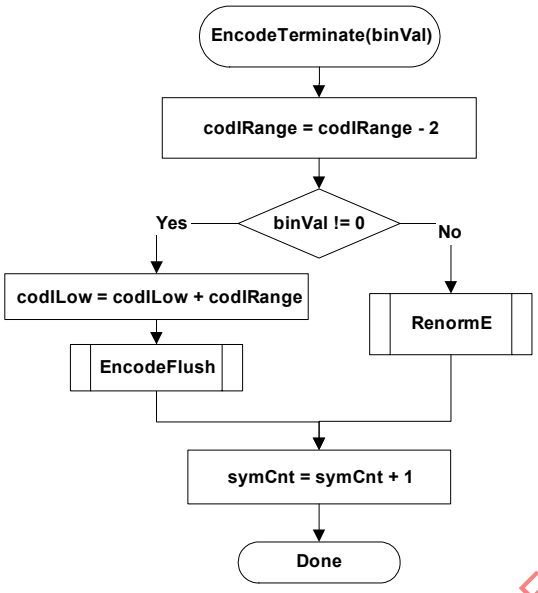


**Figure 9-11 – Flowchart of encoding a decision before termination**

When the value of binVal to encode is equal to 1, CABAC encoding is terminated and the flushing procedure shown in Figure 9-12 is applied. In this flushing procedure, the last bit written by WriteBits( B, N ) is equal to 1. When encoding end_of_slice_flag, this last bit is interpreted as the rbsp_stop_one_bit.

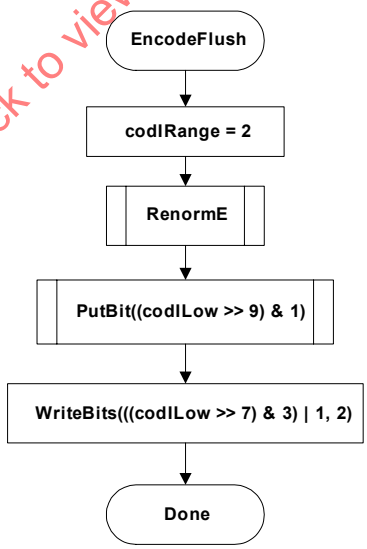


**Figure 9-12 – Flowchart of flushing at termination**

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#### 9.3.4.6 Byte stuffing process (informative)

This subclause does not form an integral part of this International Standard.

This process is invoked after encoding the last macroblock of the last slice of a picture and after encapsulation.

Inputs to this process are the number of bytes NumBytesInVclNALunits of all VCL NAL units of a picture, the number of macroblocks PicSizeInMbs in the picture, and the number of binary symbols BinCountsInNALunits resulting from encoding the contents of all VCL NAL units of the picture.

Outputs of this process are zero or more bytes appended to the NAL unit.

Let the variable k be set equal to Ceil( ( Ceil( 3 * ( 32 * BinCountsInNALunits – RawMbBits * PicSizeInMbs ) ÷ 1024 ) – NumBytesInVclNALunits ) ÷ 3 ). Depending on the variable k the following applies.

– If k is less than or equal to 0, no cabac_zero_word is appended to the NAL unit.

– Otherwise (k is greater than 0), the 3-byte sequence 0x000003 is appended k times to the NAL unit after encapsulation, where the first two bytes 0x0000 represent a cabac_zero_word and the third byte 0x03 represents an emulation_prevention_three_byte.

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# Annex A
# Profiles and levels

(This annex forms an integral part of this International Standard)

Profiles and levels specify restrictions on bitstreams and hence limits on the capabilities needed to decode the bitstreams. Profiles and levels may also be used to indicate interoperability points between individual decoder implementations.

NOTE 1 – This International Standard does not include individually selectable "options" at the decoder, as this would increase interoperability difficulties.

Each profile specifies a subset of algorithmic features and limits that shall be supported by all decoders conforming to that profile.

NOTE 2 – Encoders are not required to make use of any particular subset of features supported in a profile.

Each level specifies a set of limits on the values that may be taken by the syntax elements of this International Standard. The same set of level definitions is used with all profiles, but individual implementations may support a different level for each supported profile. For any given profile, levels generally correspond to decoder processing load and memory capability.

## A.1 Requirements on video decoder capability

Capabilities of video decoders conforming to this International Standard are specified in terms of the ability to decode video streams conforming to the constraints of profiles and levels specified in this Annex. For each such profile, the level supported for that profile shall also be expressed.

Specific values are specified in this annex for the syntax elements profile_idc and level_idc. All other values of profile_idc and level_idc are reserved for future use by ITU-T | ISO/IEC.

NOTE – Decoders should not infer that when a reserved value of profile_idc or level_idc falls between the values specified in this International Standard that this indicates intermediate capabilities between the specified profiles or levels, as there are no restrictions on the method to be chosen by ITU-T | ISO/IEC for the use of such future reserved values.

## A.2 Profiles

### A.2.1 Baseline profile

Bitstreams conforming to the Baseline profile shall obey the following constraints:

- Only I and P slice types may be present.
- NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.
- Sequence parameter sets shall have frame_mbs_only_flag equal to 1.
- The syntax elements chroma_format_idc, bit_depth_luma_minus8, bit_depth_chroma_minus8, qpprime_y_zero_transform_bypass_flag, and seq_scaling_matrix_present_flag shall not be present in sequence parameter sets.
- Picture parameter sets shall have weighted_pred_flag and weighted_bipred_idc both equal to 0.
- Picture parameter sets shall have entropy_coding_mode_flag equal to 0.
- Picture parameter sets shall have num_slice_groups_minus1 in the range of 0 to 7, inclusive.
- The syntax elements transform_8x8_mode_flag, pic_scaling_matrix_present_flag, and second_chroma_qp_index_offset shall not be present in picture parameter sets.
- The syntax element level_prefix shall not be greater than 15.
- The level constraints specified for the Baseline profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the Baseline profile is specified by profile_idc being equal to 66.

Decoders conforming to the Baseline profile at a specific level shall be capable of decoding all bitstreams in which profile_idc is equal to 66 or constraint_set0_flag is equal to 1 and in which level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

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### A.2.2 Main profile

Bitstreams conforming to the Main profile shall obey the following constraints:

– Only I, P, and B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– The syntax elements chroma_format_idc, bit_depth_luma_minus8, bit_depth_chroma_minus8, qpprime_y_zero_transform_bypass_flag, and seq_scaling_matrix_present_flag shall not be present in sequence parameter sets.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– The syntax elements transform_8x8_mode_flag, pic_scaling_matrix_present_flag, and second_chroma_qp_index_offset shall not be present in picture parameter sets.

– The syntax element level_prefix shall not be greater than 15 (when present).

– The level constraints specified for the Main profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the Main profile is specified by profile_idc being equal to 77.

Decoders conforming to the Main profile at a specified level shall be capable of decoding all bitstreams in which profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and in which level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

### A.2.3 Extended profile

Bitstreams conforming to the Extended profile shall obey the following constraints:

– Sequence parameter sets shall have direct_8x8_inference_flag equal to 1.

– The syntax elements chroma_format_idc, bit_depth_luma_minus8, bit_depth_chroma_minus8, qpprime_y_zero_transform_bypass_flag, and seq_scaling_matrix_present_flag shall not be present in sequence parameter sets.

– Picture parameter sets shall have entropy_coding_mode_flag equal to 0.

– Picture parameter sets shall have num_slice_groups_minus1 in the range of 0 to 7, inclusive.

– The syntax elements transform_8x8_mode_flag, pic_scaling_matrix_present_flag, and second_chroma_qp_index_offset shall not be present in picture parameter sets.

– The syntax element level_prefix shall not be greater than 15 (when present).

– The level constraints specified for the Extended profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the Extended profile is specified by profile_idc being equal to 88.

Decoders conforming to the Extended profile at a specified level shall be capable of decoding all bitstreams in which profile_idc is equal to 88 or constraint_set2_flag is equal to 1 and in which level_idc represents a level less than or equal to specified level.

Decoders conforming to the Extended profile at a specified level shall also be capable of decoding all bitstreams in which profile_idc is equal to 66 or constraint_set0_flag is equal to 1, in which level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

### A.2.4 High profile

Bitstreams conforming to the High profile shall obey the following constraints:

– Only I, P, and B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– Sequence parameter sets shall have chroma_format_idc in the range of 0 to 1 inclusive.

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– Sequence parameter sets shall have bit_depth_luma_minus8 equal to 0 only.
– Sequence parameter sets shall have bit_depth_chroma_minus8 equal to 0 only.
– Sequence parameter sets shall have qpprime_y_zero_transform_bypass_flag equal to 0 only.
– The level constraints specified for the High profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High profile is specified by profile_idc being equal to 100. Decoders conforming to the High profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and the combination of level_idc and constraint_set3_flag represent a level less than or equal to the specified level.
– profile_idc is equal to 100 and level_idc represents a level less than or equal to the specified level.

NOTE – The value 100 for profile_idc indicates that the bitstream conforms to the High profile as specified in this subclause. When profile_idc is equal to 100 and constraint_set3_flag is equal to 1, this indicates that the bitstream conforms to the High profile and additionally conforms to the constraints specified for the High 10 Intra profile in subclause A.2.8. For example, such a bitstream must have bit_depth_luma_minus8 equal to 0, have bit_depth_chroma_minus8 equal to 0, obey the MinCr, MaxBR and MaxCPB constraints of the High profile, contain only IDR pictures, have num_ref_frames equal to 0, have dpb_output_delay equal to 0, and obey the maximum slice size constraint of the High 10 Intra profile.

### A.2.5 High 10 profile

Bitstreams conforming to the High 10 profile shall obey the following constraints:

– Only I, P, and B slice types may be present.
– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.
– Arbitrary slice order is not allowed.
– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.
– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.
– Sequence parameter sets shall have chroma_format_idc in the range of 0 to 1 inclusive.
– Sequence parameter sets shall have bit_depth_luma_minus8 in the range of 0 to 2 inclusive.
– Sequence parameter sets shall have bit_depth_chroma_minus8 in the range of 0 to 2 inclusive.
– Sequence parameter sets shall have qpprime_y_zero_transform_bypass_flag equal to 0 only.
– The level constraints specified for the High 10 profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 10 profile is specified by profile_idc being equal to 110. Decoders conforming to the High 10 profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and the combination of level_idc and constraint_set3_flag represent a level less than or equal to the specified level.
– profile_idc is equal to 100 or 110 and level_idc represents a level less than or equal to the specified level.

### A.2.6 High 4:2:2 profile

Bitstreams conforming to the High 4:2:2 profile shall obey the following constraints:

– Only I, P, and B slice types may be present.
– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.
– Arbitrary slice order is not allowed.
– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.
– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.
– Sequence parameter sets shall have chroma_format_idc in the range of 0 to 2 inclusive
– Sequence parameter sets shall have bit_depth_luma_minus8 in the range of 0 to 2 inclusive.
– Sequence parameter sets shall have bit_depth_chroma_minus8 in the range of 0 to 2 inclusive.
– Sequence parameter sets shall have qpprime_y_zero_transform_bypass_flag equal to 0 only.
– The level constraints specified for the High 4:2:2 profile in subclause A.3 shall be fulfilled.

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Conformance of a bitstream to the High 4:2:2 profile is specified by profile_idc being equal to 122. Decoders conforming to the High 4:2:2 profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and the combination of level_idc and constraint_set3_flag represent a level less than or equal to the specified level.

– profile_idc is equal to 100, 110, or 122 and level_idc represents a level less than or equal to the specified level.

### A.2.7 High 4:4:4 Predictive profile

Bitstreams conforming to the High 4:4:4 Predictive profile shall obey the following constraints:

– Only I, P, B slice types may be present.

– NAL unit streams shall not contain nal_unit_type values in the range of 2 to 4, inclusive.

– Arbitrary slice order is not allowed.

– Picture parameter sets shall have num_slice_groups_minus1 equal to 0 only.

– Picture parameter sets shall have redundant_pic_cnt_present_flag equal to 0 only.

– Sequence parameter sets shall have bit_depth_luma_minus8 in the range of 0 to 6 inclusive.

– Sequence parameter sets shall have bit_depth_chroma_minus8 in the range of 0 to 6 inclusive.

– The level constraints specified for the High 4:4:4 Predictive profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 4:4:4 Predictive profile is specified by profile_idc being equal to 244. Decoders conforming to the High 4:4:4 Predictive profile at a specific level shall be capable of decoding all bitstreams in which either or both of the following conditions are true:

– profile_idc is equal to 77 or constraint_set1_flag is equal to 1 and the combination of level_idc and constraint_set3_flag represent a level less than or equal to the specified level

– profile_idc is equal to 44, 100, 110, 122, or 244 and the value of level_idc represents a level less than or equal to the specified level

### A.2.8 High 10 Intra profile

Bitstreams conforming to the High 10 Intra profile shall obey the following constraints:

– All constraints specified in subclause A.2.5 for the High 10 profile shall be obeyed.

– All pictures shall be IDR pictures.

– Sequence parameter sets shall have num_ref_frames equal to 0.

– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have num_reorder_frames equal to 0.

– When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have max_dec_frame_buffering equal to 0.

– Picture timing SEI messages, whether present in the bitstream (by non-VCL NAL units) or conveyed equivalently by other means not specified in this International Standard, shall have dpb_output_delay equal to 0.

– The level constraints specified for the High 10 Intra profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 10 Intra profile is specified by constraint_set3_flag being equal to 1 with profile_idc equal to 110. Decoders conforming to the High 10 Intra profile at a specific level shall be capable of decoding all bitstreams in which all of the following conditions are true.

– profile_idc is equal to 100 or 110.

– constraint_set3_flag is equal to 1.

– level_idc represents a level less than or equal to the specified level.

NOTE – The value 100 for profile_idc indicates that the bitstream conforms to the High profile as specified in subclause A.2.4. When profile_idc is equal to 100 and constraint_set3_flag is equal to 1, this indicates that the bitstream conforms to the High profile and additionally conforms to the constraints specified for the High 10 Intra profile in this subclause. For example, such a bitstream must have bit_depth_luma_minus8 equal to 0, have bit_depth_chroma_minus8 equal to 0, obey the MinCr, MaxBR and MaxCPB constraints of the High profile, contain only IDR pictures, have num_ref_frames equal to 0, have dpb_output_delay equal to 0, and obey the maximum slice size constraint of the High 10 Intra profile.

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The operation of the deblocking filter process specified in subclause 8.7 is not required for decoder conformance to the High 10 Intra profile.

NOTE – The deblocking filter process specified in subclause 8.7 or some similar post-processing filter should be performed, although this is not a requirement for decoder conformance to the High 10 Intra profile. The syntax elements sent by an encoder for control of the deblocking filter process specified in subclause 8.7 are considered only as advisory information for decoders conformance to the High 10 Intra profile. However, the application of the deblocking filter process specified in subclause 8.7 is required for decoder conformance to the High 10, High 4:2:2, and High 4:4:4 Predictive profiles when decoding bitstreams that conform to the High 10 Intra profile.

### A.2.9 High 4:2:2 Intra profile

Bitstreams conforming to the High 4:2:2 Intra profile shall obey the following constraints:

- All constraints specified in subclause A.2.6 for the High 4:2:2 profile shall be obeyed.
- All pictures shall be IDR pictures.
- Sequence parameter sets shall have num_ref_frames equal to 0.
- When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have num_reorder_frames equal to 0.
- When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have max_dec_frame_buffering equal to 0.
- Picture timing SEI messages, whether present in the bitstream (by non-VCL NAL units) or conveyed equivalently by other means not specified in this International Standard, shall have dpb_output_delay equal to 0.
- The level constraints specified for the High 4:2:2 Intra profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the High 4:2:2 Intra profile is specified by constraint_set3_flag being equal to 1 with profile_idc equal to 122. Decoders conforming to the High 4:2:2 Intra profile at a specific level shall be capable of decoding all bitstreams in which all of the following conditions are true:

- profile_idc is equal to 100, 110, or 122.
- constraint_set3_flag is equal to 1.
- level_idc represents a level less than or equal to the specified level.

The operation of the deblocking filter process specified in subclause 8.7 is not required for decoder conformance to the High 4:2:2 Intra profile.

NOTE – The deblocking filter process specified in subclause 8.7 or some similar post-processing filter should be performed, although this is not a requirement for decoder conformance to the High 4:2:2 Intra profile. The syntax elements sent by an encoder for control of the deblocking filter process specified in subclause 8.7 are considered only as advisory information for decoders conformance to the High 4:2:2 Intra profile. However, the application of the deblocking filter process specified in subclause 8.7 is required for decoder conformance to the High 4:2:2, and High 4:4:4 Predictive profiles when decoding bitstreams that conform to the High 4:2:2 Intra profile.

### A.2.10 High 4:4:4 Intra profile

Bitstreams conforming to the High 4:4:4 Intra profile shall obey the following constraints:

- All constraints specified in subclause A.2.7 for the High 4:4:4 Predictive profile shall be obeyed.
- All pictures shall be IDR pictures.
- Sequence parameter sets shall have num_ref_frames equal to 0.
- When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have num_reorder_frames equal to 0.
- When vui_parameters_present_flag is equal to 1 and bitstream_restriction_flag is equal to 1, sequence parameter sets shall have max_dec_frame_buffering equal to 0.
- Picture timing SEI messages, whether present in the bitstream (by non-VCL NAL units) or conveyed equivalently by other means not specified in this International Standard, shall have dpb_output_delay equal to 0.
- The level constraints specified for the High 4:4:4 Intra profile in subclause A.3 shall be fulfilled.

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Conformance of a bitstream to the High 4:4:4 Intra profile is specified by constraint_set3_flag being equal to 1 with profile_idc equal to 244. Decoders conforming to the High 4:4:4 Intra profile at a specific level shall be capable of decoding all bitstreams in which all of the following conditions are true:

– profile_idc is equal to 44, 100, 110, 122, or 244.

– constraint_set3_flag is equal to 1.

– level_idc represents a level less than or equal to the specified level.

The operation of the deblocking filter process specified in subclause 8.7 is not required for decoder conformance to the High 4:4:4 Intra profile.

NOTE – The deblocking filter process specified in subclause 8.7 or some similar post-processing filter should be performed, although this is not a requirement for decoder conformance to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles. The syntax elements sent by an encoder for control of the deblocking filter process specified in subclause 8.7 are considered only as advisory information for decoders conformance to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles. However, the application of the deblocking filter process specified in subclause 8.7 is required for decoder conformance to the High 4:4:4 Predictive profile when decoding bitstreams that conform to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles.

### A.2.11 CAVLC 4:4:4 Intra profile

Bitstreams conforming to the CAVLC 4:4:4 Intra profile shall obey the following constraints:

– All constraints specified in subclause A.2.10 for the High 4:4:4 Intra profile shall be obeyed.

– Picture parameter sets shall have entropy_coding_mode_flag equal to 0.

– The level constraints specified for the CAVLC 4:4:4 Intra profile in subclause A.3 shall be fulfilled.

Conformance of a bitstream to the CAVLC 4:4:4 Intra profile is specified by profile_idc being equal to 44. Decoders conforming to the CAVLC 4:4:4 Intra profile at a specific level shall be capable of decoding all bitstreams in which all of the following conditions are true:

– profile_idc is equal to 44.

– level_idc represents a level less than or equal to the specified level.

The operation of the deblocking filter process specified in subclause 8.7 is not required for decoder conformance to the CAVLC 4:4:4 Intra profile.

NOTE – The deblocking filter process specified in subclause 8.7 or some similar post-processing filter should be performed, although this is not a requirement for decoder conformance to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles. The syntax elements sent by an encoder for control of the deblocking filter process specified in subclause 8.7 are considered only as advisory information for decoders conformance to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles. However, the application of the deblocking filter process specified in subclause 8.7 is required for decoder conformance to the High 4:4:4 Predictive profile when decoding bitstreams that conform to the High 4:4:4 Intra and CAVLC 4:4:4 Intra profiles.

## A.3 Levels

The following is specified for expressing the constraints in this Annex.

– Let access unit n be the n-th access unit in decoding order with the first access unit being access unit 0.

– Let picture n be the primary coded picture or the corresponding decoded picture of access unit n.

### A.3.1 Level limits common to the Baseline, Main, and Extended profiles

Let the variable fR be derived as follows.

– If picture n is a frame, fR is set equal to 1 ÷ 172.

– Otherwise (picture n is a field), fR is set equal to 1 ÷ (172 * 2).

Bitstreams conforming to the Baseline, Main, or Extended profiles at a specified level shall obey the following constraints:

a) The nominal removal time of access unit n (with n > 0) from the CPB as specified in subclause C.1.2, satisfies the constraint that $t_{r,n}( n ) - t_r( n - 1 )$ is greater than or equal to Max( PicSizeInMbs ÷ MaxMBPS, fR ), where MaxMBPS is the value specified in Table A-1 that applies to picture n – 1, and PicSizeInMbs is the number of macroblocks in picture n – 1.

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b) The difference between consecutive output times of pictures from the DPB as specified in subclause C.2.2, satisfies the constraint that $\Delta t_{o,dpb}( n ) >= Max( PicSizeInMbs \div MaxMBPS, fR )$, where MaxMBPS is the value specified in Table A-1 for picture n, and PicSizeInMbs is the number of macroblocks of picture n, provided that picture n is a picture that is output and is not the last picture of the bitstream that is output.

c) The sum of the NumBytesInNALunit variables for access unit 0 is less than or equal to $384 * ( PicSizeInMbs + MaxMBPS * ( t_r( 0 ) - t_{r,n}( 0 ) ) ) \div MinCR$, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture 0 and PicSizeInMbs is the number of macroblocks in picture 0.

d) The sum of the NumBytesInNALunit variables for access unit n (with $n > 0$) is less than or equal to $384 * MaxMBPS * ( t_r( n ) - t_r( n - 1 ) ) \div MinCR$, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture n.

e) PicWidthInMbs * FrameHeightInMbs <= MaxFS, where MaxFS is specified in Table A-1

f) PicWidthInMbs <= Sqrt( MaxFS * 8 )

g) FrameHeightInMbs <= Sqrt( MaxFS * 8 )

h) max_dec_frame_buffering <= MaxDpbSize, where MaxDpbSize is equal to Min( 1024 * MaxDPB / ( PicWidthInMbs * FrameHeightInMbs * 384 ), 16 ) and MaxDPB is given in Table A-1 in units of 1024 bytes.

i) For the VCL HRD parameters, BitRate[ SchedSelIdx ] <= 1000 * MaxBR and CpbSize[ SchedSelIdx ] <= 1000 * MaxCPB for at least one value of SchedSelIdx, where BitRate[ SchedSelIdx ] is given by Equation E-37 and CpbSize[ SchedSelIdx ] is given by Equation E-38 when vcl_hrd_parameters_present_flag is equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of 1000 bits/s and 1000 bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1, inclusive.

j) For the NAL HRD parameters, BitRate[ SchedSelIdx ] <= 1200 * MaxBR and CpbSize[ SchedSelIdx ] <= 1200 * MaxCPB for at least one value of SchedSelIdx, where BitRate[ SchedSelIdx ] is given by Equation E-37 and CpbSize[ SchedSelIdx ] is given by Equation E-38 when nal_hrd_parameters_present_flag equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of 1200 bits/s and 1200 bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1.

k) Vertical motion vector component range luma motion vectors does not exceed MaxVmvR in units of luma frame samples, where MaxVmvR is specified in Table A-1

NOTE 1 – When chroma_format_idc is equal to 1 and the current macroblock is a field macroblock, the motion vector component range for chroma motion vectors may exceed MaxVmvR in units of luma frame samples, due to the method of deriving chroma motion vectors as specified in subclause 8.4.1.4.

l) Horizontal motion vector range does not exceed the range of -2048 to 2047.75, inclusive, in units of luma samples

m) Number of motion vectors per two consecutive macroblocks in decoding order (also applying to the total from the last macroblock of a slice and the first macroblock of the next slice in decoding order, and in particular also applying to the total from the last macroblock of the last slice of a picture and the first macroblock of the first slice of the next picture in decoding order) does not exceed MaxMvsPer2Mb, where MaxMvsPer2Mb is specified in Table A-1. The number of motion vectors for each macroblock is the value of the variable MvCnt after the completion of the intra or inter prediction process for the macroblock.

n) Number of bits of macroblock_layer( ) data for any macroblock is not greater than 3200. Depending on entropy_coding_mode_flag, the bits of macroblock_layer( ) data are counted as follows.

– If entropy_coding_mode_flag is equal to 0, the number of bits of macroblock_layer( ) data is given by the number of bits in the macroblock_layer( ) syntax structure for a macroblock.

– Otherwise (entropy_coding_mode_flag is equal to 1), the number of bits of macroblock_layer( ) data for a macroblock is given by the number of times read_bits( 1 ) is called in subclauses 9.3.3.2.2 and 9.3.3.2.3 when parsing the macroblock_layer( ) associated with the macroblock.

Table A-1 specifies the limits for each level. Entries marked "-" in Table A-1 denote the absence of a corresponding limit. For purposes of comparison of level capabilities, a level shall be considered to be a lower (higher) level than some other level if the level appears nearer to the top (bottom) row of Table A-1 than the other level.

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A level to which the bitstream conforms shall be indicated by the syntax elements level_idc and constraint_set3_flag as follows.

– If level_idc is equal to 11 and constraint_set3_flag is equal to 1, the indicated level is level 1b.

– Otherwise (level_idc is not equal to 11 or constraint_set3_flag is not equal to 1), level_idc shall be set equal to a value of ten times the level number specified in Table A-1 and constraint_set3_flag shall be set equal to 0.

**Table A-1 – Level limits**

| Level number | Max macroblock processing rate MaxMBPS (MB/s) | Max frame size MaxFS (MBs) | Max decoded picture buffer size MaxDPB (1024 bytes for 4:2:0) | Max video bit rate MaxBR (1000 bits/s, 1200 bits/s, cpbBrVclFactor bits/s, or cpbBrNalFactor bits/s) | Max CPB size MaxCPB (1000 bits, 1200 bits, cpbBrVclFactor bits, or cpbBrNalFactor bits) | Vertical MV component range MaxVmvR (luma frame samples) | Min compression ratio MinCR | Max number of motion vectors per two consecutive MBs MaxMvsPer2Mb |
|---|---|---|---|---|---|---|---|---|
| **1** | 1 485 | 99 | 148.5 | 64 | 175 | [-64,+63.75] | 2 | - |
| **1b** | 1 485 | 99 | 148.5 | 128 | 350 | [-64,+63.75] | 2 | - |
| **1.1** | 3 000 | 396 | 337.5 | 192 | 500 | [-128,+127.75] | 2 | - |
| **1.2** | 6 000 | 396 | 891.0 | 384 | 1 000 | [-128,+127.75] | 2 | - |
| **1.3** | 11 880 | 396 | 891.0 | 768 | 2 000 | [-128,+127.75] | 2 | - |
| **2** | 11 880 | 396 | 891.0 | 2 000 | 2 000 | [-128,+127.75] | 2 | - |
| **2.1** | 19 800 | 792 | 1 782.0 | 4 000 | 4 000 | [-256,+255.75] | 2 | - |
| **2.2** | 20 250 | 1 620 | 3 037.5 | 4 000 | 4 000 | [-256,+255.75] | 2 | - |
| **3** | 40 500 | 1 620 | 3 037.5 | 10 000 | 10 000 | [-256,+255.75] | 2 | 32 |
| **3.1** | 108 000 | 3 600 | 6 750.0 | 14 000 | 14 000 | [-512,+511.75] | 4 | 16 |
| **3.2** | 216 000 | 5 120 | 7 680.0 | 20 000 | 20 000 | [-512,+511.75] | 4 | 16 |
| **4** | 245 760 | 8 192 | 12 288.0 | 20 000 | 25 000 | [-512,+511.75] | 4 | 16 |
| **4.1** | 245 760 | 8 192 | 12 288.0 | 50 000 | 62 500 | [-512,+511.75] | 2 | 16 |
| **4.2** | 522 240 | 8 704 | 13 056.0 | 50 000 | 62 500 | [-512,+511.75] | 2 | 16 |
| **5** | 589 824 | 22 080 | 41 400.0 | 135 000 | 135 000 | [-512,+511.75] | 2 | 16 |
| **5.1** | 983 040 | 36 864 | 69 120.0 | 240 000 | 240 000 | [-512,+511.75] | 2 | 16 |

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Levels with non-integer level numbers in Table A-1 are referred to as “intermediate levels”.

NOTE 2 – All levels have the same status, but some applications may choose to use only the integer-numbered levels.

Informative subclause A.3.4 shows the effect of these limits on frame rates for several example picture formats.

### A.3.2 Level limits common to the High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles

Let the variable fR be derived as follows.

– If picture n is a frame, fR is set equal to 1 ÷ 172.

– Otherwise (picture n is a field), fR is set equal to 1 ÷ (172 * 2).


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Bitstreams conforming to the High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles at a specified level shall obey the following constraints:

a) The nominal removal time of access unit n (with n > 0) from the CPB as specified in subclause C.1.2, satisfies the constraint that $t_{r,n}( n ) - t_r( n - 1 )$ is greater than or equal to Max( PicSizeInMbs ÷ MaxMBPS, fR ), where MaxMBPS is the value specified in Table A-1 that applies to picture n – 1, and PicSizeInMbs is the number of macroblocks in picture n – 1.

b) The difference between consecutive output times of pictures from the DPB as specified in subclause C.2.2, satisfies the constraint that $\Delta t_{o,dpb}( n ) >= Max( PicSizeInMbs ÷ MaxMBPS, fR )$, where MaxMBPS is the value specified in Table A-1 for picture n, and PicSizeInMbs is the number of macroblocks of picture n, provided that picture n is a picture that is output and is not the last picture of the bitstream that is output.

c) PicWidthInMbs * FrameHeightInMbs <= MaxFS, where MaxFS is specified in Table A-1

d) PicWidthInMbs <= Sqrt( MaxFS * 8 )

e) FrameHeightInMbs <= Sqrt( MaxFS * 8 )

f) max_dec_frame_buffering <= MaxDpbSize, where MaxDpbSize is equal to Min( 1024 * MaxDPB / ( PicWidthInMbs * FrameHeightInMbs * 384 ), 16 ) and MaxDPB is specified in Table A-1.

g) Vertical motion vector component range does not exceed MaxVmvR in units of luma frame samples, where MaxVmvR is specified in Table A-1.

h) Horizontal motion vector range does not exceed the range of -2048 to 2047.75, inclusive, in units of luma samples.

i) Number of motion vectors per two consecutive macroblocks in decoding order (also applying to the total from the last macroblock of a slice and the first macroblock of the next slice in decoding order) does not exceed MaxMvsPer2Mb, where MaxMvsPer2Mb is specified in Table A-1. The number of motion vectors for each macroblock is value of the variable MvCnt after the completion of the intra or inter prediction process for the macroblock.

j) Number of bits of macroblock_layer( ) data for any macroblock is not greater than 128 + RawMbBits. Depending on entropy_coding_mode_flag, the bits of macroblock_layer( ) data are counted as follows.

   – If entropy_coding_mode_flag is equal to 0, the number of bits of macroblock_layer( ) data is given by the number of bits in the macroblock_layer( ) syntax structure for a macroblock.

   – Otherwise (entropy_coding_mode_flag is equal to 1), the number of bits of macroblock_layer( ) data for a macroblock is given by the number of times read_bits( 1 ) is called in subclauses 9.3.3.2.2 and 9.3.3.2.3 when parsing the macroblock_layer( ) associated with the macroblock.

Table A-1 specifies the limits for each level. Entries marked "-" in Table A-1 denote the absence of a corresponding limit. The use of the MinCR parameter column of Table A-1 for these profiles is specified in subclause A.3.3.

A level to which the bitstream conforms shall be indicated by the syntax element level_idc as follows.

– If level_idc is equal to 9, the indicated level is level 1b.

– Otherwise (level_idc is not equal to 9), level_idc shall be set equal to a value of ten times the level number specified in Table A-1.

### A.3.3 Profile-specific level limits

a) In bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, the removal time of access unit 0 shall satisfy the constraint that the number of slices in picture 0 is less than or equal to $( PicSizeInMbs + MaxMBPS * ( t_r( 0 ) - t_{r,n}( 0 ) ) ) ÷ SliceRate$, where SliceRate is the value specified in Table A-4 that applies to picture 0.

b) In bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, the difference between consecutive removal time of access units n and n - 1 (with n > 0) shall satisfy the constraint that the number of slices in picture n is less than or equal to $MaxMBPS * ( t_r( n ) - t_r( n - 1 ) ) ÷ SliceRate$, where SliceRate is the value specified in Table A-4 that applies to picture n.

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c) In bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, sequence parameter sets shall have direct_8x8_inference_flag equal to 1 for the levels specified in Table A-4.

NOTE 1 – direct_8x8_inference_flag is not relevant to the Baseline profile as it does not allow B slice types (specified in subclause A.2.1), and direct_8x8_inference_flag is equal to 1 for all levels of the Extended profile (specified in subclause A.2.3).

d) In bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, CAVLC 4:4:4 Intra, or Extended profiles, sequence parameter sets shall have frame_mbs_only_flag equal to 1 for the levels specified in Table A-4 for the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles and in Table A-5 for the Extended profile.

NOTE 2 – frame_mbs_only_flag is equal to 1 for all levels of the Baseline profile (specified in subclause A.2.1).

e) In bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, CAVLC 4:4:4 Intra, or Extended profiles, the value of sub_mb_type in B macroblocks shall not be equal to B_Bi_8x4, B_Bi_4x8, or B_Bi_4x4 for the levels in which MinLumaBiPredSize is shown as 8x8 in Table A-4 for the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles and in Table A-5 for the Extended profile.

f) In bitstreams conforming to the Baseline or Extended profiles, ( $xInt_{max} - xInt_{min} + 6$ ) * ( $yInt_{max} - yInt_{min} + 6$ ) <= MaxSubMbRectSize in macroblocks coded with mb_type equal to P_8x8, P_8x8ref0 or B_8x8 for all invocations of the process specified in subclause 8.4.2.2.1 used to generate the predicted luma sample array for a single reference picture list (reference picture list 0 or reference picture list 1) for each 8x8 sub-macroblock, where NumSubMbPart( sub_mb_type ) > 1, where MaxSubMbRectSize is specified in Table A-3 for the Baseline profile and in Table A-5 for the Extended profile and

- $xInt_{min}$ is the minimum value of $xInt_L$ among all luma sample predictions for the sub-macroblock
- $xInt_{max}$ is the maximum value of $xInt_L$ among all luma sample predictions for the sub-macroblock
- $yInt_{min}$ is the minimum value of $yInt_L$ among all luma sample predictions for the sub-macroblock
- $yInt_{max}$ is the maximum value of $yInt_L$ among all luma sample predictions for the sub-macroblock

g) In bitstreams conforming to the High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, for the VCL HRD parameters, BitRate[ SchedSelIdx ] <= cpbBrVclFactor * MaxBR and CpbSize[ SchedSelIdx ] <= cpbBrVclFactor * MaxCPB for at least one value of SchedSelIdx, where cpbBrVclFactor is specified in Table A-2, BitRate[ SchedSelIdx ] is specified by Equation E-37 and CpbSize[ SchedSelIdx ] is specified by Equation E-38 when vcl_hrd_parameters_present_flag is equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of cpbBrVclFactor bits/s and cpbBrVclFactor bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1, inclusive.

h) In bitstreams conforming to the High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, for the NAL HRD parameters, BitRate[ SchedSelIdx ] <= cpbBrNalFactor * MaxBR and CpbSize[ SchedSelIdx ] <= cpbBrNalFactor * MaxCPB for at least one value of SchedSelIdx, where cpbBrNalFactor is specified in Table A-2, BitRate[ SchedSelIdx ] is specified by Equation E-37 and CpbSize[ SchedSelIdx ] is specified by Equation E-38 when nal_hrd_parameters_present_flag equal to 1. MaxBR and MaxCPB are specified in Table A-1 in units of cpbBrNalFactor bits/s and cpbBrNalFactor bits, respectively. The bitstream shall satisfy these conditions for at least one value of SchedSelIdx in the range 0 to cpb_cnt_minus1.

i) In bitstreams conforming to the High profile, the sum of the NumBytesInNALunit variables for access unit 0 is less than or equal to 384 * ( PicSizeInMbs + MaxMBPS * ( $t_r(0) - t_{r,n}(0)$ ) ) ÷ MinCR, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture 0 and PicSizeInMbs is the number of macroblocks in picture 0.

NOTE 2 – Such a limit involving MinCR is not imposed for bitstream conformance to the High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles.

j) In bitstreams conforming to the High profile, the sum of the NumBytesInNALunit variables for access unit n (with n > 0) is less than or equal to 384 * MaxMBPS * ( $t_r(n) - t_r(n-1)$ ) ÷ MinCR, where MaxMBPS and MinCR are the values specified in Table A-1 that apply to picture n.

NOTE 3 – Such a limit involving MinCR is not imposed for bitstream conformance to the High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles.

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k) In bitstreams conforming to the High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles, when PicSizeInMbs is greater than 1620, the number of macroblocks in any coded slice shall not exceed MaxFS / 4, where MaxFS is specified in Table A-1.

NOTE 4 – Items i), j), and k) above are included herein for purposes of specification of the High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profiles. The aspects of these items as they relate to the High, High 10, and High 4:2:2 profiles are included herein for completeness, and reflect corrections of the intended specification of these profiles.

**Table A-2 – Specification of cpbBrVclFactor and cpbBrNalFactor**

| Profile | cpbBrVclFactor | cpbBrNalFactor |
|---|---|---|
| **High** | 1 250 | 1 500 |
| **High 10**<br>**High 10 Intra** | 3 000 | 3 600 |
| **High 4:2:2**<br>**High 4:2:2 Intra** | 4 000 | 4 800 |
| **High 4:4:4 Predictive**<br>**High 4:4:4 Intra**<br>**CAVLC 4:4:4 Intra** | 4 000 | 4 800 |

### A.3.3.1 Baseline profile level limits

Table A-3 specifies limits for each level that are specific to bitstreams conforming to the Baseline profile. Entries marked "-" in Table A-3 denote the absence of a corresponding limit.

**Table A-3 – Baseline profile level limits**

| Level number | MaxSubMbRectSize |
|---|---|
| **1** | 576 |
| **1b** | 576 |
| **1.1** | 576 |
| **1.2** | 576 |
| **1.3** | 576 |
| **2** | 576 |
| **2.1** | 576 |
| **2.2** | 576 |
| **3** | 576 |
| **3.1** | - |
| **3.2** | - |
| **4** | - |
| **4.1** | - |
| **4.2** | - |
| **5** | - |
| **5.1** | - |

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### A.3.3.2 Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profile level limits

Table A-4 specifies limits for each level that are specific to bitstreams conforming to the Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, or CAVLC 4:4:4 Intra profiles. Entries marked "-" in Table A-4 denote the absence of a corresponding limit.

**Table A-4 – Main, High, High 10, High 4:2:2, High 4:4:4 Predictive, High 10 Intra, High 4:2:2 Intra, High 4:4:4 Intra, and CAVLC 4:4:4 Intra profile level limits**

| Level_number | SliceRate | MinLumaBiPredSize | direct_8x8_inference_flag | frame_mbs_only_flag |
|---|---|---|---|---|
| **1** | - | - | - | 1 |
| **1b** | - | - | - | 1 |
| **1.1** | - | - | - | 1 |
| **1.2** | - | - | - | 1 |
| **1.3** | - | - | - | 1 |
| **2** | - | - | - | 1 |
| **2.1** | - | - | - | - |
| **2.2** | - | - | - | - |
| **3** | 22 | - | 1 | - |
| **3.1** | 60 | 8x8 | 1 | - |
| **3.2** | 60 | 8x8 | 1 | - |
| **4** | 60 | 8x8 | 1 | - |
| **4.1** | 24 | 8x8 | 1 | - |
| **4.2** | 24 | 8x8 | 1 | 1 |
| **5** | 24 | 8x8 | 1 | 1 |
| **5.1** | 24 | 8x8 | 1 | 1 |

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### A.3.3.3 Extended Profile level limits

Table A-5 specifies limits for each level that are specific to bitstreams conforming to the Extended profile. Entries marked "-" in Table A-5 denote the absence of a corresponding limit.


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**Table A-5 – Extended profile level limits**

| Level number | MaxSubMbRectSize | MinLumaBiPredSize | frame_mbs_only_flag |
|---|---|---|---|
| **1** | 576 | - | 1 |
| **1b** | 576 | - | 1 |
| **1.1** | 576 | - | 1 |
| **1.2** | 576 | - | 1 |
| **1.3** | 576 | - | 1 |
| **2** | 576 | - | 1 |
| **2.1** | 576 | - | - |
| **2.2** | 576 | - | - |
| **3** | 576 | - | - |
| **3.1** | - | 8x8 | - |
| **3.2** | - | 8x8 | - |
| **4** | - | 8x8 | - |
| **4.1** | - | 8x8 | - |
| **4.2** | - | 8x8 | 1 |
| **5** | - | 8x8 | 1 |
| **5.1** | - | 8x8 | 1 |

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### A.3.4 Effect of level limits on frame rate (informative)

This subclause does not form an integral part of this International Standard.

**Table A-6 – Maximum frame rates (frames per second) for some example frame sizes**

| **Level:** | | | | | **1** | **1b** | **1.1** | **1.2** | **1.3** | **2** | **2.1** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Max frame size (macroblocks):** | | | | | **99** | **99** | **396** | **396** | **396** | **396** | **792** |
| **Max macroblocks/second:** | | | | | **1 485** | **1 485** | **3 000** | **6 000** | **11 880** | **11 880** | **19 800** |
| | | | | | | | | | | | |
| **Max frame size (samples):** | | | | | 25 344 | 25 344 | 101 376 | 101 376 | 101 376 | 101 376 | 202 752 |
| **Max samples/second:** | | | | | 380 160 | 380 160 | 768 000 | 1 536 000 | 3 041 280 | 3 041 280 | 5 068 800 |
| **Format** | **Luma Width** | **Luma Height** | **MBs Total** | **Luma Samples** | | | | | | | |
| **SQCIF** | **128** | **96** | 48 | 12 288 | 30.9 | 30.9 | 62.5 | 125.0 | 172.0 | 172.0 | 172.0 |
| **QCIF** | **176** | **144** | 99 | 25 344 | 15.0 | 15.0 | 30.3 | 60.6 | 120.0 | 120.0 | 172.0 |
| **QVGA** | **320** | **240** | 300 | 76 800 | - | - | 10.0 | 20.0 | 39.6 | 39.6 | 66.0 |
| **525 SIF** | **352** | **240** | 330 | 84 480 | - | - | 9.1 | 18.2 | 36.0 | 36.0 | 60.0 |
| **CIF** | **352** | **288** | 396 | 101 376 | - | - | 7.6 | 15.2 | 30.0 | 30.0 | 50.0 |
| **525 HHR** | **352** | **480** | 660 | 168 960 | - | - | - | - | - | - | 30.0 |
| **625 HHR** | **352** | **576** | 792 | 202 752 | - | - | - | - | - | - | 25.0 |
| **VGA** | **640** | **480** | 1 200 | 307 200 | - | - | - | - | - | - | - |
| **525 4SIF** | **704** | **480** | 1 320 | 337 920 | - | - | - | - | - | - | - |
| **525 SD** | **720** | **480** | 1 350 | 345 600 | - | - | - | - | - | - | - |
| **4CIF** | **704** | **576** | 1 584 | 405 504 | - | - | - | - | - | - | - |
| **625 SD** | **720** | **576** | 1 620 | 414 720 | - | - | - | - | - | - | - |
| **SVGA** | **800** | **600** | 1 900 | 486 400 | - | - | - | - | - | - | - |
| **XGA** | **1024** | **768** | 3 072 | 786 432 | - | - | - | - | - | - | - |
| **720p HD** | **1280** | **720** | 3 600 | 921 600 | - | - | - | - | - | - | - |
| **4VGA** | **1280** | **960** | 4 800 | 1 228 800 | - | - | - | - | - | - | - |
| **SXGA** | **1280** | **1024** | 5 120 | 1 310 720 | - | - | - | - | - | - | - |
| **525 16SIF** | **1408** | **960** | 5 280 | 1 351 680 | - | - | - | - | - | - | - |
| **16CIF** | **1408** | **1152** | 6 336 | 1 622 016 | - | - | - | - | - | - | - |
| **4SVGA** | **1600** | **1200** | 7 500 | 1 920 000 | - | - | - | - | - | - | - |
| **1080 HD** | **1920** | **1088** | 8 160 | 2 088 960 | - | - | - | - | - | - | - |
| **2Kx1K** | **2048** | **1024** | 8 192 | 2 097 152 | - | - | - | - | - | - | - |
| **2Kx1080** | **2048** | **1088** | 8 704 | 2 228 224 | - | - | - | - | - | - | - |
| **4XGA** | **2048** | **1536** | 12 288 | 3 145 728 | - | - | - | - | - | - | - |
| **16VGA** | **2560** | **1920** | 19 200 | 4 915 200 | - | - | - | - | - | - | - |
| **3616x1536 (2.35:1)** | **3616** | **1536** | 21 696 | 5 554 176 | - | - | - | - | - | - | - |
| **3672x1536 (2.39:1)** | **3680** | **1536** | 22 080 | 5 652 480 | - | - | - | - | - | - | - |
| **4Kx2K** | **4096** | **2048** | 32 768 | 8 388 608 | - | - | - | - | - | - | - |
| **4096x2304 (16:9)** | **4096** | **2304** | 36 864 | 9 437 184 | - | - | - | - | - | - | - |

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**Table A-6 (continued) – Maximum frame rates (frames per second) for some example frame sizes**

| **Level:** | | | | | **2.2** | **3** | **3.1** | **3.2** | **4** | **4.1** | **4.2** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Max frame size (macroblocks):** | | | | | **1 620** | **1 620** | **3 600** | **5 120** | **8 192** | **8 192** | **8 704** |
| **Max macroblocks/second:** | | | | | **20 250** | **40 500** | **108 000** | **216 000** | **245 760** | **245 760** | **522 240** |
| | | | | | | | | | | | |
| **Max frame size (samples):** | | | | | 414 720 | 414 720 | 921 600 | 1 310 720 | 2 097 152 | 2 097 152 | 2 228 224 |
| **Max samples/second:** | | | | | 5 184 000 | 10 368 000 | 27 648 000 | 55 296 000 | 62 914 560 | 62 914 560 | 133 693 440 |
| **Format** | **Luma Width** | **Luma Height** | **MBs Total** | **Luma Samples** | | | | | | | |
| **SQCIF** | **128** | **96** | 48 | 12 288 | 172.0 | 172.0 | 172.0 | 172.0 | 172.0 | 172.0 | 172.0 |
| **QCIF** | **176** | **144** | 99 | 25 344 | 172.0 | 172.0 | 172.0 | 172.0 | 172.0 | 172.0 | 172.0 |
| **QVGA** | **320** | **240** | 300 | 76 800 | 67.5 | 135.0 | 172.0 | 172.0 | 172.0 | 172.0 | 172.0 |
| **525 SIF** | **352** | **240** | 330 | 84 480 | 61.4 | 122.7 | 172.0 | 172.0 | 172.0 | 172.0 | 172.0 |
| **CIF** | **352** | **288** | 396 | 101 376 | 51.1 | 102.3 | 172.0 | 172.0 | 172.0 | 172.0 | 172.0 |
| **525 HHR** | **352** | **480** | 660 | 168 960 | 30.7 | 61.4 | 163.6 | 172.0 | 172.0 | 172.0 | 172.0 |
| **625 HHR** | **352** | **576** | 792 | 202 752 | 25.6 | 51.1 | 136.4 | 172.0 | 172.0 | 172.0 | 172.0 |
| **VGA** | **640** | **480** | 1 200 | 307 200 | 16.9 | 33.8 | 90.0 | 172.0 | 172.0 | 172.0 | 172.0 |
| **525 4SIF** | **704** | **480** | 1 320 | 337 920 | 15.3 | 30.7 | 81.8 | 163.6 | 172.0 | 172.0 | 172.0 |
| **525 SD** | **720** | **480** | 1 350 | 345 600 | 15.0 | 30.0 | 80.0 | 160.0 | 172.0 | 172.0 | 172.0 |
| **4CIF** | **704** | **576** | 1 584 | 405 504 | 12.8 | 25.6 | 68.2 | 136.4 | 155.2 | 155.2 | 172.0 |
| **625 SD** | **720** | **576** | 1 620 | 414 720 | 12.5 | 25.0 | 66.7 | 133.3 | 151.7 | 151.7 | 172.0 |
| **SVGA** | **800** | **600** | 1 900 | 486 400 | - | - | 56.8 | 113.7 | 129.3 | 129.3 | 172.0 |
| **XGA** | **1024** | **768** | 3 072 | 786 432 | - | - | 35.2 | 70.3 | 80.0 | 80.0 | 172.0 |
| **720p HD** | **1280** | **720** | 3 600 | 921 600 | - | - | 30.0 | 60.0 | 68.3 | 68.3 | 145.1 |
| **4VGA** | **1280** | **960** | 4 800 | 1 228 800 | - | - | - | 45.0 | 51.2 | 51.2 | 108.8 |
| **SXGA** | **1280** | **1024** | 5 120 | 1 310 720 | - | - | - | 42.2 | 48.0 | 48.0 | 102.0 |
| **525 16SIF** | **1408** | **960** | 5 280 | 1 351 680 | - | - | - | - | 46.5 | 46.5 | 98.9 |
| **16CIF** | **1408** | **1152** | 6 336 | 1 622 016 | - | - | - | - | 38.8 | 38.8 | 82.4 |
| **4SVGA** | **1600** | **1200** | 7 500 | 1 920 000 | - | - | - | - | 32.8 | 32.8 | 69.6 |
| **1080 HD** | **1920** | **1088** | 8 160 | 2 088 960 | - | - | - | - | 30.1 | 30.1 | 64.0 |
| **2Kx1K** | **2048** | **1024** | 8 192 | 2 097 152 | - | - | - | - | 30.0 | 30.0 | 63.8 |
| **2Kx1080** | **2048** | **1088** | 8 704 | 2 228 224 | - | - | - | - | - | - | 60.0 |
| **4XGA** | **2048** | **1536** | 12 288 | 3 145 728 | - | - | - | - | - | - | - |
| **16VGA** | **2560** | **1920** | 19 200 | 4 915 200 | - | - | - | - | - | - | - |
| **3616x1536 (2.35:1)** | **3616** | **1536** | 21 696 | 5 554 176 | - | - | - | - | - | - | - |
| **3672x1536 (2.39:1)** | **3680** | **1536** | 22 080 | 5 652 480 | - | - | - | - | - | - | - |
| **4Kx2K** | **4096** | **2048** | 32 768 | 8 388 608 | - | - | - | - | - | - | - |
| **4096x2304 (16:9)** | **4096** | **2304** | 36 864 | 9 437 184 | - | - | - | - | - | - | - |

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**Table A-6 (concluded) – Maximum frame rates (frames per second) for some example frame sizes**

| Level: | | | | | 5 | 5.1 |
|---|---|---|---|---|---|---|
| Max frame size (macroblocks): | | | | | 22 080 | 36 864 |
| Max macroblocks/second: | | | | | 589 824 | 983 040 |
| | | | | | | |
| Max frame size (samples): | | | | | 5 652 480 | 9 437 184 |
| Max samples/second: | | | | | 150 994 944 | 251 658 240 |
| Format | Luma Width | Luma Height | MBs Total | Luma Samples | | |
| SQCIF | 128 | 96 | 48 | 12 288 | 172.0 | 172.0 |
| QCIF | 176 | 144 | 99 | 25 344 | 172.0 | 172.0 |
| QVGA | 320 | 240 | 300 | 76 800 | 172.0 | 172.0 |
| 525 SIF | 352 | 240 | 330 | 84 480 | 172.0 | 172.0 |
| CIF | 352 | 288 | 396 | 101 376 | 172.0 | 172.0 |
| 525 HHR | 352 | 480 | 660 | 168 960 | 172.0 | 172.0 |
| 625 HHR | 352 | 576 | 792 | 202 752 | 172.0 | 172.0 |
| VGA | 640 | 480 | 1 200 | 307 200 | 172.0 | 172.0 |
| 525 4SIF | 704 | 480 | 1 320 | 337 920 | 172.0 | 172.0 |
| 525 SD | 720 | 480 | 1 350 | 345 600 | 172.0 | 172.0 |
| 4CIF | 704 | 576 | 1 584 | 405 504 | 172.0 | 172.0 |
| 625 SD | 720 | 576 | 1 620 | 414 720 | 172.0 | 172.0 |
| SVGA | 800 | 600 | 1 900 | 486 400 | 172.0 | 172.0 |
| XGA | 1024 | 768 | 3 072 | 786 432 | 172.0 | 172.0 |
| 720p HD | 1280 | 720 | 3 600 | 921 600 | 163.8 | 172.0 |
| 4VGA | 1280 | 960 | 4 800 | 1 228 800 | 122.9 | 172.0 |
| SXGA | 1280 | 1024 | 5 120 | 1 310 720 | 115.2 | 172.0 |
| 525 16SIF | 1408 | 960 | 5 280 | 1 351 680 | 111.7 | 172.0 |
| 16CIF | 1408 | 1152 | 6 336 | 1 622 016 | 93.1 | 155.2 |
| 4SVGA | 1600 | 1200 | 7 500 | 1 920 000 | 78.6 | 131.1 |
| 1080 HD | 1920 | 1088 | 8 160 | 2 088 960 | 72.3 | 120.5 |
| 2Kx1K | 2048 | 1024 | 8 192 | 2 097 152 | 72.0 | 120.0 |
| 2Kx1080 | 2048 | 1088 | 8 704 | 2 228 224 | 67.8 | 112.9 |
| 4XGA | 2048 | 1536 | 12 288 | 3 145 728 | 48.0 | 80.0 |
| 16VGA | 2560 | 1920 | 19 200 | 4 915 200 | 30.7 | 51.2 |
| 3616x1536 (2.35:1) | 3616 | 1536 | 21 696 | 5 554 176 | 27.2 | 45.3 |
| 3672x1536 (2.39:1) | 3680 | 1536 | 22 080 | 5 652 480 | 26.7 | 44.5 |
| 4Kx2K | 4096 | 2048 | 32 768 | 8 388 608 | - | 30.0 |
| 4096x2304 (16:9) | 4096 | 2304 | 36 864 | 9 437 184 | - | 26.7 |

The following should be noted.

– This International Standard is a variable-frame-size specification. The specific frame sizes in Table A-6 are illustrative examples only.

– As used in Table A-6, "525" refers to typical use for environments using 525 analogue scan lines (of which approximately 480 lines contain the visible picture region), and "625" refers to environments using 625 analogue scan lines (of which approximately 576 lines contain the visible picture region).

– XGA is also known as (aka) XVGA, 4SVGA aka UXGA, 16XGA aka 4Kx3K, CIF aka 625 SIF, 625 HHR aka 2CIF aka half 625 D-1, aka half 625 ITU-R BT.601, 525 SD aka 525 D-1 aka 525 ITU-R BT.601, 625 SD aka 625 D-1 aka 625 ITU-R BT.601.

– Frame rates given are correct for progressive scan modes. The frame rates are also correct for interlaced video coding for the cases of frame height divisible by 32.

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# Annex B
# Byte stream format

(This annex forms an integral part of this International Standard)

This annex specifies syntax and semantics of a byte stream format specified for use by applications that deliver some or all of the NAL unit stream as an ordered stream of bytes or bits within which the locations of NAL unit boundaries need to be identifiable from patterns in the data, such as ITU-T Rec. H.222.0 | ISO/IEC 13818-1 systems or ITU-T Rec. H.320 systems. For bit-oriented delivery, the bit order for the byte stream format is specified to start with the MSB of the first byte, proceed to the LSB of the first byte, followed by the MSB of the second byte, etc.

The byte stream format consists of a sequence of byte stream NAL unit syntax structures. Each byte stream NAL unit syntax structure contains one start code prefix followed by one nal_unit( NumBytesInNALunit ) syntax structure. It may (and under some circumstances, it shall) also contain an additional zero_byte syntax element. It may also contain one or more additional trailing_zero_8bits syntax elements. When it is the first byte stream NAL unit in the bitstream, it may also contain one or more additional leading_zero_8bits syntax elements.

## B.1 Byte stream NAL unit syntax and semantics

### B.1.1 Byte stream NAL unit syntax

| byte_stream_nal_unit( NumBytesInNALunit ) { | C | Descriptor |
|---|---|---|
| while( next_bits( 24 ) != 0x000001 && next_bits( 32 ) != 0x00000001 ) | | |
| **leading_zero_8bits** /* equal to 0x00 */ | | f(8) |
| if( next_bits( 24 ) != 0x000001 ) | | |
| **zero_byte** /* equal to 0x00 */ | | f(8) |
| **start_code_prefix_one_3bytes** /* equal to 0x000001 */ | | f(24) |
| nal_unit( NumBytesInNALunit ) | | |
| while( more_data_in_byte_stream( ) && next_bits( 24 ) != 0x000001 && next_bits( 32 ) != 0x00000001 ) | | |
| **trailing_zero_8bits** /* equal to 0x00 */ | | f(8) |
| } | | |

### B.1.2 Byte stream NAL unit semantics

The order of byte stream NAL units in the byte stream shall follow the decoding order of the NAL units contained in the byte stream NAL units (see subclause 7.4.1.2). The content of each byte stream NAL unit is associated with the same access unit as the NAL unit contained in the byte stream NAL unit (see subclause 7.4.1.2.3).

**leading_zero_8bits** is a byte equal to 0x00.

NOTE The leading_zero_8bits syntax element can only be present in the first byte stream NAL unit of the bitstream, because (as shown in the syntax diagram of subclause B.1.1) any bytes equal to 0x00 that follow a NAL unit syntax structure and precede the four-byte sequence 0x00000001 (which is to be interpreted as a zero_byte followed by a start_code_prefix_one_3bytes) will be considered to be trailing_zero_8bits syntax elements that are part of the preceding byte stream NAL unit.

**zero_byte** is a single byte equal to 0x00.

When any of the following conditions are fulfilled, the zero_byte syntax element shall be present.

– the nal_unit_type within the nal_unit( ) is equal to 7 (sequence parameter set) or 8 (picture parameter set)

– the byte stream NAL unit syntax structure contains the first NAL unit of an access unit in decoding order, as specified by subclause 7.4.1.2.3.

**start_code_prefix_one_3bytes** is a fixed-value sequence of 3 bytes equal to 0x000001. This syntax element is called a start code prefix.

**trailing_zero_8bits** is a byte equal to 0x00.

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## B.2 Byte stream NAL unit decoding process

Input to this process consists of an ordered stream of bytes consisting of a sequence of byte stream NAL unit syntax structures.

Output of this process consists of a sequence of NAL unit syntax structures.

At the beginning of the decoding process, the decoder initialises its current position in the byte stream to the beginning of the byte stream. It then extracts and discards each leading_zero_8bits syntax element (if present), moving the current position in the byte stream forward one byte at a time, until the current position in the byte stream is such that the next four bytes in the bitstream form the four-byte sequence 0x00000001.

The decoder then performs the following step-wise process repeatedly to extract and decode each NAL unit syntax structure in the byte stream until the end of the byte stream has been encountered (as determined by unspecified means) and the last NAL unit in the byte stream has been decoded:

1. When the next four bytes in the bitstream form the four-byte sequence 0x00000001, the next byte in the byte stream (which is a zero_byte syntax element) is extracted and discarded and the current position in the byte stream is set equal to the position of the byte following this discarded byte.
2. The next three-byte sequence in the byte stream (which is a start_code_prefix_one_3bytes) is extracted and discarded and the current position in the byte stream is set equal to the position of the byte following this three-byte sequence.
3. NumBytesInNALunit is set equal to the number of bytes starting with the byte at the current position in the byte stream up to and including the last byte that precedes the location of any of the following conditions:
    a. A subsequent byte-aligned three-byte sequence equal to 0x000000, or
    b. A subsequent byte-aligned three-byte sequence equal to 0x000001, or
    c. The end of the byte stream, as determined by unspecified means.
4. NumBytesInNALunit bytes are removed from the bitstream and the current position in the byte stream is advanced by NumBytesInNALunit bytes. This sequence of bytes is nal_unit( NumBytesInNALunit ) and is decoded using the NAL unit decoding process.
5. When the current position in the byte stream is not at the end of the byte stream (as determined by unspecified means) and the next bytes in the byte stream do not start with a three-byte sequence equal to 0x000001 and the next bytes in the byte stream do not start with a four byte sequence equal to 0x00000001, the decoder extracts and discards each trailing_zero_8bits syntax element, moving the current position in the byte stream forward one byte at a time, until the current position in the byte stream is such that the next bytes in the byte stream form the four-byte sequence 0x00000001 or the end of the byte stream has been encountered (as determined by unspecified means).

## B.3 Decoder byte-alignment recovery (informative)

This subclause does not form an integral part of this International Standard.

Many applications provide data to a decoder in a manner that is inherently byte aligned, and thus have no need for the bit-oriented byte alignment detection procedure described in this subclause.

A decoder is said to have byte-alignment with a bitstream when the decoder is able to determine whether or not the positions of data in the bitstream are byte-aligned. When a decoder does not have byte alignment with the encoder's byte stream, the decoder may examine the incoming bitstream for the binary pattern '00000000 00000000 00000000 00000001' (31 consecutive bits equal to 0 followed by a bit equal to 1). The bit immediately following this pattern is the first bit of an aligned byte following a start code prefix. Upon detecting this pattern, the decoder will be byte aligned with the encoder and positioned at the start of a NAL unit in the byte stream.

Once byte aligned with the encoder, the decoder can examine the incoming byte stream for subsequent three-byte sequences 0x000001 and 0x000003.

When the three-byte sequence 0x000001 is detected, this is a start code prefix.

When the three-byte sequence 0x000003 is detected, the third byte (0x03) is an emulation_prevention_three_byte to be discarded as specified in subclause 7.4.1.

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When an error in the bitstream syntax is detected (e.g., a non-zero value of the forbidden_zero_bit or one of the three-byte or four-byte sequences that are prohibited in subclause 7.4.1), the decoder may consider the detected condition as an indication that byte alignment may have been lost and may discard all bitstream data until the detection of byte alignment at a later position in the bitstream as described in this subclause.

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# Annex C
# Hypothetical reference decoder

(This annex forms an integral part of this International Standard)

This annex specifies the hypothetical reference decoder (HRD) and its use to check bitstream and decoder conformance.

Two types of bitstreams are subject to HRD conformance checking for this International Standard. The first such type of bitstream, called Type I bitstream, is a NAL unit stream containing only the VCL NAL units and filler data NAL units for all access units in the bitstream. The second type of bitstream, called a Type II bitstream, contains, in addition to the VCL NAL units and filler data NAL units for all access units in the bitstream, at least one of the following:

- additional non-VCL NAL units other than filler data NAL units
- all leading_zero_8bits, zero_byte, start_code_prefix_one_3bytes, and trailing_zero_8bits syntax elements that form a byte stream from the NAL unit stream (as specified in Annex B)

Figure C-1 shows the types of bitstream conformance points checked by the HRD.

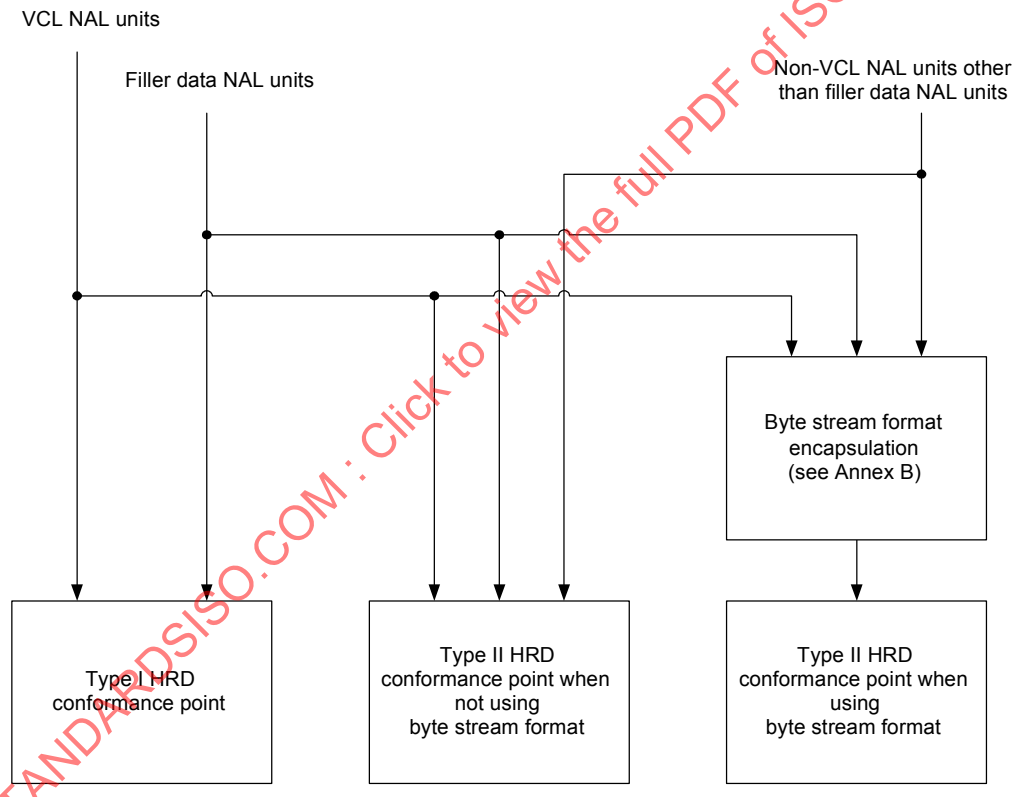


**Figure C-1 – Structure of byte streams and NAL unit streams for HRD conformance checks**

The syntax elements of non-VCL NAL units (or their default values for some of the syntax elements), required for the HRD, are specified in the semantic subclauses of clause 7 and Annexes D and E.

Two types of HRD parameter sets are used. The HRD parameter sets are signalled through video usability information as specified in subclauses E.1 and E.2, which is part of the sequence parameters set syntax structure.

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In order to check conformance of a bitstream using the HRD, all sequence parameter sets and picture parameters sets referred to in the VCL NAL units, and corresponding buffering period and picture timing SEI messages shall be conveyed to the HRD, in a timely manner, either in the bitstream (by non-VCL NAL units), or by other means not specified in this International Standard.

In Annexes C, D and E, the specification for "presence" of non-VCL NAL units is also satisfied when those NAL units (or just some of them) are conveyed to decoders (or to the HRD) by other means not specified by this International Standard. For the purpose of counting bits, only the appropriate bits that are actually present in the bitstream are counted.

NOTE 1 – As an example, synchronization of a non-VCL NAL unit, conveyed by means other than presence in the bitstream, with the NAL units that are present in the bitstream, can be achieved by indicating two points in the bitstream, between which the non-VCL NAL unit would have been present in the bitstream, had the encoder decided to convey it in the bitstream.

When the content of a non-VCL NAL unit is conveyed for the application by some means other than presence within the bitstream, the representation of the content of the non-VCL NAL unit is not required to use the same syntax specified in this annex.

NOTE 2 – When HRD information is contained within the bitstream, it is possible to verify the conformance of a bitstream to the requirements of this subclause based solely on information contained in the bitstream. When the HRD information is not present in the bitstream, as is the case for all "stand-alone" Type I bitstreams, conformance can only be verified when the HRD data is supplied by some other means not specified in this International Standard.

The HRD contains a coded picture buffer (CPB), an instantaneous decoding process, a decoded picture buffer (DPB), and output cropping as shown in Figure C-2.

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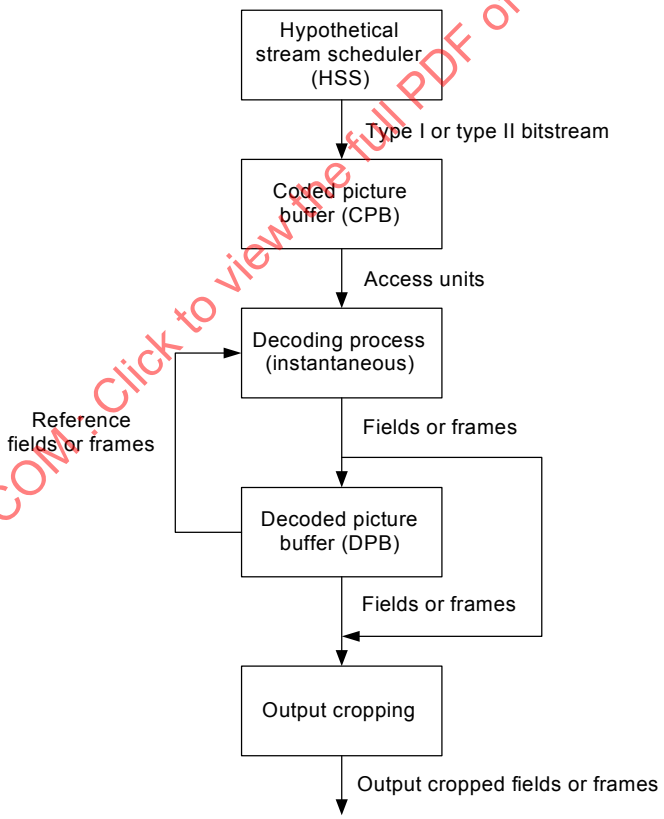


**Figure C-2 – HRD buffer model**

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The CPB size (number of bits) is CpbSize[ SchedSelIdx ]. The DPB size (number of frame buffers) is Max( 1, max_dec_frame_buffering ).

The HRD operates as follows. Data associated with access units that flow into the CPB according to a specified arrival schedule are delivered by the HSS. The data associated with each access unit are removed and decoded instantaneously by the instantaneous decoding process at CPB removal times. Each decoded picture is placed in the DPB at its CPB removal time unless it is output at its CPB removal time and is a non-reference picture. When a picture is placed in the DPB it is removed from the DPB at the later of the DPB output time or the time that it is marked as "unused for reference".

For each picture in the bitstream, the variable OutputFlag for the decoded picture and, when applicable, the reference base picture is set as follows.

– If the coded video sequence containing the picture conforms to one or more of the profiles specified in Annex A and the decoding process specified in clauses 2-9 is used), OutputFlag is set equal to 1.
– Otherwise (the coded video sequence containing the picture conforms to a profile specified in Annex G and the decoding process specified in Annex G is used), the following applies.
  – For a reference base picture, OutputFlag is set equal to 0.
  – For a decoded picture, OutputFlag is set equal to the value of the output_flag syntax element of the target layer representation.

The operation of the CPB is specified in subclause C.1. The instantaneous decoder operation is specified in clauses 8 and 9. The operation of the DPB is specified in subclause C.2. The output cropping is specified in subclause C.2.2.

HSS and HRD information concerning the number of enumerated delivery schedules and their associated bit rates and buffer sizes is specified in subclauses E.1.1, E.1.2, E.2.1 and E.2.2. The HRD is initialised as specified by the buffering period SEI message as specified in subclauses D.1.1 and D.2.1. The removal timing of access units from the CPB and output timing from the DPB are specified in the picture timing SEI message as specified in subclauses D.1.2 and D.2.2. All timing information relating to a specific access unit shall arrive prior to the CPB removal time of the access unit.

The HRD is used to check conformance of bitstreams and decoders as specified in subclauses C.3 and C.4, respectively.

> NOTE 3 – While conformance is guaranteed under the assumption that all frame-rates and clocks used to generate the bitstream match exactly the values signalled in the bitstream, in a real system each of these may vary from the signalled or specified value.

All the arithmetic in this annex is done with real values, so that no rounding errors can propagate. For example, the number of bits in a CPB just prior to or after removal of an access unit is not necessarily an integer.

The variable $t_c$ is derived as follows and is called a clock tick.

$$t_c = \text{num_units_in_tick} \div \text{time_scale} \qquad \text{(C-1)}$$

The following is specified for expressing the constraints in this Annex.

– Let access unit n be the n-th access unit in decoding order with the first access unit being access unit 0.
– Let picture n be the primary coded picture or the decoded primary picture of access unit n.

## C.1 Operation of coded picture buffer (CPB)

The specifications in this subclause apply independently to each set of CPB parameters that is present and to both the Type I and Type II conformance points shown in Figure C-1.

### C.1.1 Timing of bitstream arrival

The HRD may be initialised at any one of the buffering period SEI messages. Prior to initialisation, the CPB is empty.

> NOTE – After initialisation, the HRD is not initialised again by subsequent buffering period SEI messages.

Each access unit is referred to as access unit n, where the number n identifies the particular access unit. The access unit that is associated with the buffering period SEI message that initializes the CPB is referred to as access unit 0. The value of n is incremented by 1 for each subsequent access unit in decoding order.

The time at which the first bit of access unit n begins to enter the CPB is referred to as the initial arrival time $t_{ai}( n )$.

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The initial arrival time of access units is derived as follows.

– If the access unit is access unit 0, $t_{ai}( 0 ) = 0$,

– Otherwise (the access unit is access unit n with n > 0), the following applies.

  – If cbr_flag[ SchedSelIdx ] is equal to 1, the initial arrival time for access unit n, is equal to the final arrival time (which is derived below) of access unit n - 1, i.e.

$$t_{ai}( n ) = t_{af}( n - 1 ) \quad \text{(C-2)}$$

  – Otherwise (cbr_flag[ SchedSelIdx ] is equal to 0), the initial arrival time for access unit n is derived by

$$t_{ai}( n ) = \text{Max}( t_{af}( n - 1 ), t_{ai,earliest}( n ) ) \quad \text{(C-3)}$$

where $t_{ai,earliest}( n )$ is derived as follows

  – If access unit n is not the first access unit of a subsequent buffering period, $t_{ai,earliest}( n )$ is derived as

$$t_{ai,earliest}( n ) = t_{r,n}( n ) - ( \text{initial_cpb_removal_delay}[ \text{SchedSelIdx} ] + \text{initial_cpb_removal_delay_offset}[ \text{SchedSelIdx} ] ) \div 90000 \quad \text{(C-4)}$$

with $t_{r,n}( n )$ being the nominal removal time of access unit n from the CPB as specified in subclause C.1.2 and initial_cpb_removal_delay[ SchedSelIdx ] and initial_cpb_removal_delay_offset[ SchedSelIdx ] being specified in the previous buffering period SEI message.

  – Otherwise (access unit n is the first access unit of a subsequent buffering period), $t_{ai,earliest}( n )$ is derived as

$$t_{ai,earliest}( n ) = t_{r,n}( n ) - ( \text{initial_cpb_removal_delay}[ \text{SchedSelIdx} ] \div 90000 ) \quad \text{(C-5)}$$

with initial_cpb_removal_delay[ SchedSelIdx ] being specified in the buffering period SEI message associated with access unit n.

The final arrival time for access unit n is derived by

$$t_{af}( n ) = t_{ai}( n ) + b( n ) \div \text{BitRate}[ \text{SchedSelIdx} ] \quad \text{(C-6)}$$

where b( n ) is the size in bits of access unit n, counting the bits of the VCL NAL units and the filler data NAL units for the Type I conformance point or all bits of the Type II bitstream for the Type II conformance point, where the Type I and Type II conformance points are as shown in Figure C-1.

The values of SchedSelIdx, BitRate[ SchedSelIdx ], and CpbSize[ SchedSelIdx ] are constrained as follows.

– If the content of the active sequence parameter sets for access unit n and access unit n – 1 differ, the HSS selects a value SchedSelIdx1 of SchedSelIdx from among the values of SchedSelIdx provided in the active sequence parameter set for access unit n that results in a BitRate[ SchedSelIdx1 ] or CpbSize[ SchedSelIdx1 ] for access unit n. The value of BitRate[ SchedSelIdx1 ] or CpbSize[ SchedSelIdx1 ] may differ from the value of BitRate[ SchedSelIdx0 ] or CpbSize[ SchedSelIdx0 ] for the value SchedSelIdx0 of SchedSelIdx that was in use for access unit n - 1.

– Otherwise, the HSS continues to operate with the previous values of SchedSelIdx, BitRate[ SchedSelIdx ] and CpbSize[ SchedSelIdx ].

When the HSS selects values of BitRate[ SchedSelIdx ] or CpbSize[ SchedSelIdx ] that differ from those of the previous access unit, the following applies.

– the variable BitRate[ SchedSelIdx ] comes into effect at time $t_{ai}( n )$

– the variable CpbSize[ SchedSelIdx ] comes into effect as follows.

  – If the new value of CpbSize[ SchedSelIdx ] exceeds the old CPB size, it comes into effect at time $t_{ai}( n )$,

  – Otherwise, the new value of CpbSize[ SchedSelIdx ] comes into effect at the time $t_r( n )$.

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### C.1.2 Timing of coded picture removal

For access unit 0, the nominal removal time of the access unit from the CPB is specified by

$$t_{r,n}( 0 ) = \text{initial_cpb_removal_delay}[ \text{SchedSelIdx} ] \div 90000 \quad \text{(C-7)}$$

For the first access unit of a buffering period that does not initialise the HRD, the nominal removal time of the access unit from the CPB is specified by

$$t_{r,n}( n ) = t_{r,n}( n_b ) + t_c * \text{cpb_removal_delay}( n ) \quad \text{(C-8)}$$

where $t_{r,n}( n_b )$ is the nominal removal time of the first access unit of the previous buffering period and cpb_removal_delay( n ) is the value of cpb_removal_delay specified in the picture timing SEI message associated with access unit n.

When an access unit n is the first access unit of a buffering period, $n_b$ is set equal to n at the removal time of access unit n.

The nominal removal time $t_{r,n}(n)$ of an access unit n that is not the first access unit of a buffering period is given by

$$t_{r,n}( n ) = t_{r,n}( n_b ) + t_c * \text{cpb_removal_delay}( n ) \quad \text{(C-9)}$$

where $t_{r,n}( n_b )$ is the nominal removal time of the first access unit of the current buffering period and cpb_removal_delay( n ) is the value of cpb_removal_delay specified in the picture timing SEI message associated with access unit n.

The removal time of access unit n is specified as follows.

– If low_delay_hrd_flag is equal to 0 or $t_{r,n}( n ) >= t_{af}( n )$, the removal time of access unit n is specified by

$$t_r( n ) = t_{r,n}( n ) \quad \text{(C-10)}$$

– Otherwise (low_delay_hrd_flag is equal to 1 and $t_{r,n}( n ) < t_{af}( n )$), the removal time of access unit n is specified by

$$t_r( n ) = t_{r,n}( n ) + t_c * \text{Ceil}( ( t_{af}( n ) - t_{r,n}( n ) ) \div t_c ) \quad \text{(C-11)}$$

NOTE – The latter case indicates that the size of access unit n, b(n), is so large that it prevents removal at the nominal removal time.

## C.2 Operation of the decoded picture buffer (DPB)

The decoded picture buffer contains frame buffers. When decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, each of the frame buffers may contain a decoded frame, a decoded complementary field pair or a single (non-paired) decoded field that are marked as "used for reference" (reference pictures) or are held for future output (reordered or delayed pictures). When decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G, each frame buffer may contain a decoded frame, a decoded complementary field pair, a single (non-paired) decoded field, a decoded reference base frame, a decoded reference base complementary field pair or a single (non-paired) decoded reference base field that are marked as "used for reference" (reference pictures) or are held for future output (reordered or delayed pictures). Prior to initialisation, the DPB is empty (the DPB fullness is set to zero). The following steps of the subclauses of this subclause all happen instantaneously at $t_r( n )$ and in the sequence listed.

### C.2.1 Decoding of gaps in frame_num and storage of "non-existing" frames

If applicable, gaps in frame_num are detected by the decoding process and the generated frames are marked and inserted into the DPB as specified below.

Gaps in frame_num are detected by the decoding process and the generated frames are marked as specified in subclause 8.2.5.2.

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After the marking of each generated frame, each picture m marked by the “sliding window” process as “unused for reference” is removed from the DPB when it is also marked as "non-existing" or its DPB output time is less than or equal to the CPB removal time of the current picture n; i.e., $t_{o,dpb}( m ) <= t_r( n )$, or it has OutputFlag equal to 0. When a frame or the last field in a frame buffer is removed from the DPB, the DPB fullness is decremented by one. The “non-existing” generated frame is inserted into the DPB and the DPB fullness is incremented by one.

### C.2.2 Picture decoding and output

Picture n is decoded. When it has OutputFlag equal to 1, its DPB output time $t_{o,dpb}( n )$ is derived by

$$t_{o,dpb}( n ) = t_r( n ) + t_c * dpb_output_delay( n ) \quad \text{(C-12)}$$

The output of the current picture is specified as follows.

– If OutputFlag is equal to 1 and $t_{o,dpb}(n) = t_r(n)$, the current picture is output.
NOTE – When the current picture is a reference picture it will be stored in the DPB.

– Otherwise, if OutputFlag is equal to 0, the current picture is not output, but it may be stored in the DPB as specified in subclause C.2.4.

– Otherwise (OutputFlag is equal to 1 and $t_{o,dpb}(n) > t_r(n)$ ), the current picture is output later and will be stored in the DPB (as specified in subclause C.2.4) and is output at time $t_{o,dpb}(n)$ unless indicated not to be output by the decoding or inference of no_output_of_prior_pics_flag equal to 1 at a time that precedes $t_{o,dpb}(n)$.

When output, the picture shall be cropped, using the cropping rectangle specified in the active sequence parameter set for the picture.

When picture n is a picture that is output and is not the last picture of the bitstream that is output, the value of $\Delta t_{o,dpb}( n )$ is defined as:

$$\Delta t_{o,dpb}( n ) = t_{o,dpb}( n_n ) - t_{o,dpb}( n ) \quad \text{(C-13)}$$

where $n_n$ indicates the picture that follows after picture n in output order and has OutputFlag equal to 1.

The decoded picture is temporarily stored (not in the DPB).

### C.2.3 Removal of pictures from the DPB before possible insertion of the current picture

The removal of pictures from the DPB before possible insertion of the current picture proceeds as follows.

– If the decoded picture is an IDR picture the following applies.
  – All reference pictures in the DPB are marked as "unused for reference" as specified in subclause 8.2.5.1 when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, or as specified in subclause G.8.2.4when decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G.
  – When the IDR picture is not the first IDR picture decoded and the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering derived from the active sequence parameter set is different from the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering derived from the sequence parameter set that was active for the preceding picture, respectively, no_output_of_prior_pics_flag is inferred to be equal to 1 by the HRD, regardless of the actual value of no_output_of_prior_pics_flag.
    NOTE – Decoder implementations should try to handle frame or DPB size changes more gracefully than the HRD in regard to changes in PicWidthInMbs or FrameHeightInMbs.
  – When no_output_of_prior_pics_flag is equal to 1 or is inferred to be equal to 1, all frame buffers in the DPB are emptied without output of the pictures they contain, and DPB fullness is set to 0.

– Otherwise (the decoded picture is not an IDR picture), the following applies.
  – If the slice header of the current picture includes memory_management_control_operation equal to 5, all reference pictures in the DPB are marked as "unused for reference".

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– Otherwise (the slice header of the current picture does not include memory_management_control_operation equal to 5), the decoded reference picture marking process specified in subclause 8.2.5 is invoked when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, or the decoded reference picture marking process specified in subclause G.8.2.4 is invoked when decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G.

All pictures m in the DPB, for which all of the following conditions are true, are removed from the DPB.

– picture m is marked as “unused for reference” or picture m is a non-reference picture. When a picture is a reference frame, it is considered to be marked as "unused for reference" only when both of its fields have been marked as "unused for reference".

– picture m is marked as "non-existing" or it has OutputFlag equal to 0 or its DPB output time is less than or equal to the CPB removal time of the current picture n; i.e., $t_{o,dpb}( m ) <= t_r( n )$

When a frame or the last field in a frame buffer is removed from the DPB, the DPB fullness is decremented by one.

### C.2.4 Current decoded picture marking and storage

#### C.2.4.1 Marking and storage of a reference decoded picture into the DPB

When the current picture is a reference picture it is stored in the DPB as follows.

– If the current decoded picture is a second field (in decoding order) of a complementary reference field pair, and the first field of the pair is still in the DPB, the current decoded picture is stored in the same frame buffer as the first field of the pair.

– Otherwise, the current decoded picture is stored in an empty frame buffer, and the DPB fullness is incremented by one.

#### C.2.4.2 Storage of a non-reference picture into the DPB

When the current picture is a non-reference picture and current picture n has $t_{o,dpb}(n) > t_r(n)$, it is stored in the DPB as follows.

– If the current decoded picture is a second field (in decoding order) of a complementary non-reference field pair, and the first field of the pair is still in the DPB, the current decoded picture is stored in the same frame buffer as the first field of the pair.

– Otherwise, the current decoded picture is stored in an empty frame buffer, and the DPB fullness is incremented by one.

## C.3 Bitstream conformance

A bitstream of coded data conforming to this International Standard fulfils the following requirements.

The bitstream is constructed according to the syntax, semantics, and constraints specified in this International Standard outside of this Annex.

The bitstream is tested by the HRD as specified below:

For Type I bitstreams, the number of tests carried out is equal to cpb_cnt_minus1 + 1 where cpb_cnt_minus1 is either the syntax element of hrd_parameters( ) following the vcl_hrd_parameters_present_flag or is determined by the application by other means not specified in this International Standard. One test is carried out for each bit rate and CPB size combination specified by hrd_parameters( ) following the vcl_hrd_parameters_present_flag. Each of these tests is conducted at the Type I conformance point shown in Figure C-1.

For Type II bitstreams there are two sets of tests. The number of tests of the first set is equal to cpb_cnt_minus1 + 1 where cpb_cnt_minus1 is either the syntax element of hrd_parameters( ) following the vcl_hrd_parameters_present_flag or is determined by the application by other means not specified in this International Standard. One test is carried out for each bit rate and CPB size combination. Each of these tests is conducted at the Type I conformance point shown in Figure C-1. For these tests, only VCL and filler data NAL units are counted for the input bit rate and CPB storage.

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The number of tests of the second set, for Type II bitstreams, is equal to cpb_cnt_minus1 + 1 where cpb_cnt_minus1 is either the syntax element of hrd_parameters( ) following the nal_hrd_parameters_present_flag or is determined by the application by other means not specified in this International Standard. One test is carried out for each bit rate and CPB size combination specified by hrd_parameters( ) following the nal_hrd_parameters_present_flag. Each of these tests is conducted at the Type II conformance point shown in Figure C-1. For these tests, all NAL units (of a Type II NAL unit stream) or all bytes (of a byte stream) are counted for the input bit rate and CPB storage.

NOTE 1 – NAL HRD parameters established by a value of SchedSelIdx for the Type II conformance point shown in Figure C-1 are sufficient to also establish VCL HRD conformance for the Type I conformance point shown in Figure C-1 for the same values of initial_cpb_removal_delay[ SchedSelIdx ], BitRate[ SchedSelIdx ], and CpbSize[ SchedSelIdx ] for the VBR case (cbr_flag[ SchedSelIdx ] equal to 0). This is because the data flow into the Type I conformance point is a subset of the data flow into the Type II conformance point and because, for the VBR case, the CPB is allowed to become empty and stay empty until the time a next picture is scheduled to begin to arrive. For example, when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, when NAL HRD parameters are provided for the Type II conformance point that not only fall within the bounds set for NAL HRD parameters for profile conformance in item j of subclause A.3.1 or item i of subclause A.3.3 (depending on the profile in use) but also fall within the bounds set for VCL HRD parameters for profile conformance in item i of subclause A.3.1 or item h of subclause A.3.3 (depending on the profile in use), conformance of the VCL HRD for the Type I conformance point is also assured to fall within the bounds of item i of subclause A.3.1.

For conforming bitstreams, all of the following conditions shall be fulfilled for each of the tests.

– For each access unit n, with n>0, associated with a buffering period SEI message, with $\Delta t_{g,90}( n )$ specified by

$$\Delta t_{g,90}( n ) = 90000 * ( t_{r,n}( n ) - t_{af}( n - 1 ) ) \quad \text{(C-14)}$$

The value of initial_cpb_removal_delay[ SchedSelIdx ] shall be constrained as follows.

– If cbr_flag[ SchedSelIdx ] is equal to 0,

$$\text{initial_cpb_removal_delay[ SchedSelIdx ]} <= \text{Ceil}( \Delta t_{g,90}( n ) ) \quad \text{(C-15)}$$

– Otherwise (cbr_flag[ SchedSelIdx ] is equal to 1),

$$\text{Floor}( \Delta t_{g,90}( n ) ) <= \text{initial_cpb_removal_delay[ SchedSelIdx ]} <= \text{Ceil}( \Delta t_{g,90}( n ) ) \quad \text{(C-16)}$$

NOTE 2 – The exact number of bits in the CPB at the removal time of each picture may depend on which buffering period SEI message is selected to initialize the HRD. Encoders must take this into account to ensure that all specified constraints must be obeyed regardless of which buffering period SEI message is selected to initialize the HRD, as the HRD may be initialised at any one of the buffering period SEI messages.

– A CPB overflow is specified as the condition in which the total number of bits in the CPB is larger than the CPB size. The CPB shall never overflow.

– A CPB underflow is specified as the condition in which tr,n(n) is less than taf(n). When low_delay_hrd_flag is equal to 0, the CPB shall never underflow.

– The nominal removal times of pictures from the CPB (starting from the second picture in decoding order), shall satisfy the constraints on $t_{r,n}(n)$ and $t_r(n)$ expressed in subclauses A.3.1 through A.3.3 for the profile and level specified in the bitstream when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, and they shall satisfy the constraints on tr,n(n) and tr(n) expressed in subclauses G.10.2.1 and G.10.2.2 for profile and level specified in the bitstream when decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G.

– Immediately after any decoded picture is added to the DPB, the fullness of the DPB shall be less than or equal to the DPB size as constrained by Annexes A, D, and E for the profile and level specified in the bitstream.

– All reference pictures shall be present in the DPB when needed for prediction. Each picture shall be present in the DPB at its DPB output time unless it is not stored in the DPB at all, or is removed from the DPB before its output time by one of the processes specified in subclause C.2.

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– The value of $\Delta_{to,dpb}(n)$ as given by Equation C-13, which is the difference between the output time of a picture and that of the first picture following it in output order and having OutputFlag equal to 1, shall satisfy the constraint expressed in subclause A.3.1 for the profile and level specified in the bitstream when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, and it shall satisfy the constraint expressed in subclause G.10.2.1 for profile and level specified in the bitstream when decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G.

## C.4 Decoder conformance

A decoder conforming to this International Standard fulfils the following requirements.

A decoder claiming conformance to a specific profile and level shall be able to decode successfully all conforming bitstreams specified for decoder conformance in subclause C.3, provided that all sequence parameter sets and picture parameters sets referred to in the VCL NAL units, and appropriate buffering period and picture timing SEI messages are conveyed to the decoder, in a timely manner, either in the bitstream (by non-VCL NAL units), or by external means not specified by this International Standard.

There are two types of conformance that can be claimed by a decoder: output timing conformance and output order conformance.

To check conformance of a decoder, test bitstreams conforming to the claimed profile and level, as specified by subclause C.3 are delivered by a hypothetical stream scheduler (HSS) both to the HRD and to the decoder under test (DUT). All pictures output by the HRD shall also be output by the DUT and, for each picture output by the HRD, the values of all samples that are output by the DUT for the corresponding picture shall be equal to the values of the samples output by the HRD.

For output timing decoder conformance, the HSS operates as described above, with delivery schedules selected only from the subset of values of SchedSelIdx for which the bit rate and CPB size are restricted as specified in Annex A for the specified profile and level, or with "interpolated" delivery schedules as specified below for which the bit rate and CPB size are restricted as specified in Annex A. The same delivery schedule is used for both the HRD and DUT.

When the HRD parameters and the buffering period SEI messages are present with cpb_cnt_minus1 greater than 0, the decoder shall be capable of decoding the bitstream as delivered from the HSS operating using an "interpolated" delivery schedule specified as having peak bit rate r, CPB size c( r ), and initial CPB removal delay ( f( r ) ÷ r ) as follows

$$\alpha = ( r - BitRate[ SchedSelIdx - 1 ] ) \div ( BitRate[ SchedSelIdx ] - BitRate[ SchedSelIdx - 1 ] ), \quad \text{(C-17)}$$

$$c( r ) = \alpha * CpbSize[ SchedSelIdx ] + (1 - \alpha) * CpbSize[ SchedSelIdx-1 ], \quad \text{(C-18)}$$

$$f( r ) = \alpha * initial_cpb_removal_delay[ SchedSelIdx ] * BitRate[ SchedSelIdx ] + ( 1 - \alpha ) * initial_cpb_removal_delay[ SchedSelIdx - 1 ] * BitRate[ SchedSelIdx - 1 ] \quad \text{(C-19)}$$

for any SchedSelIdx > 0 and r such that BitRate[ SchedSelIdx - 1 ] <= r <= BitRate[ SchedSelIdx ] such that r and c( r ) are within the limits as specified in Annex A for the maximum bit rate and buffer size for the specified profile and level.

NOTE 1 – initial_cpb_removal_delay[ SchedSelIdx ] can be different from one buffering period to another and have to be re-calculated.

For output timing decoder conformance, an HRD as described above is used and the timing (relative to the delivery time of the first bit) of picture output is the same for both HRD and the DUT up to a fixed delay.

For output order decoder conformance, the HSS delivers the bitstream to the DUT "by demand" from the DUT, meaning that the HSS delivers bits (in decoding order) only when the DUT requires more bits to proceed with its processing.

NOTE 2 – This means that for this test, the coded picture buffer of the DUT could be as small as the size of the largest access unit.

A modified HRD as described below is used, and the HSS delivers the bitstream to the HRD by one of the schedules specified in the bitstream such that the bit rate and CPB size are restricted as specified in Annex A. The order of pictures output shall be the same for both HRD and the DUT.

For output order decoder conformance, the HRD CPB size is equal to CpbSize[ SchedSelIdx ] for the selected schedule and the DPB size is equal to MaxDpbSize. Removal time from the CPB for the HRD is equal to final bit arrival time and decoding is immediate. The operation of the DPB of this HRD is described below.

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### C.4.1 Operation of the output order DPB

The decoded picture buffer contains frame buffers. When decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, each of the frame buffers may contain a decoded frame, a decoded complementary field pair or a single (non-paired) decoded field that is marked as "used for reference" or is held for future output (reordered pictures). When decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G, each frame buffer may contain a decoded frame, a decoded complementary field pair, a single (non-paired) decoded field, a decoded reference base frame, a decoded reference base complementary field pair or a single (non-paired) decoded reference base field that are marked as "used for reference" (reference pictures) or are held for future output (reordered or delayed pictures). At HRD initialization, the DPB fullness, measured in frames, is set to 0. The following steps all happen instantaneously when an access unit is removed from the CPB, and in the order listed.

### C.4.2 Decoding of gaps in frame_num and storage of "non-existing" pictures

When applicable, gaps in frame_num are detected by the decoding process and the necessary number of "non-existing" frames are inferred in the order specified by the generation of values of UnusedShortTermFrameNum in Equation 7-22 and are marked as specified in subclause 8.2.5.2. Frame buffers containing a frame or a complementary field pair or a non-paired field which are marked as "not needed for output" and "unused for reference" are emptied (without output), and the DPB fullness is decremented by the number of frame buffers emptied. Each "non-existing" frame is stored in the DPB as follows.

- When there is no empty frame buffer (i.e., DPB fullness is equal to DPB size), the "bumping" process specified in subclause C.4.5.3 is invoked repeatedly until there is an empty frame buffer in which to store the "non-existing" frame.
- The "non-existing" frame is stored in an empty frame buffer and is marked as "not needed for output", and the DPB fullness is incremented by one.

### C.4.3 Picture decoding

Primary coded picture n is decoded and is temporarily stored (not in the DPB).

### C.4.4 Removal of pictures from the DPB before possible insertion of the current picture

The removal of pictures from the DPB before possible insertion of the current picture proceeds as follows.

- If the decoded picture is an IDR picture the following applies.
  - All reference pictures in the DPB are marked as "unused for reference" as specified in subclause 8.2.5 when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, or as specified in subclause G.8.2.4 when decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G.
  - When the IDR picture is not the first IDR picture decoded and the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering derived from the active sequence parameter set is different from the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering derived from the sequence parameter set that was active for the preceding picture, respectively, no_output_of_prior_pics_flag is inferred to be equal to 1 by the HRD, regardless of the actual value of no_output_of_prior_pics_flag.

    NOTE – Decoder implementations should try to handle changes in the value of PicWidthInMbs or FrameHeightInMbs or max_dec_frame_buffering more gracefully than the HRD.
  - When no_output_of_prior_pics_flag is equal to 1 or is inferred to be equal to 1, all frame buffers in the DPB are emptied without output of the pictures they contain, and DPB fullness is set to 0.
- Otherwise (the decoded picture is not an IDR picture), the decoded reference picture marking process is invoked as specified in subclause 8.2.5 when decoding a coded video sequence conforming to one or more of the profiles specified in Annex A using the decoding process specified in clauses 2-9, or as specified in subclause G.8.2.4 when decoding a coded video sequence conforming to one or more of the profiles specified in Annex G using the decoding process specified in Annex G. Frame buffers containing a frame or a complementary field pair or a non-paired field which are marked as "not needed for output" and "unused for reference" are emptied (without output), and the DPB fullness is decremented by the number of frame buffers emptied.

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When the current picture has a memory_management_control_operation equal to 5 or is an IDR picture for which no_output_of_prior_pics_flag is not equal to 1 and is not inferred to be equal to 1, the following two steps are performed.

1. Frame buffers containing a frame or a complementary field pair or a non-paired field which are marked as "not needed for output" and "unused for reference" are emptied (without output), and the DPB fullness is decremented by the number of frame buffers emptied.
2. All non-empty frame buffers in the DPB are emptied by repeatedly invoking the “bumping” process specified in subclause C.4.5.3, and the DPB fullness is set to 0.

### C.4.5 Current decoded picture marking and storage

#### C.4.5.1 Storage and marking of a reference decoded picture into the DPB

When the current picture is a reference picture, it is stored in the DPB as follows.

- If the current decoded picture is the second field (in decoding order) of a complementary reference field pair, and the first field of the pair is still in the DPB, the current picture is stored in the same frame buffer as the first field of the pair and the following applies.
  - If the current decoded picture has OutputFlag equal to 1, it is marked as "needed for output".
  - Otherwise (the current decoded picture has OutputFlag equal to 0), it is marked as "not needed for output".
- Otherwise, the following operations are performed:
  - When there is no empty frame buffer (i.e., DPB fullness is equal to DPB size), the "bumping" process specified in subclause C.4.5.3 is invoked repeatedly until there is an empty frame buffer in which to store the current decoded picture.
  - The current decoded picture is stored in an empty frame buffer, the DPB fullness is incremented by one, and the following applies.
    - If the current decoded picture has OutputFlag equal to 1, it is marked as “needed for output”.
    - Otherwise (the current decoded picture has OutputFlag equal to 0), it is marked as “not needed for output”.

#### C.4.5.2 Storage and marking of a non-reference decoded picture into the DPB

When the current picture is a non-reference picture, the following operations are performed.

- If the current decoded picture is the second field (in decoding order) of a complementary non-reference field pair and the first field of the pair is still in the DPB, the current picture is stored in the same frame buffer as the first field of the pair and the following applies.
  - If the current decoded picture has OutputFlag equal to 1, it is marked as "needed for output".
  - Otherwise (the current decoded picture has OutputFlag equal to 0), it is marked as "not needed for output".
- Otherwise, if the current picture has OutputFlag equal to 0, the DPB is not modified and the current picture is not output.
- Otherwise, the following operations are performed repeatedly until the current decoded picture has been cropped and output or has been stored in the DPB:
  - If there is no empty frame buffer (i.e., DPB fullness is equal to DPB size), the following applies.
    - If the current picture does not have a lower value of PicOrderCnt( ) than all pictures in the DPB that are marked as "needed for output", the "bumping" process described in subclause C.4.5.3 is performed.
    - Otherwise (the current picture has a lower value of PicOrderCnt( ) than all pictures in the DPB that are marked as "needed for output"), the current picture is cropped, using the cropping rectangle specified in the active sequence parameter set for the picture and the cropped picture is output.
  - Otherwise (there is an empty frame buffer, i.e., DPB fullness is less than DPB size) the current decoded picture is stored in an empty frame buffer and is marked as "needed for output", and the DPB fullness is incremented by one.

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### C.4.5.3 "Bumping" process

The "bumping" process is invoked in the following cases.

- There is no empty frame buffer (i.e., DPB fullness is equal to DPB size) and an empty frame buffer is needed for storage of an inferred "non-existing" frame, as specified in subclause C.4.2.
- The current picture is an IDR picture and no_output_of_prior_pics_flag is not equal to 1 and is not inferred to be equal to 1, as specified in subclause C.4.4.
- The current picture has memory_management_control_operation equal to 5, as specified in subclause C.4.4.
- There is no empty frame buffer (i.e., DPB fullness is equal to DPB size) and an empty frame buffer is needed for storage of a decoded (non-IDR) reference picture, as specified in subclause C.4.5.1.
- There is no empty frame buffer (i.e., DPB fullness is equal to DPB size) and the current picture is a non-reference picture that is not the second field of a complementary non-reference field pair and the current picture has OutputFlag equal to 1 and there are pictures in the DPB that are marked as "needed for output" that precede the current non-reference picture in output order, as specified in subclause C.4.5.2, so an empty buffer is needed for storage of the current picture.

The "bumping" process consists of the following:

- The picture or complementary reference field pair that is first for output is selected as follows.
  - The frame buffer is selected that contains the picture having the smallest value of PicOrderCnt( ) of all pictures in the DPB marked as "needed for output".
  - If this frame buffer contains a complementary non-reference field pair with both fields marked as "needed for output" and both fields have the same PicOrderCnt( ), the first of these two fields in decoding order is considered first for output.
  - Otherwise, if this frame buffer contains a complementary reference field pair with both fields marked as "needed for output" and both fields have the same PicOrderCnt( ), the entire complementary reference field pair is considered first for output.
  - Otherwise, the picture in this frame buffer that has the smallest value of PicOrderCnt( ) is considered first for output.
- If a single picture is considered first for output, this picture is cropped, using the cropping rectangle specified in the active sequence parameter set for the picture, the cropped picture is output, and the picture is marked as "not needed for output".
- Otherwise (a complementary reference field pair is considered first for output), the two fields of the complementary reference field pair are both cropped, using the cropping rectangle specified in the active sequence parameter set for the pictures, the two fields of the complementary reference field pair are output together, and both fields of the complementary reference field pair are marked as "not needed for output".
- The frame buffer that included the picture or complementary reference field pair that was cropped and output is checked, and when any of the following conditions is satisfied, the frame buffer is emptied and the DPB fullness is decremented by 1.
  - The frame buffer contains a non-reference non-paired field.
  - The frame buffer contains a non-reference frame.
  - The frame buffer contains a complementary non-reference field pair with both fields marked as "not needed for output".
  - The frame buffer contains a non-paired reference field marked as "unused for reference".
  - The frame buffer contains a reference frame with both fields marked as "unused for reference".
  - The frame buffer contains a complementary reference field pair with both fields marked as "unused for reference" and "not needed for output".

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# Annex D
# Supplemental enhancement information

(This annex forms an integral part of this International Standard)

This annex specifies syntax and semantics for SEI message payloads.

SEI messages assist in processes related to decoding, display or other purposes. However, SEI messages are not required for constructing the luma or chroma samples by the decoding process. Conforming decoders are not required to process this information for output order conformance to this International Standard (see Annex C for the specification of conformance). Some SEI message information is required to check bitstream conformance and for output timing decoder conformance.

In Annex D, specification for presence of SEI messages are also satisfied when those messages (or some subset of them) are conveyed to decoders (or to the HRD) by other means not specified by this International Standard. When present in the bitstream, SEI messages shall obey the syntax and semantics specified in subclauses 7.3.2.3 and 7.4.2.3 and this annex. When the content of an SEI message is conveyed for the application by some means other than presence within the bitstream, the representation of the content of the SEI message is not required to use the same syntax specified in this annex. For the purpose of counting bits, only the appropriate bits that are actually present in the bitstream are counted.

## D.1 SEI payload syntax

| sei_payload( payloadType, payloadSize ) { | C | Descriptor |
|---|---|---|
| if( payloadType == 0 ) | | |
| buffering_period( payloadSize ) | 5 | |
| else if( payloadType == 1 ) | | |
| pic_timing( payloadSize ) | 5 | |
| else if( payloadType == 2 ) | | |
| pan_scan_rect( payloadSize ) | 5 | |
| else if( payloadType == 3 ) | | |
| filler_payload( payloadSize ) | 5 | |
| else if( payloadType == 4 ) | | |
| user_data_registered_itu_t_t35( payloadSize ) | 5 | |
| else if( payloadType == 5 ) | | |
| user_data_unregistered( payloadSize ) | 5 | |
| else if( payloadType == 6 ) | | |
| recovery_point( payloadSize ) | 5 | |
| else if( payloadType == 7 ) | | |
| dec_ref_pic_marking_repetition( payloadSize ) | 5 | |
| else if( payloadType == 8 ) | | |
| spare_pic( payloadSize ) | 5 | |
| else if( payloadType == 9 ) | | |
| scene_info( payloadSize ) | 5 | |
| else if( payloadType == 10 ) | | |
| sub_seq_info( payloadSize ) | 5 | |
| else if( payloadType == 11 ) | | |
| sub_seq_layer_characteristics( payloadSize ) | 5 | |
| else if( payloadType == 12 ) | | |
| sub_seq_characteristics( payloadSize ) | 5 | |
| else if( payloadType == 13 ) | | |
| full_frame_freeze( payloadSize ) | 5 | |
| else if( payloadType == 14 ) | | |

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| | | |
|---|---|---|
| full_frame_freeze_release( payloadSize ) | 5 | |
| else if( payloadType == 15 ) | | |
| full_frame_snapshot( payloadSize ) | 5 | |
| else if( payloadType == 16 ) | | |
| progressive_refinement_segment_start( payloadSize ) | 5 | |
| else if( payloadType == 17 ) | | |
| progressive_refinement_segment_end( payloadSize ) | 5 | |
| else if( payloadType == 18 ) | | |
| motion_constrained_slice_group_set( payloadSize ) | 5 | |
| else if( payloadType == 19 ) | | |
| film_grain_characteristics( payloadSize ) | 5 | |
| else if( payloadType == 20 ) | | |
| deblocking_filter_display_preference( payloadSize ) | 5 | |
| else if( payloadType == 21 ) | | |
| stereo_video_info( payloadSize ) | 5 | |
| else if( payloadType == 22 ) | | |
| post_filter_hint( payloadSize ) | 5 | |
| else if( payloadType == 23 ) | | |
| tone_mapping_info( payloadSize ) | 5 | |
| else if( payloadType == 24 ) | | |
| scalability_info( payloadSize ) /* specified in Annex G */ | 5 | |
| else if( payloadType == 25 ) | | |
| sub_pic_scalable_layer( payloadSize ) /* specified in Annex G */ | 5 | |
| else if( payloadType == 26 ) | | |
| non_required_layer_rep( payloadSize ) /* specified in Annex G */ | 5 | |
| else if( payloadType == 27 ) | | |
| priority_layer_info( payloadSize ) /* specified in Annex G */ | 5 | |
| else if( payloadType == 28 ) | | |
| layers_not_present( payloadSize ) /* specified in Annex G */ | 5 | |
| else if( payloadType == 29 ) | | |
| layer_dependency_change( payloadSize ) /* specified in Annex G */ | 5 | |
| else if( payloadType == 30 ) | | |
| scalable_nesting( payloadSize ) /* specified in Annex G */ | 5 | |
| else if( payloadType == 31 ) | | |
| base_layer_temporal_hrd( payloadSize ) /* specified in Annex G */ | 5 | |
| else if( payloadType == 32 ) | | |
| quality_layer_integrity_check( payloadSize ) /* specified in Annex G */ | 5 | |
| else if( payloadType == 33 ) | | |
| redundant_pic_property( payloadSize ) /* specified in Annex G */ | 5 | |
| else if( payloadType == 34 ) | | |
| tl0_picture_index( payloadSize ) /* specified in Annex G */ | 5 | |
| else if( payloadType == 35 ) | | |
| tl_switching_point( payloadSize ) /* specified in Annex G */ | 5 | |
| else | | |
| reserved_sei_message( payloadSize ) | 5 | |
| if( !byte_aligned( ) ) { | | |
| **bit_equal_to_one** /* equal to 1 */ | 5 | f(1) |
| while( !byte_aligned( ) ) | | |
| **bit_equal_to_zero** /* equal to 0 */ | 5 | f(1) |
| } | | |
| } | | |

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### D.1.1 Buffering period SEI message syntax

| buffering_period( payloadSize ) { | C | Descriptor |
|---|---|---|
| **seq_parameter_set_id** | 5 | ue(v) |
| if( NalHrdBpPresentFlag ) { | | |
| for( SchedSelIdx = 0; SchedSelIdx <= cpb_cnt_minus1; SchedSelIdx++ ) { | | |
| **initial_cpb_removal_delay[** SchedSelIdx **]** | 5 | u(v) |
| **initial_cpb_removal_delay_offset[** SchedSelIdx **]** | 5 | u(v) |
| } | | |
| } | | |
| if( VclHrdBpPresentFlag ) { | | |
| for( SchedSelIdx = 0; SchedSelIdx <= cpb_cnt_minus1; SchedSelIdx++ ) { | | |
| **initial_cpb_removal_delay[** SchedSelIdx **]** | 5 | u(v) |
| **initial_cpb_removal_delay_offset[** SchedSelIdx **]** | 5 | u(v) |
| } | | |
| } | | |
| } | | |

### D.1.2 Picture timing SEI message syntax

| pic_timing( payloadSize ) { | C | Descriptor |
|---|---|---|
| if( CpbDpbDelaysPresentFlag ) { | | |
| **cpb_removal_delay** | 5 | u(v) |
| **dpb_output_delay** | 5 | u(v) |
| } | | |
| if( pic_struct_present_flag ) { | | |
| **pic_struct** | 5 | u(4) |
| for( i = 0; i < NumClockTS ; i++ ) { | | |
| **clock_timestamp_flag[ i ]** | 5 | u(1) |
| if( clock_timestamp_flag[i] ) { | | |
| **ct_type** | 5 | u(2) |
| **nuit_field_based_flag** | 5 | u(1) |
| **counting_type** | 5 | u(5) |
| **full_timestamp_flag** | 5 | u(1) |
| **discontinuity_flag** | 5 | u(1) |
| **cnt_dropped_flag** | 5 | u(1) |
| **n_frames** | 5 | u(8) |
| if( full_timestamp_flag ) { | | |
| **seconds_value** /* 0..59 */ | 5 | u(6) |
| **minutes_value** /* 0..59 */ | 5 | u(6) |
| **hours_value** /* 0..23 */ | 5 | u(5) |
| } else { | | |
| **seconds_flag** | 5 | u(1) |
| if( seconds_flag ) { | | |

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| | | |
|---|---|---|
| **seconds_value** /* range 0..59 */ | 5 | u(6) |
| **minutes_flag** | 5 | u(1) |
| if( minutes_flag ) { | | |
| **minutes_value** /* 0..59 */ | 5 | u(6) |
| **hours_flag** | 5 | u(1) |
| if( hours_flag ) | | |
| **hours_value** /* 0..23 */ | 5 | u(5) |
| } | | |
| } | | |
| } | | |
| if( time_offset_length > 0 ) | | |
| **time_offset** | 5 | i(v) |
| } | | |
| } | | |
| } | | |
| } | | |

### D.1.3 Pan-scan rectangle SEI message syntax

| pan_scan_rect( payloadSize ) { | C | Descriptor |
|---|---|---|
| **pan_scan_rect_id** | 5 | ue(v) |
| **pan_scan_rect_cancel_flag** | 5 | u(1) |
| if( !pan_scan_rect_cancel_flag ) { | | |
| **pan_scan_cnt_minus1** | 5 | ue(v) |
| for( i = 0; i <= pan_scan_cnt_minus1; i++ ) { | | |
| **pan_scan_rect_left_offset[** i **]** | 5 | se(v) |
| **pan_scan_rect_right_offset[** i **]** | 5 | se(v) |
| **pan_scan_rect_top_offset[** i **]** | 5 | se(v) |
| **pan_scan_rect_bottom_offset[** i **]** | 5 | se(v) |
| } | | |
| **pan_scan_rect_repetition_period** | 5 | ue(v) |
| } | | |
| } | | |

### D.1.4 Filler payload SEI message syntax

| filler_payload( payloadSize ) { | C | Descriptor |
|---|---|---|
| for( k = 0; k < payloadSize; k++) | | |
| **ff_byte** /* equal to 0xFF */ | 5 | f(8) |
| } | | |

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### D.1.5 User data registered by ITU-T Rec. T.35 SEI message syntax

| user_data_registered_itu_t_t35( payloadSize ) { | C | Descriptor |
|---|---|---|
| **itu_t_t35_country_code** | 5 | b(8) |
| if( itu_t_t35_country_code != 0xFF ) | | |
| i = 1 | | |
| else { | | |
| **itu_t_t35_country_code_extension_byte** | 5 | b(8) |
| i = 2 | | |
| } | | |
| do { | | |
| **itu_t_t35_payload_byte** | 5 | b(8) |
| i++ | | |
| } while( i < payloadSize ) | | |
| } | | |

### D.1.6 User data unregistered SEI message syntax

| user_data_unregistered( payloadSize ) { | C | Descriptor |
|---|---|---|
| **uuid_iso_iec_11578** | **5** | u(128) |
| for( i = 16; i < payloadSize; i++ ) | | |
| **user_data_payload_byte** | 5 | b(8) |
| } | | |

### D.1.7 Recovery point SEI message syntax

| recovery_point( payloadSize ) { | C | Descriptor |
|---|---|---|
| **recovery_frame_cnt** | 5 | ue(v) |
| **exact_match_flag** | 5 | u(1) |
| **broken_link_flag** | 5 | u(1) |
| **changing_slice_group_idc** | 5 | u(2) |
| } | | |

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### D.1.8 Decoded reference picture marking repetition SEI message syntax

| dec_ref_pic_marking_repetition( payloadSize ) { | C | Descriptor |
|---|---|---|
| **original_idr_flag** | 5 | u(1) |
| **original_frame_num** | 5 | ue(v) |
| if( !frame_mbs_only_flag ) { | | |
| **original_field_pic_flag** | 5 | u(1) |
| if( original_field_pic_flag ) | | |
| **original_bottom_field_flag** | 5 | u(1) |
| } | | |
| dec_ref_pic_marking( ) | 5 | |
| } | | |

### D.1.9 Spare picture SEI message syntax

| spare_pic( payloadSize ) { | C | Descriptor |
|---|---|---|
| **target_frame_num** | 5 | ue(v) |
| **spare_field_flag** | 5 | u(1) |
| if( spare_field_flag ) | | |
| **target_bottom_field_flag** | 5 | u(1) |
| **num_spare_pics_minus1** | 5 | ue(v) |
| for( i = 0; i < num_spare_pics_minus1 + 1; i++ ) { | | |
| **delta_spare_frame_num[** i **]** | 5 | ue(v) |
| if( spare_field_flag ) | | |
| **spare_bottom_field_flag[** i **]** | 5 | u(1) |
| **spare_area_idc[** i **]** | 5 | ue(v) |
| if( spare_area_idc[ i ] == 1 ) | | |
| for( j = 0; j < PicSizeInMapUnits; j++ ) | | |
| **spare_unit_flag[** i **][** j **]** | 5 | u(1) |
| else if( spare_area_idc[ i ] == 2 ) { | | |
| mapUnitCnt = 0 | | |
| for( j=0; mapUnitCnt < PicSizeInMapUnits; j++ ) { | | |
| **zero_run_length[** i **][** j **]** | 5 | ue(v) |
| mapUnitCnt += zero_run_length[ i ][ j ] + 1 | | |
| } | | |
| } | | |
| } | | |
| } | | |

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### D.1.10 Scene information SEI message syntax

| scene_info( payloadSize ) { | C | Descriptor |
|---|---|---|
| **scene_info_present_flag** | 5 | u(1) |
| if( scene_info_present_flag ) { | | |
| **scene_id** | 5 | ue(v) |
| **scene_transition_type** | 5 | ue(v) |
| if( scene_transition_type > 3 ) | | |
| **second_scene_id** | 5 | ue(v) |
| } | | |
| } | | |

### D.1.11 Sub-sequence information SEI message syntax

| sub_seq_info( payloadSize ) { | C | Descriptor |
|---|---|---|
| **sub_seq_layer_num** | 5 | ue(v) |
| **sub_seq_id** | 5 | ue(v) |
| **first_ref_pic_flag** | 5 | u(1) |
| **leading_non_ref_pic_flag** | 5 | u(1) |
| **last_pic_flag** | 5 | u(1) |
| **sub_seq_frame_num_flag** | 5 | u(1) |
| if( sub_seq_frame_num_flag ) | | |
| **sub_seq_frame_num** | 5 | ue(v) |
| } | | |

### D.1.12 Sub-sequence layer characteristics SEI message syntax

| sub_seq_layer_characteristics( payloadSize ) { | C | Descriptor |
|---|---|---|
| **num_sub_seq_layers_minus1** | 5 | ue(v) |
| for( layer = 0; layer <= num_sub_seq_layers_minus1; layer++ ) { | | |
| **accurate_statistics_flag** | 5 | u(1) |
| **average_bit_rate** | 5 | u(16) |
| **average_frame_rate** | 5 | u(16) |
| } | | |
| } | | |

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### D.1.13 Sub-sequence characteristics SEI message syntax

| sub_seq_characteristics( payloadSize ) { | C | Descriptor |
|---|---|---|
| **sub_seq_layer_num** | 5 | ue(v) |
| **sub_seq_id** | 5 | ue(v) |
| **duration_flag** | 5 | u(1) |
| if( duration_flag) | | |
| **sub_seq_duration** | 5 | u(32) |
| **average_rate_flag** | 5 | u(1) |
| if( average_rate_flag ) { | | |
| **accurate_statistics_flag** | 5 | u(1) |
| **average_bit_rate** | 5 | u(16) |
| **average_frame_rate** | 5 | u(16) |
| } | | |
| **num_referenced_subseqs** | 5 | ue(v) |
| for( n = 0; n < num_referenced_subseqs; n++ ) { | | |
| **ref_sub_seq_layer_num** | 5 | ue(v) |
| **ref_sub_seq_id** | 5 | ue(v) |
| **ref_sub_seq_direction** | 5 | u(1) |
| } | | |
| } | | |

### D.1.14 Full-frame freeze SEI message syntax

| full_frame_freeze( payloadSize ) { | C | Descriptor |
|---|---|---|
| **full_frame_freeze_repetition_period** | 5 | ue(v) |
| } | | |

### D.1.15 Full-frame freeze release SEI message syntax

| full_frame_freeze_release( payloadSize ) { | C | Descriptor |
|---|---|---|
| } | | |

### D.1.16 Full-frame snapshot SEI message syntax

| full_frame_snapshot( payloadSize ) { | C | Descriptor |
|---|---|---|
| **snapshot_id** | 5 | ue(v) |
| } | | |

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### D.1.17 Progressive refinement segment start SEI message syntax

| progressive_refinement_segment_start( payloadSize ) { | C | Descriptor |
|---|---|---|
| **progressive_refinement_id** | 5 | ue(v) |
| **num_refinement_steps_minus1** | 5 | ue(v) |
| } | | |

### D.1.18 Progressive refinement segment end SEI message syntax

| progressive_refinement_segment_end( payloadSize ) { | C | Descriptor |
|---|---|---|
| **progressive_refinement_id** | 5 | ue(v) |
| } | | |

### D.1.19 Motion-constrained slice group set SEI message syntax

| motion_constrained_slice_group_set( payloadSize ) { | C | Descriptor |
|---|---|---|
| **num_slice_groups_in_set_minus1** | 5 | ue(v) |
| for( i = 0; i <= num_slice_groups_in_set_minus1; i++) | | |
| **slice_group_id[** i **]** | 5 | u(v) |
| **exact_sample_value_match_flag** | 5 | u(1) |
| **pan_scan_rect_flag** | 5 | u(1) |
| if( pan_scan_rect_flag ) | | |
| **pan_scan_rect_id** | 5 | ue(v) |
| } | | |

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### D.1.20 Film grain characteristics SEI message syntax

| film_grain_characteristics( payloadSize ) { | C | Descriptor |
|---|---|---|
| **film_grain_characteristics_cancel_flag** | 5 | u(1) |
| if( !film_grain_**characteristics**_cancel_flag ) { | | |
| **model_id** | 5 | u(2) |
| **separate_colour_description_present_flag** | 5 | u(1) |
| if( separate_colour_description_present_flag ) { | | |
| **film_grain_bit_depth_luma_minus8** | 5 | u(3) |
| **film_grain_bit_depth_chroma_minus8** | 5 | u(3) |
| **film_grain_full_range_flag** | 5 | u(1) |
| **film_grain_colour_primaries** | 5 | u(8) |
| **film_grain_transfer_characteristics** | 5 | u(8) |
| **film_grain_matrix_coefficients** | 5 | u(8) |
| } | | |
| **blending_mode_id** | 5 | u(2) |
| **log2_scale_factor** | 5 | u(4) |
| for( c = 0; c < 3; c++ ) | | |
| **comp_model_present_flag**[ c ] | 5 | u(1) |
| for( c = 0; c < 3; c++ ) | | |
| if( comp_model_present_flag[ c ] ) { | | |
| **num_intensity_intervals_minus1[** c **]** | 5 | u(8) |
| **num_model_values_minus1[** c **]** | 5 | u(3) |
| for( i = 0; i <= num_intensity_intervals_minus1[ c ]; i++ ) { | | |
| **intensity_interval_lower_bound[** c **][** i **]** | 5 | u(8) |
| **intensity_interval_upper_bound[** c **][** i **]** | 5 | u(8) |
| for( j = 0; j <= num_model_values_minus1[ c ]; j++ ) | | |
| **comp_model_value[** c **][** i **][** j **]** | 5 | se(v) |
| } | | |
| } | | |
| **film_grain_characteristics_repetition_period** | 5 | ue(v) |
| } | | |
| } | | |

### D.1.21 Deblocking filter display preference SEI message syntax

| deblocking_filter_display_preference( payloadSize ) { | C | Descriptor |
|---|---|---|
| **deblocking_display_preference_cancel_flag** | 5 | u(1) |
| if( !deblocking_display_preference_cancel_flag ) { | | |
| **display_prior_to_deblocking_preferred_flag** | 5 | u(1) |
| **dec_frame_buffering_constraint_flag** | 5 | u(1) |
| **deblocking_display_preference_repetition_period** | 5 | ue(v) |
| } | | |
| } | | |

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### D.1.22 Stereo video information SEI message syntax

| stereo_video_info( payloadSize ) { | C | Descriptor |
|---|---|---|
| **field_views_flag** | 5 | u(1) |
| if( field_views_flag ) | | |
| **top_field_is_left_view_flag** | 5 | u(1) |
| else { | | |
| **current_frame_is_left_view_flag** | 5 | u(1) |
| **next_frame_is_second_view_flag** | 5 | u(1) |
| } | | |
| **left_view_self_contained_flag** | 5 | u(1) |
| **right_view_self_contained_flag** | 5 | u(1) |
| } | | |

### D.1.23 Post-filter hint SEI message syntax

| post_filter_hint( payloadSize ) { | C | Descriptor |
|---|---|---|
| **filter_hint_size_y** | 5 | ue(v) |
| **filter_hint_size_x** | 5 | ue(v) |
| **filter_hint_type** | 5 | u(2) |
| for( colour_component = 0; colour_component < 3; colour_component ++ ) | | |
| for( cy = 0; cy < filter_hint_size_y; cy ++ ) | | |
| for( cx = 0; cx < filter_hint_size_x; cx ++ ) | | |
| **filter_hint[** colour_component **][** cy **][** cx **]** | 5 | se(v) |
| **additional_extension_flag** | 5 | u(1) |
| } | | |

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### D.1.24 Tone mapping information SEI message syntax

| tone_mapping_info( payloadSize ) { | C | Descriptor |
|---|---|---|
| **tone_map_id** | 5 | ue(v) |
| **tone_map_cancel_flag** | 5 | u(1) |
| if( !tone_map_cancel_flag ) { | | |
| **tone_map_repetition_period** | 5 | ue(v) |
| **coded_data_bit_depth** | 5 | u(8) |
| **target_bit_depth** | 5 | u(8) |
| **model_id** | 5 | ue(v) |
| if( model_id == 0 ) { | | |
| **min_value** | 5 | u(32) |
| **max_value** | 5 | u(32) |
| } | | |
| if( model_id == 1 ) { | | |
| **sigmoid_midpoint** | 5 | u(32) |
| **sigmoid_width** | 5 | u(32) |
| } | | |
| if( model_id == 2 ) | | |
| for( i = 0; i < ( 1 << target_bit_depth ); i++ ) | | |
| **start_of_coded_interval**[ i ] | 5 | u(v) |
| if( model_id == 3 ) { | | |
| **num_pivots** | 5 | u(16) |
| for( i=0; i < num_pivots; i++ ) { | | |
| **coded_pivot_value**[ i ] | 5 | u(v) |
| **target_pivot_value**[ i ] | 5 | u(v) |
| } | | |
| } | | |
| } | | |
| } | | |

### D.1.25 Reserved SEI message syntax

| reserved_sei_message( payloadSize ) { | C | Descriptor |
|---|---|---|
| for( i = 0; i < payloadSize; i++ ) | | |
| **reserved_sei_message_payload_byte** | 5 | b(8) |
| } | | |

## D.2 SEI payload semantics

### D.2.1 Buffering period SEI message semantics

When NalHrdBpPresentFlag or VclHrdBpPresentFlag are equal to 1, a buffering period SEI message can be associated with any access unit in the bitstream, and a buffering period SEI message shall be associated with each IDR access unit and with each access unit associated with a recovery point SEI message.

NOTE – For some applications, the frequent presence of a buffering period SEI message may be desirable.

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A buffering period is specified as the set of access units between two instances of the buffering period SEI message in decoding order.

**seq_parameter_set_id** specifies the sequence parameter set that contains the sequence HRD attributes. The value of seq_parameter_set_id shall be equal to the value of seq_parameter_set_id in the picture parameter set referenced by the primary coded picture associated with the buffering period SEI message. The value of seq_parameter_set_id shall be in the range of 0 to 31, inclusive.

**initial_cpb_removal_delay**[ SchedSelIdx ] specifies the delay for the SchedSelIdx-th CPB between the time of arrival in the CPB of the first bit of the coded data associated with the access unit associated with the buffering period SEI message and the time of removal from the CPB of the coded data associated with the same access unit, for the first buffering period after HRD initialisation. The syntax element has a length in bits given by initial_cpb_removal_delay_length_minus1 + 1. It is in units of a 90 kHz clock. initial_cpb_removal_delay[ SchedSelIdx ] shall not be equal to 0 and shall not exceed 90000 * ( CpbSize[ SchedSelIdx ] ÷ BitRate[ SchedSelIdx ] ), the time-equivalent of the CPB size in 90 kHz clock units.

**initial_cpb_removal_delay_offset**[ SchedSelIdx ] is used for the SchedSelIdx-th CPB in combination with the cpb_removal_delay to specify the initial delivery time of coded access units to the CPB. initial_cpb_removal_delay_offset[ SchedSelIdx ] is in units of a 90 kHz clock. The initial_cpb_removal_delay_offset[ SchedSelIdx ] syntax element is a fixed length code whose length in bits is given by initial_cpb_removal_delay_length_minus1 + 1. This syntax element is not used by decoders and is needed only for the delivery scheduler (HSS) specified in Annex C.

Over the entire coded video sequence, the sum of initial_cpb_removal_delay[ SchedSelIdx ] and initial_cpb_removal_delay_offset[ SchedSelIdx ] shall be constant for each value of SchedSelIdx.

### D.2.2 Picture timing SEI message semantics

The presence of picture timing SEI message in the bitstream is specified as follows.

– If CpbDpbDelaysPresentFlag is equal to 1 or pic_struct_present_flag is equal to 1, one picture timing SEI message shall be present in every access unit of the coded video sequence.

– Otherwise (CpbDpbDelaysPresentFlag is equal to 0 and pic_struct_present_flag is equal to 0), no picture timing SEI messages shall be present in any access unit of the coded video sequence.

**cpb_removal_delay** specifies how many clock ticks (see subclause E.2.1) to wait after removal from the CPB of the access unit associated with the most recent buffering period SEI message before removing from the buffer the access unit data associated with the picture timing SEI message. This value is also used to calculate an earliest possible time of arrival of access unit data into the CPB for the HSS, as specified in Annex C. The syntax element is a fixed length code whose length in bits is given by cpb_removal_delay_length_minus1 + 1. The cpb_removal_delay is the remainder of a $2^{(\text{cpb_removal_delay_length_minus1} + 1)}$ counter.

The value of cpb_removal_delay for the first picture in the bitstream shall be equal to 0.

**dpb_output_delay** is used to compute the DPB output time of the picture. It specifies how many clock ticks to wait after removal of an access unit from the CPB before the decoded picture can be output from the DPB (see subclause C.2).

NOTE 1 – A picture is not removed from the DPB at its output time when it is still marked as "used for short-term reference" or "used for long-term reference".

NOTE 2 – Only one dpb_output_delay is specified for a decoded picture.

The size of the syntax element dpb_output_delay is given in bits by dpb_output_delay_length_minus1 + 1. When max_dec_frame_buffering is equal to 0, dpb_output_delay shall be equal to 0.

The output time derived from the dpb_output_delay of any picture that is output from an output timing conforming decoder as specified in subclause C.2 shall precede the output time derived from the dpb_output_delay of all pictures in any subsequent coded video sequence in decoding order.

The output time derived from the dpb_output_delay of the second field, in decoding order, of a complementary non-reference field pair shall exceed the output time derived from the dpb_output_delay of the first field of the same complementary non-reference field pair.

The picture output order established by the values of this syntax element shall be the same order as established by the values of PicOrderCnt( ) as specified by subclauses C.4.1 to C.4.5, except that when the two fields of a complementary reference field pair have the same value of PicOrderCnt( ), the two fields have different output times.

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For pictures that are not output by the "bumping" process of subclause C.4.5 because they precede, in decoding order, an IDR picture with no_output_of_prior_pics_flag equal to 1 or inferred to be equal to 1, the output times derived from dpb_output_delay shall be increasing with increasing value of PicOrderCnt( ) relative to all pictures within the same coded video sequence subsequent to any picture having a memory_management_control_operation equal to 5.

**pic_struct** indicates whether a picture should be displayed as a frame or one or more fields, according to Table D-1. Frame doubling (pic_struct equal to 7) indicates that the frame should be displayed two times consecutively, and frame tripling (pic_struct equal to 8) indicates that the frame should be displayed three times consecutively.

NOTE 3 – Frame doubling can facilitate the display, for example, of 25p video on a 50p display and 29.97p video on a 59.94p display. Using frame doubling and frame tripling in combination on every other frame can facilitate the display of 23.98p video on a 59.94p display.

**Table D-1 – Interpretation of pic_struct**

| **Value** | Indicated display of picture | **Restrictions** | **NumClockTS** |
|---|---|---|---|
| 0 | frame | field_pic_flag shall be 0 | 1 |
| 1 | top field | field_pic_flag shall be 1,<br>bottom_field_flag shall be 0 | 1 |
| 2 | bottom field | field_pic_flag shall be 1,<br>bottom_field_flag shall be 1 | 1 |
| 3 | top field, bottom field, in that order | field_pic_flag shall be 0 | 2 |
| 4 | bottom field, top field, in that order | field_pic_flag shall be 0 | 2 |
| 5 | top field, bottom field, top field repeated, in that order | field_pic_flag shall be 0 | 3 |
| 6 | bottom field, top field, bottom field repeated, in that order | field_pic_flag shall be 0 | 3 |
| 7 | frame doubling | field_pic_flag shall be 0<br>fixed_frame_rate_flag shall be 1 | 2 |
| 8 | frame tripling | field_pic_flag shall be 0<br>fixed_frame_rate_flag shall be 1 | 3 |
| 9..15 | reserved | | |

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NumClockTS is determined by pic_struct as specified in Table D-1. There are up to NumClockTS sets of clock timestamp information for a picture, as specified by clock_timestamp_flag[ i ] for each set. The sets of clock timestamp information apply to the field(s) or the frame(s) associated with the picture by pic_struct.

The contents of the clock timestamp syntax elements indicate a time of origin, capture, or alternative ideal display. This indicated time is computed as

$$\begin{aligned} \text{clockTimestamp} = &( ( \text{hH} * 60 + \text{mM} ) * 60 + \text{sS} ) * \text{time_scale} + \\ &\text{nFrames} * ( \text{num_units_in_tick} * ( 1 + \text{nuit_field_based_flag} ) ) + \text{tOffset}, \end{aligned} \tag{D-1}$$

in units of clock ticks of a clock with clock frequency equal to time_scale Hz, relative to some unspecified point in time for which clockTimestamp is equal to 0. Output order and DPB output timing are not affected by the value of clockTimestamp. When two or more frames with pic_struct equal to 0 are consecutive in output order and have equal values of clockTimestamp, the indication is that the frames represent the same content and that the last such frame in output order is the preferred representation.

NOTE 4 – clockTimestamp time indications may aid display on devices with refresh rates other than those well-matched to DPB output times.

**clock_timestamp_flag[** i **]** equal to 1 indicates that a number of clock timestamp syntax elements are present and follow immediately. clock_timestamp_flag[ i ] equal to 0 indicates that the associated clock timestamp syntax elements are not

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present. When NumClockTS is greater than 1 and clock_timestamp_flag[ i ] is equal to 1 for more than one value of i, the value of clockTimestamp shall be non-decreasing with increasing value of i.

**ct_type** indicates the scan type (interlaced or progressive) of the source material as specified in Table D-2.

Two fields of a coded frame may have different values of ct_type.

When clockTimestamp is equal for two fields of opposite parity that are consecutive in output order, both with ct_type equal to 0 (progressive) or ct_type equal to 2 (unknown), the two fields are indicated to have come from the same original progressive frame. Two consecutive fields in output order shall have different values of clockTimestamp when the value of ct_type for either field is 1 (interlaced).

**Table D-2 – Mapping of ct_type to source picture scan**

| Value | Original picture scan |
|---|---|
| 0 | progressive |
| 1 | interlaced |
| 2 | unknown |
| 3 | reserved |

**nuit_field_based_flag** is used in calculating clockTimestamp, as specified in Equation D-1.

**counting_type** specifies the method of dropping values of the n_frames as specified in Table D-3.

**Table D-3 – Definition of counting_type values**

| Value | Interpretation |
|---|---|
| 0 | no dropping of n_frames count values and no use of time_offset |
| 1 | no dropping of n_frames count values |
| 2 | dropping of individual zero values of n_frames count |
| 3 | dropping of individual MaxFPS-1 values of n_frames count |
| 4 | dropping of the two lowest (value 0 and 1) n_frames counts when seconds_value is equal to 0 and minutes_value is not an integer multiple of 10 |
| 5 | dropping of unspecified individual n_frames count values |
| 6 | dropping of unspecified numbers of unspecified n_frames count values |
| 7..31 | reserved |

**full_timestamp_flag** equal to 1 specifies that the n_frames syntax element is followed by seconds_value, minutes_value, and hours_value. full_timestamp_flag equal to 0 specifies that the n_frames syntax element is followed by seconds_flag.

**discontinuity_flag** equal to 0 indicates that the difference between the current value of clockTimestamp and the value of clockTimestamp computed from the previous clock timestamp in output order can be interpreted as the time difference between the times of origin or capture of the associated frames or fields. discontinuity_flag equal to 1 indicates that the difference between the current value of clockTimestamp and the value of clockTimestamp computed from the previous clock timestamp in output order should not be interpreted as the time difference between the times of origin or capture of the associated frames or fields. When discontinuity_flag is equal to 0, the value of clockTimestamp shall be greater than or equal to all values of clockTimestamp present for the preceding picture in DPB output order.

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**cnt_dropped_flag** specifies the skipping of one or more values of n_frames using the counting method specified by counting_type.

**n_frames** specifies the value of nFrames used to compute clockTimestamp. n_frames shall be less than

$$MaxFPS = Ceil( time_scale \div num_units_in_tick ) \quad (D\text{-}2)$$

NOTE 5 – n_frames is a frame-based counter. For field-specific timing indications, time_offset should be used to indicate a distinct clockTimestamp for each field.

When counting_type is equal to 2 and cnt_dropped_flag is equal to 1, n_frames shall be equal to 1 and the value of n_frames for the previous picture in output order shall not be equal to 0 unless discontinuity_flag is equal to 1.

NOTE 6 – When counting_type is equal to 2, the need for increasingly large magnitudes of tOffset in Equation D-1 when using fixed non-integer frame rates (e.g., 12.5 frames per second with time_scale equal to 25 and num_units_in_tick equal to 2 and nuit_field_based_flag equal to 0) can be avoided by occasionally skipping over the value n_frames equal to 0 when counting (e.g., counting n_frames from 0 to 12, then incrementing seconds_value and counting n_frames from 1 to 12, then incrementing seconds_value and counting n_frames from 0 to 12, etc.).

When counting_type is equal to 3 and cnt_dropped_flag is equal to 1, n_frames shall be equal to 0 and the value of n_frames for the previous picture in output order shall not be equal to MaxFPS – 1 unless discontinuity_flag is equal to 1.

NOTE 7 – When counting_type is equal to 3, the need for increasingly large magnitudes of tOffset in Equation D-1 when using fixed non-integer frame rates (e.g., 12.5 frames per second with time_scale equal to 25 and num_units_in_tick equal to 2 and nuit_field_based_flag equal to 0) can be avoided by occasionally skipping over the value n_frames equal to MaxFPS when counting (e.g., counting n_frames from 0 to 12, then incrementing seconds_value and counting n_frames from 0 to 11, then incrementing seconds_value and counting n_frames from 0 to 12, etc.).

When counting_type is equal to 4 and cnt_dropped_flag is equal to 1, n_frames shall be equal to 2 and the specified value of sS shall be zero and the specified value of mM shall not be an integer multiple of ten and n_frames for the previous picture in output order shall not be equal to 0 or 1 unless discontinuity_flag is equal to 1.

NOTE 8 – When counting_type is equal to 4, the need for increasingly large magnitudes of tOffset in Equation D-1 when using fixed non-integer frame rates (e.g., 30000÷1001 frames per second with time_scale equal to 60000 and num_units_in_tick equal to 1 001 and nuit_field_based_flag equal to 1) can be reduced by occasionally skipping over the value n_frames equal to MaxFPS when counting (e.g., counting n_frames from 0 to 29, then incrementing seconds_value and counting n_frames from 0 to 29, etc., until the seconds_value is zero and minutes_value is not an integer multiple of ten, then counting n_frames from 2 to 29, then incrementing seconds_value and counting n_frames from 0 to 29, etc.). This counting method is well known in industry and is often referred to as "NTSC drop-frame" counting.

When counting_type is equal to 5 or 6 and cnt_dropped_flag is equal to 1, n_frames shall not be equal to 1 plus the value of n_frames for the previous picture in output order modulo MaxFPS unless discontinuity_flag is equal to 1.

NOTE 9 – When counting_type is equal to 5 or 6, the need for increasingly large magnitudes of tOffset in Equation D-1 when using fixed non-integer frame rates can be avoided by occasionally skipping over some values of n_frames when counting. The specific values of n_frames that are skipped are not specified when counting_type is equal to 5 or 6.

**seconds_flag** equal to 1 specifies that seconds_value and minutes_flag are present when full_timestamp_flag is equal to 0. seconds_flag equal to 0 specifies that seconds_value and minutes_flag are not present.

**seconds_value** specifies the value of sS used to compute clockTimestamp. The value of seconds_value shall be in the range of 0 to 59, inclusive. When seconds_value is not present, the previous seconds_value in decoding order shall be used as sS to compute clockTimestamp.

**minutes_flag** equal to 1 specifies that minutes_value and hours_flag are present when full_timestamp_flag is equal to 0 and seconds_flag is equal to 1. minutes_flag equal to 0 specifies that minutes_value and hours_flag are not present.

**minutes_value** specifies the value of mM used to compute clockTimestamp. The value of minutes_value shall be in the range of 0 to 59, inclusive. When minutes_value is not present, the previous minutes_value in decoding order shall be used as mM to compute clockTimestamp.

**hours_flag** equal to 1 specifies that hours_value is present when full_timestamp_flag is equal to 0 and seconds_flag is equal to 1 and minutes_flag is equal to 1.

**hours_value** specifies the value of hH used to compute clockTimestamp. The value of hours_value shall be in the range of 0 to 23, inclusive. When hours_value is not present, the previous hours_value in decoding order shall be used as hH to compute clockTimestamp.

**time_offset** specifies the value of tOffset used to compute clockTimestamp. The number of bits used to represent time_offset shall be equal to time_offset_length. When time_offset is not present, the value 0 shall be used as tOffset to compute clockTimestamp.

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### D.2.3 Pan-scan rectangle SEI message semantics

The pan-scan rectangle SEI message syntax elements specify the coordinates of a rectangle relative to the cropping rectangle of the sequence parameter set. Each coordinate of this rectangle is specified in units of one-sixteenth sample spacing relative to the luma sampling grid.

**pan_scan_rect_id** contains an identifying number that may be used to identify the purpose of the pan-scan rectangle (for example, to identify the rectangle as the area to be shown on a particular display device or as the area that contains a particular actor in the scene). The value of pan_scan_rect_id shall be in the range of 0 to $2^{32} - 1$, inclusive.

Values of pan_scan_rect_id from 0 to 255 and from 512 to $2^{31}$-1 may be used as determined by the application. Values of pan_scan_rect_id from 256 to 511 and from $2^{31}$ to $2^{32}$-1 are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of pan_scan_rect_id in the range of 256 to 511 or in the range of $2^{31}$ to $2^{32}$ - 1 shall ignore (remove from the bitstream and discard) it.

**pan_scan_rect_cancel_flag** equal to 1 indicates that the SEI message cancels the persistence of any previous pan-scan rectangle SEI message in output order. pan_scan_rect_cancel_flag equal to 0 indicates that pan-scan rectangle information follows.

**pan_scan_cnt_minus1** specifies the number of pan-scan rectangles that are present in the SEI message. pan_scan_cnt_minus1 shall be in the range of 0 to 2, inclusive. pan_scan_cnt_minus1 equal to 0 indicates that a single pan-scan rectangle is present that applies to all fields of the decoded picture. pan_scan_cnt_minus1 shall be equal to 0 when the current picture is a field. pan_scan_cnt_minus1 equal to 1 indicates that two pan-scan rectangles are present, the first of which applies to the first field of the picture in output order and the second of which applies to the second field of the picture in output order. pan_scan_cnt_minus1 equal to 2 indicates that three pan-scan rectangles are present, the first of which applies to the first field of the picture in output order, the second of which applies to the second field of the picture in output order, and the third of which applies to a repetition of the first field as a third field in output order.

**pan_scan_rect_left_offset[** i **]**, **pan_scan_rect_right_offset[** i **]**, **pan_scan_rect_top_offset[** i **]**, and **pan_scan_rect_bottom_offset[** i **]**, specify, as signed integer quantities in units of one-sixteenth sample spacing relative to the luma sampling grid, the location of the pan-scan rectangle. The values of each of these four syntax elements shall be in the range of $-2^{31}$ to $2^{31}$ - 1, inclusive.

The pan-scan rectangle is specified, in units of one-sixteenth sample spacing relative to a luma frame sampling grid, as the region with frame horizontal coordinates from 16*CropUnitX * frame_crop_left_offset + pan_scan_rect_left_offset[ i ] to 16 * ( 16 * PicWidthInMbs – CropUnitX * frame_crop_right_offset ) + pan_scan_rect_right_offset[ i ] – 1 and with vertical coordinates from 16 *CropUnitY * frame_crop_top_offset + pan_scan_rect_top_offset[ i ] to 16 * ( 16 * PicHeightInMbs – CropUnitY * frame_crop_bottom_offset ) + pan_scan_rect_bottom_offset[ i ] – 1, inclusive. The value of 16 * CropUnitX * frame_crop_left_offset + pan_scan_rect_left_offset[ i ] shall be less than or equal to 16 * ( 16 * PicWidthInMbs – CropUnitX * frame_crop_right_offset ) + pan_scan_rect_right_offset[ i ] – 1; and the value of 16 CropUnitY * frame_crop_top_offset + pan_scan_rect_top_offset[ i ] shall be less than or equal to 16 * ( 16 * PicHeightInMbs – CropUnitY * frame_crop_bottom_offset ) + pan_scan_rect_bottom_offset[ i ] – 1.

When the pan-scan rectangular area includes samples outside of the cropping rectangle, the region outside of the cropping rectangle may be filled with synthesized content (such as black video content or neutral grey video content) for display.

**pan_scan_rect_repetition_period** specifies the persistence of the pan-scan rectangle SEI message and may specify a picture order count interval within which another pan-scan rectangle SEI message with the same value of pan_scan_rect_id or the end of the coded video sequence shall be present in the bitstream. The value of pan_scan_rect_repetition_period shall be in the range of 0 to 16 384, inclusive. When pan_scan_cnt_minus1 is greater than 0, pan_scan_rect_repetition_period shall not be greater than 1.

pan_scan_rect_repetition_period equal to 0 specifies that the pan-scan rectangle information applies to the current decoded picture only.

pan_scan_rect_repetition_period equal to 1 specifies that the pan-scan rectangle information persists in output order until any of the following conditions are true.

- A new coded video sequence begins
- A picture in an access unit containing a pan-scan rectangle SEI message with the same value of pan_scan_rect_id is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ).

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pan_scan_rect_repetition_period equal to 0 or equal to 1 indicates that another pan-scan rectangle SEI message with the same value of pan_scan_rect_id may or may not be present.

pan_scan_rect_repetition_period greater than 1 specifies that the pan-scan rectangle information persists until any of the following conditions are true.

- A new coded video sequence begins
- A picture in an access unit containing a pan-scan rectangle SEI message with the same value of pan_scan_rect_id is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ) and less than or equal to PicOrderCnt( CurrPic ) + pan_scan_rect_repetition_period.

pan_scan_rect_repetition_period greater than 1 indicates that another pan-scan rectangle SEI message with the same value of pan_scan_rect_id shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ) and less than or equal to PicOrderCnt( CurrPic ) + pan_scan_rect_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

### D.2.4 Filler payload SEI message semantics

This message contains a series of payloadSize bytes of value 0xFF, which can be discarded.

**ff_byte** shall be a byte having the value 0xFF.

### D.2.5 User data registered by ITU-T Rec. T.35 SEI message semantics

This message contains user data registered as specified by ITU-T Rec. T.35, the contents of which are not specified by this International Standard.

**itu_t_t35_country_code** shall be a byte having a value specified as a country code by ITU-T Rec. T.35 Annex A.

**itu_t_t35_country_code_extension_byte** shall be a byte having a value specified as a country code by ITU-T Rec. T.35 Annex B.

**itu_t_t35_payload_byte** shall be a byte containing data registered as specified by ITU-T Rec. T.35.

The ITU-T T.35 terminal provider code and terminal provider oriented code shall be contained in the first one or more bytes of the itu_t_t35_payload_byte, in the format specified by the Administration that issued the terminal provider code. Any remaining itu_t_t35_payload_byte data shall be data having syntax and semantics as specified by the entity identified by the ITU-T T.35 country code and terminal provider code.

### D.2.6 User data unregistered SEI message semantics

This message contains unregistered user data identified by a UUID, the contents of which are not specified by this International Standard.

**uuid_iso_iec_11578** shall have a value specified as a UUID according to the procedures of ISO/IEC 11578:1996 Annex A.

**user_data_payload_byte** shall be a byte containing data having syntax and semantics as specified by the UUID generator.

### D.2.7 Recovery point SEI message semantics

The recovery point SEI message assists a decoder in determining when the decoding process will produce acceptable pictures for display after the decoder initiates random access or after the encoder indicates a broken link in the sequence. When the decoding process is started with the access unit in decoding order associated with the recovery point SEI message, all decoded pictures at or subsequent to the recovery point in output order specified in this SEI message are indicated to be correct or approximately correct in content. Decoded pictures produced by random access at or before the picture associated with the recovery point SEI message need not be correct in content until the indicated recovery point, and the operation of the decoding process starting at the picture associated with the recovery point SEI message may contain references to pictures not available in the decoded picture buffer.

In addition, by use of the broken_link_flag, the recovery point SEI message can indicate to the decoder the location of some pictures in the bitstream that can result in serious visual artefacts when displayed, even when the decoding process was begun at the location of a previous IDR access unit in decoding order.

NOTE 1 – The broken_link_flag can be used by encoders to indicate the location of a point after which the decoding process for the decoding of some pictures may cause references to pictures that, though available for use in the decoding process, are not the pictures that were used for reference when the bitstream was originally encoded (e.g., due to a splicing operation performed during the generation of the bitstream).

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The recovery point is specified as a count in units of frame_num increments subsequent to the frame_num of the current access unit at the position of the SEI message.

NOTE 2 – When HRD information is present in the bitstream, a buffering period SEI message should be associated with the access unit associated with the recovery point SEI message in order to establish initialisation of the HRD buffer model after a random access.

**recovery_frame_cnt** specifies the recovery point of output pictures in output order. All decoded pictures in output order are indicated to be correct or approximately correct in content starting at the output order position of the reference picture having the frame_num equal to the frame_num of the VCL NAL units for the current access unit incremented by recovery_frame_cnt in modulo MaxFrameNum arithmetic. recovery_frame_cnt shall be in the range of 0 to MaxFrameNum – 1, inclusive.

**exact_match_flag** indicates whether decoded pictures at and subsequent to the specified recovery point in output order derived by starting the decoding process at the access unit associated with the recovery point SEI message shall be an exact match to the pictures that would be produced by starting the decoding process at the location of a previous IDR access unit in the NAL unit stream. The value 0 indicates that the match need not be exact and the value 1 indicates that the match shall be exact.

When decoding starts from the location of the recovery point SEI message, all references to not available reference pictures shall be inferred as references to pictures containing only macroblocks coded using Intra macroblock prediction modes and having sample values given by Y samples equal to 128, Cb samples equal to 128, and Cr samples equal to 128 (mid-level grey) for purposes of determining the conformance of the value of exact_match_flag.

NOTE 3 – When performing random access, decoders should infer all references to not available reference pictures as references to pictures containing only intra macroblocks and having sample values given by Y equal to 128, Cb equal to 128, and Cr equal to 128 (mid-level grey), regardless of the value of exact_match_flag.

When exact_match_flag is equal to 0, the quality of the approximation at the recovery point is chosen by the encoding process and is not specified by this International Standard.

**broken_link_flag** indicates the presence or absence of a broken link in the NAL unit stream at the location of the recovery point SEI message and is assigned further semantics as follows.

- If broken_link_flag is equal to 1, pictures produced by starting the decoding process at the location of a previous IDR access unit may contain undesirable visual artefacts to the extent that decoded pictures at and subsequent to the access unit associated with the recovery point SEI message in decoding order should not be displayed until the specified recovery point in output order.
- Otherwise (broken_link_flag is equal to 0), no indication is given regarding any potential presence of visual artefacts.

Regardless of the value of the broken_link_flag, pictures subsequent to the specified recovery point in output order are specified to be correct or approximately correct in content.

NOTE 4 – When a sub-sequence information SEI message is present in conjunction with a recovery point SEI message in which broken_link_flag is equal to 1 and when sub_seq_layer_num is equal to 0, sub_seq_id should be different from the latest sub_seq_id for sub_seq_layer_num equal to 0 that was decoded prior to the location of the recovery point SEI message. When broken_link_flag is equal to 0, the sub_seq_id in sub-sequence layer 0 should remain unchanged.

**changing_slice_group_idc** equal to 0 indicates that decoded pictures are correct or approximately correct in content at and subsequent to the recovery point in output order when all macroblocks of the primary coded pictures are decoded within the changing slice group period, i.e., the period between the access unit associated with the recovery point SEI message (inclusive) and the specified recovery point (inclusive) in decoding order. changing_slice_group_idc shall be equal to 0 when num_slice_groups_minus1 is equal to 0 in any primary coded picture within the changing slice group period.

When changing_slice_group_idc is equal to 1 or 2, num_slice_groups_minus1 shall be equal to 1 and the macroblock-to-slice-group map type 3, 4, or 5 shall be applied in each primary coded picture in the changing slice group period.

changing_slice_group_idc equal to 1 indicates that within the changing slice group period no sample values outside the decoded macroblocks covered by slice group 0 are used for inter prediction of any macroblock within slice group 0. In addition, changing_slice_group_idc equal to 1 indicates that when all macroblocks in slice group 0 within the changing slice group period are decoded, decoded pictures will be correct or approximately correct in content at and subsequent to the specified recovery point in output order regardless of whether any macroblock in slice group 1 within the changing slice group period is decoded.

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changing_slice_group_idc equal to 2 indicates that within the changing slice group period no sample values outside the decoded macroblocks covered by slice group 1 are used for inter prediction of any macroblock within slice group 1. In addition, changing_slice_group_idc equal to 2 indicates that when all macroblocks in slice group 1 within the changing slice group period are decoded, decoded pictures will be correct or approximately correct in content at and subsequent to the specified recovery point in output order regardless of whether any macroblock in slice group 0 within the changing slice group period is decoded.

changing_slice_group_idc shall be in the range of 0 to 2, inclusive.

### D.2.8 Decoded reference picture marking repetition SEI message semantics

The decoded reference picture marking repetition SEI message is used to repeat the decoded reference picture marking syntax structure that was located in the slice header of an earlier picture in the sequence in decoding order.

**original_idr_flag** shall be equal to 1 when the decoded reference picture marking syntax structure occurred originally in an IDR picture. original_idr_flag shall be equal to 0 when the repeated decoded reference picture marking syntax structure did not occur in an IDR picture originally.

**original_frame_num** shall be equal to the frame_num of the picture where the repeated decoded reference picture marking syntax structure originally occurred. The picture indicated by original_frame_num is the previous coded picture having the specified value of frame_num. The value of original_frame_num used to refer to a picture having a memory_management_control_operation equal to 5 shall be 0.

**original_field_pic_flag** shall be equal to the field_pic_flag of the picture where the repeated decoded reference picture marking syntax structure originally occurred.

**original_bottom_field_flag** shall be equal to the bottom_field_flag of the picture where the repeated decoded reference picture marking syntax structure originally occurred.

dec_ref_pic_marking( ) shall contain a copy of the decoded reference picture marking syntax structure of the picture whose frame_num was original_frame_num. The nal_unit_type used for specification of the repeated dec_ref_pic_marking( ) syntax structure shall be the nal_unit_type of the slice header(s) of the picture whose frame_num was original_frame_num (i.e., nal_unit_type as used in subclause 7.3.3.3 shall be considered equal to 5 when original_idr_flag is equal to 1 and shall not be considered equal to 5 when original_idr_flag is equal to 0).

### D.2.9 Spare picture SEI message semantics

This SEI message indicates that certain slice group map units, called spare slice group map units, in one or more decoded reference pictures resemble the co-located slice group map units in a specified decoded picture called the target picture. A spare slice group map unit may be used to replace a co-located, incorrectly decoded slice group map unit, in the target picture. A decoded picture containing spare slice group map units is called a spare picture.

For all spare pictures identified in a spare picture SEI message, the value of frame_mbs_only_flag shall be equal to the value of frame_mbs_only_flag of the target picture in the same SEI message. The spare pictures in the SEI message are constrained as follows.

- If the target picture is a decoded field, all spare pictures identified in the same SEI message shall be decoded fields.
- Otherwise (the target picture is a decoded frame), all spare pictures identified in the same SEI message shall be decoded frames.

For all spare pictures identified in a spare picture SEI message, the values of pic_width_in_mbs_minus1 and pic_height_in_map_units_minus1 shall be equal to the values of pic_width_in_mbs_minus1 and pic_height_in_map_units_minus1, respectively, of the target picture in the same SEI message. The picture associated (as specified in subclause 7.4.1.2.3) with this message shall appear after the target picture, in decoding order.

**target_frame_num** indicates the frame_num of the target picture.

**spare_field_flag** equal to 0 indicates that the target picture and the spare pictures are decoded frames. spare_field_flag equal to 1 indicates that the target picture and the spare pictures are decoded fields.

**target_bottom_field_flag** equal to 0 indicates that the target picture is a top field. target_bottom_field_flag equal to 1 indicates that the target picture is a bottom field.

A target picture is a decoded reference picture whose corresponding primary coded picture precedes the current picture, in decoding order, and in which the values of frame_num, field_pic_flag (when present) and bottom_field_flag (when present) are equal to target_frame_num, spare_field_flag and target_bottom_field_flag, respectively.

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**num_spare_pics_minus1** indicates the number of spare pictures for the specified target picture. The number of spare pictures is equal to num_spare_pics_minus1 + 1. The value of num_spare_pics_minus1 shall be in the range of 0 to 15, inclusive.

**delta_spare_frame_num[** i **]** is used to identify the spare picture that contains the i-th set of spare slice group map units, hereafter called the i-th spare picture, as specified below. The value of delta_spare_frame_num[ i ] shall be in the range of 0 to MaxFrameNum - 1 - !spare_field_flag, inclusive.

The frame_num of the i-th spare picture, spareFrameNum[ i ], is derived as follows for all values of i from 0 to num_spare_pics_minus1, inclusive:

```
candidateSpareFrameNum = target_frame_num - !spare_field_flag
for ( i = 0; i <= num_spare_pics_minus1; i++ ) {
    if( candidateSpareFrameNum < 0 )
        candidateSpareFrameNum = MaxFrameNum – 1
    spareFrameNum[ i ] = candidateSpareFrameNum – delta_spare_frame_num[ i ]        (D-3)
    if( spareFrameNum[ i ] < 0 )
        spareFrameNum[ i ] = MaxFrameNum + spareFrameNum[ i ]
    candidateSpareFrameNum = spareFrameNum[ i ] - !spare_field_flag
}
```

**spare_bottom_field_flag[** i **]** equal to 0 indicates that the i-th spare picture is a top field. spare_bottom_field_flag[ i ] equal to 1 indicates that the i-th spare picture is a bottom field.

The 0-th spare picture is a decoded reference picture whose corresponding primary coded picture precedes the target picture, in decoding order, and in which the values of frame_num, field_pic_flag (when present) and bottom_field_flag (when present) are equal to spareFrameNum[ 0 ], spare_field_flag and spare_bottom_field_flag[ 0 ], respectively. The i-th spare picture is a decoded reference picture whose corresponding primary coded picture precedes the ( i - 1 )-th spare picture, in decoding order, and in which the values of frame_num, field_pic_flag (when present) and bottom_field_flag (when present) are equal to spareFrameNum[ i ], spare_field_flag and spare_bottom_field_flag[ i ], respectively.

**spare_area_idc[** i **]** indicates the method used to identify the spare slice group map units in the i-th spare picture. spare_area_idc[ i ] shall be in the range of 0 to 2, inclusive. spare_area_idc[ i ] equal to 0 indicates that all slice group map units in the i-th spare picture are spare units. spare_area_idc[ i ] equal to 1 indicates that the value of the syntax element spare_unit_flag[ i ][ j ] is used to identify the spare slice group map units. spare_area_idc[ i ] equal to 2 indicates that the zero_run_length[ i ][ j ] syntax element is used to derive the values of spareUnitFlagInBoxOutOrder[ i ][ j ], as described below.

**spare_unit_flag[** i **][** j **]** equal to 0 indicates that the j-th slice group map unit in raster scan order in the i-th spare picture is a spare unit. spare_unit_flag[ i ][ j ] equal to 1 indicates that the j-th slice group map unit in raster scan order in the i-th spare picture is not a spare unit.

**zero_run_length[** i **][** j **]** is used to derive the values of spareUnitFlagInBoxOutOrder[ i ][ j ] when spare_area_idc[ i ] is equal to 2. In this case, the spare slice group map units identified in spareUnitFlagInBoxOutOrder[ i ][ j ] appear in counter-clockwise box-out order, as specified in subclause 8.2.2.4, for each spare picture. spareUnitFlagInBoxOutOrder[ i ][ j ] equal to 0 indicates that the j-th slice group map unit in counter-clockwise box-out order in the i-th spare picture is a spare unit. spareUnitFlagInBoxOutOrder[ i ][ j ] equal to 1 indicates that the j-th slice group map unit in counter-clockwise box-out order in the i-th spare picture is not a spare unit.

When spare_area_idc[ 0 ] is equal to 2, spareUnitFlagInBoxOutOrder[ 0 ][ j ] is derived as follows:

```
for( j = 0, loop = 0; j < PicSizeInMapUnits; loop++ ) {
    for( k = 0; k < zero_run_length[ 0 ][ loop ]; k++ )
        spareUnitFlagInBoxOutOrder[ 0 ][ j++ ] = 0                    (D-4)
    spareUnitFlagInBoxOutOrder[ 0 ][ j++ ] = 1
}
```

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When spare_area_idc[ i ] is equal to 2 and the value of i is greater than 0, spareUnitFlagInBoxOutOrder[ i ][ j ] is derived as follows:

```
for( j = 0, loop = 0; j < PicSizeInMapUnits; loop++ ) {
   for( k = 0; k < zero_run_length[ i ][ loop ]; k++ )
      spareUnitFlagInBoxOutOrder[ i ][ j ] = spareUnitFlagInBoxOutOrder[ i - 1 ][ j++ ]
   spareUnitFlagInBoxOutOrder[ i ][ j ] = !spareUnitFlagInBoxOutOrder[ i - 1 ][ j++ ]
}
```
(D-5)

### D.2.10 Scene information SEI message semantics

A scene and a scene transition are herein defined as a set of consecutive pictures in output order.

NOTE 1 – Decoded pictures within one scene generally have similar content. The scene information SEI message is used to label pictures with scene identifiers and to indicate scene changes. The message specifies how the source pictures for the labelled pictures were created. The decoder may use the information to select an appropriate algorithm to conceal transmission errors. For example, a specific algorithm may be used to conceal transmission errors that occurred in pictures belonging to a gradual scene transition. Furthermore, the scene information SEI message may be used in a manner determined by the application, such as for indexing the scenes of a coded sequence.

A scene information SEI message labels all pictures, in decoding order, from the primary coded picture to which the SEI message is associated (inclusive), as specified in subclause 7.4.1.2.3, to the primary coded picture to which the next scene information SEI message (if present) in decoding order is associated (exclusive) or (otherwise) to the last access unit in the bitstream (inclusive). These pictures are herein referred to as the target pictures.

**scene_info_present_flag** equal to 0 indicates that the scene or scene transition to which the target pictures belong is unspecified. scene_info_present_flag equal to 1 indicates that the target pictures belong to the same scene or scene transition.

**scene_id** identifies the scene to which the target pictures belong. When the value of scene_transition_type of the target pictures is less than 4, and the previous picture in output order is marked with a value of scene_transition_type less than 4, and the value of scene_id is the same as the value of scene_id of the previous picture in output order, this indicates that the source scene for the target pictures and the source scene for the previous picture (in output order) are considered by the encoder to have been the same scene. When the value of scene_transition_type of the target pictures is greater than 3, and the previous picture in output order is marked with a value of scene_transition_type less than 4, and the value of scene_id is the same as the value of scene_id of the previous picture in output order, this indicates that one of the source scenes for the target pictures and the source scene for the previous picture (in output order) are considered by the encoder to have been the same scene. When the value of scene_id is not equal to the value of scene_id of the previous picture in output order, this indicates that the target pictures and the previous picture (in output order) are considered by the encoder to have been from different source scenes.

The value of scene_id shall be in the range of 0 to $2^{32}$-1, inclusive. Values of scene_id in the range of 0 to 255, inclusive, and in the range of 512 to $2^{31} - 1$, inclusive, may be used as determined by the application. Values of scene_id in the range of 256 to 511, inclusive, and in the range of $2^{31}$ to $2^{32} - 1$, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of scene_id in the range of 256 to 511, inclusive, or in the range of $2^{31}$ to $2^{32}$ - 1, inclusive, shall ignore (remove from the bitstream and discard) it.

**scene_transition_type** specifies in which type of a scene transition (if any) the target pictures are involved. The valid values of scene_transition_type are specified in Table D-4.

**Table D-4 – scene_transition_type values**

| Value | Description |
|---|---|
| 0 | No transition |
| 1 | Fade to black |
| 2 | Fade from black |
| 3 | Unspecified transition from or to constant colour |
| 4 | Dissolve |
| 5 | Wipe |
| 6 | Unspecified mixture of two scenes |

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When scene_transition_type is greater than 3, the target pictures include contents both from the scene labelled by its scene_id and the next scene, in output order, which is labelled by second_scene_id (see below). The term “the current scene” is used to indicate the scene labelled by scene_id. The term “the next scene” is used to indicate the scene labelled by second_scene_id. It is not required for any following picture, in output order, to be labelled with scene_id equal to second_scene_id of the current SEI message.

Scene transition types are specified as follows.

“No transition” specifies that the target pictures are not involved in a gradual scene transition.

NOTE 2 – When two consecutive pictures in output order have scene_transition_type equal to 0 and different values of scene_id, a scene cut occurred between the two pictures.

“Fade to black” indicates that the target pictures are part of a sequence of pictures, in output order, involved in a fade to black scene transition, i.e., the luma samples of the scene gradually approach zero and the chroma samples of the scene gradually approach 128.

NOTE 3 – When two pictures are labelled to belong to the same scene transition and their scene_transition_type is "Fade to black", the later one, in output order, is darker than the previous one.

“Fade from black” indicates that the target pictures are part of a sequence of pictures, in output order, involved in a fade from black scene transition, i.e., the luma samples of the scene gradually diverge from zero and the chroma samples of the scene may gradually diverge from 128.

NOTE 4 – When two pictures are labelled to belong to the same scene transition and their scene_transition_type is "Fade from black", the later one in output order is lighter than the previous one.

“Dissolve” indicates that the sample values of each target picture (before encoding) were generated by calculating a sum of co-located weighted sample values of a picture from the current scene and a picture from the next scene. The weight of the current scene gradually decreases from full level to zero level, whereas the weight of the next scene gradually increases from zero level to full level. When two pictures are labelled to belong to the same scene transition and their scene_transition_type is "Dissolve", the weight of the current scene for the later one, in output order, is less than the weight of the current scene for the previous one, and the weight of the next scene for the later one, in output order, is greater than the weight of the next scene for the previous one.

"Wipe" indicates that some of the sample values of each target picture (before encoding) were generated by copying co-located sample values of a picture in the current scene and the remaining sample values of each target picture (before encoding) were generated by copying co-located sample values of a picture in the next scene. When two pictures are labelled to belong to the same scene transition and their scene_transition_type is "Wipe", the number of samples copied from the next scene to the later picture in output order is greater than the number of samples copied from the next scene to the previous picture.

**second_scene_id** identifies the next scene in the gradual scene transition in which the target pictures are involved. The value of second_scene_id shall not be equal to the value of scene_id. The value of second_scene_id shall not be equal to the value of scene_id in the previous picture in output order. When the next picture in output order is marked with a value of scene_transition_type less than 4, and the value of second_scene_id is the same as the value of scene_id of the next picture in output order, this indicates that the encoder considers one of the source scenes for the target pictures and the source scene for the next picture (in output order) to have been the same scene. When the value of second_scene_id is not equal to the value of scene_id or second_scene_id (if present) of the next picture in output order, this indicates that the encoder considers the target pictures and the next picture (in output order) to have been from different source scenes.

When the value of scene_id of a picture is equal to the value of scene_id of the following picture in output order and the value of scene_transition_type in both of these pictures is less than 4, this indicates that the encoder considers the two pictures to have been from the same source scene. When the values of scene_id, scene_transition_type and second_scene_id (if present) of a picture are equal to the values of scene_id, scene_transition_type and second_scene_id (respectively) of the following picture in output order and the value of scene_transition_type is greater than 0, this indicates that the encoder considers the two pictures to have been from the same source gradual scene transition.

The value of second_scene_id shall be in the range of 0 to $2^{32}$-1, inclusive. Values of second_scene_id in the range of 0 to 255, inclusive, and in the range of 512 to $2^{31}$-1, inclusive, may be used as determined by the application. Values of second_scene_id in the range of 256 to 511, inclusive, and in the range of $2^{31}$ to $2^{32}$-1, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of second_scene_id in the range of 256 to 511, inclusive, or in the range of $2^{31}$ to $2^{32}$-1, inclusive, shall ignore (remove from the bitstream and discard) it.

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### D.2.11 Sub-sequence information SEI message semantics

The sub-sequence information SEI message is used to indicate the position of a picture in data dependency hierarchy that consists of sub-sequence layers and sub-sequences.

A sub-sequence layer contains a subset of the coded pictures in a sequence. Sub-sequence layers are numbered with non-negative integers. A layer having a larger layer number is a higher layer than a layer having a smaller layer number. The layers are ordered hierarchically based on their dependency on each other so that any picture in a layer shall not be predicted from any picture on any higher layer.

NOTE 1 – In other words, any picture in layer 0 must not be predicted from any picture in layer 1 or above, pictures in layer 1 may be predicted from layer 0, pictures in layer 2 may be predicted from layers 0 and 1, etc.

NOTE 2 – The subjective quality is expected to increase along with the number of decoded layers.

A sub-sequence is a set of coded pictures within a sub-sequence layer. A picture shall reside in one sub-sequence layer and in one sub-sequence only. Any picture in a sub-sequence shall not be predicted from any picture in another sub-sequence in the same or in a higher sub-sequence layer. A sub-sequence in layer 0 can be decoded independently of any picture that does not belong to the sub-sequence.

The sub-sequence information SEI message concerns the current access unit. The primary coded picture in the access unit is herein referred to as the current picture.

The sub-sequence information SEI message shall not be present unless gaps_in_frame_num_value_allowed_flag in the sequence parameter set referenced by the picture associated with the sub-sequence SEI message is equal to 1.

**sub_seq_layer_num** specifies the sub-sequence layer number of the current picture. When sub_seq_layer_num is greater than 0, memory management control operations shall not be used in any slice header of the current picture. When the current picture resides in a sub-sequence whose first picture in decoding order is an IDR picture, the value of sub_seq_layer_num shall be equal to 0. For a non-paired reference field, the value of sub_seq_layer_num shall be equal to 0. sub_seq_layer_num shall be in the range of 0 to 255, inclusive.

**sub_seq_id** identifies the sub-sequence within a layer. When the current picture resides in a sub-sequence whose first picture in decoding order is an IDR picture, the value of sub_seq_id shall be the same as the value of idr_pic_id of the IDR picture. sub_seq_id shall be in the range of 0 to 65535, inclusive.

**first_ref_pic_flag** equal to 1 specifies that the current picture is the first reference picture of the sub-sequence in decoding order. When the current picture is not the first picture of the sub-sequence in decoding order, the first_ref_pic_flag shall be equal to 0.

**leading_non_ref_pic_flag** equal to 1 specifies that the current picture is a non-reference picture preceding any reference picture in decoding order within the sub-sequence or that the sub-sequence contains no reference pictures. When the current picture is a reference picture or the current picture is a non-reference picture succeeding at least one reference picture in decoding order within the sub-sequence, the leading_non_ref_pic_flag shall be equal to 0.

**last_pic_flag** equal to 1 indicates that the current picture is the last picture of the sub-sequence (in decoding order), including all reference and non-reference pictures of the sub-sequence. When the current picture is not the last picture of the sub-sequence (in decoding order), last_pic_flag shall be equal to 0.

The current picture is assigned to a sub-sequence as follows.

- If one or more of the following conditions is true, the current picture is the first picture of a sub-sequence in decoding order.
  - no earlier picture in decoding order is labelled with the same values of sub_seq_id and sub_seq_layer_num as the current picture
  - the value of leading_non_ref_pic_flag is equal to 1 and the value of leading_non_ref_pic_flag is equal to 0 in the previous picture in decoding order having the same values of sub_seq_id and sub_seq_layer_num as the current picture
  - the value of first_ref_pic_flag is equal to 1 and the value of leading_non_ref_pic_flag is equal to 0 in the previous picture in decoding order having the same values of sub_seq_id and sub_seq_layer_num as the current picture
  - the value of last_pic_flag is equal to 1 in the previous picture in decoding order having the same values of sub_seq_id and sub_seq_layer_num as the current picture
- Otherwise, the current picture belongs to the same sub-sequence as the previous picture in decoding order having the same values of sub_seq_id and sub_seq_layer_num as the current picture.

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**sub_seq_frame_num_flag** equal to 0 specifies that sub_seq_frame_num is not present. sub_seq_frame_num_flag equal to 1 specifies that sub_seq_frame_num is present.

**sub_seq_frame_num** shall be equal to 0 for the first reference picture of the sub-sequence and for any non-reference picture preceding the first reference picture of the sub-sequence in decoding order. sub_seq_frame_num is further constrained as follows.

- If the current picture is not the second field of a complementary field pair, sub_seq_frame_num shall be incremented by 1, in modulo MaxFrameNum operation, relative to the previous reference picture, in decoding order, that belongs to the sub-sequence.
- Otherwise (the current picture is the second field of a complementary field pair), the value of sub_seq_frame_num shall be the same as the value of sub_seq_frame_num for the first field of the complementary field pair.

sub_seq_frame_num shall be in the range of 0 to MaxFrameNum – 1, inclusive.

When the current picture is an IDR picture, it shall start a new sub-sequence in sub-sequence layer 0. Thus, the sub_seq_layer_num shall be 0, the sub_seq_id shall be different from the previous sub-sequence in sub-sequence layer 0, first_ref_pic_flag shall be 1, and leading_non_ref_pic_flag shall be equal to 0.

When the sub-sequence information SEI message is present for both coded fields of a complementary field pair, the values of sub_seq_layer_num, sub_seq_id, leading_non_ref_pic_flag and sub_seq_frame_num, when present, shall be identical for both of these pictures.

When the sub-sequence information SEI message is present only for one coded field of a complementary field pair, the values of sub_seq_layer_num, sub_seq_id, leading_non_ref_pic_flag and sub_seq_frame_num, when present, are also applicable to the other coded field of the complementary field pair.

### D.2.12 Sub-sequence layer characteristics SEI message semantics

The sub-sequence layer characteristics SEI message specifies the characteristics of sub-sequence layers.

**num_sub_seq_layers_minus1** plus 1 specifies the number of sub-sequence layers in the sequence. num_sub_seq_layers_minus1 shall be in the range of 0 to 255, inclusive.

A pair of average_bit_rate and average_frame_rate characterizes each sub-sequence layer. The first pair of average_bit_rate and average_frame_rate specifies the characteristics of sub-sequence layer 0. When present, the second pair specifies the characteristics of sub-sequence layers 0 and 1 jointly. Each pair in decoding order specifies the characteristics for a range of sub-sequence layers from layer number 0 to the layer number specified by the layer loop counter. The values are in effect from the point they are decoded until an update of the values is decoded.

**accurate_statistics_flag** equal to 1 indicates that the values of average_bit_rate and average_frame_rate are rounded from statistically correct values. accurate_statistics_flag equal to 0 indicates that the average_bit_rate and the average_frame_rate are estimates and may deviate somewhat from the correct values.

When accurate_statistics_flag is equal to 0, the quality of the approximation used in the computation of the values of average_bit_rate and the average_frame_rate is chosen by the encoding process and is not specified by this International Standard.

**average_bit_rate** indicates the average bit rate in units of 1000 bits per second. All NAL units in the range of sub-sequence layers specified above are taken into account in the calculation. The average bit rate is derived according to the access unit removal time specified in Annex C of the International Standard. In the following, bTotal is the number of bits in all NAL units succeeding a sub-sequence layer characteristics SEI message (including the bits of the NAL units of the current access unit) and preceding the next access unit (in decoding order) including a sub-sequence layer characteristics SEI message (if present) or the end of the stream (otherwise). $t_1$ is the removal time (in seconds) of the current access unit, and $t_2$ is the removal time (in seconds) of the latest access unit (in decoding order) before the next sub-sequence layer characteristics SEI message (if present) or the end of the stream (otherwise).

When accurate_statistics_flag is equal to 1, the following conditions shall be fulfilled as follows.

– If $t_1$ is not equal to $t_2$, the following condition shall be true

$$\text{average_bit_rate} == \text{Round}( \text{bTotal} \div ( ( t_2 - t_1 ) * 1000 ) ) ) \quad \text{(D-6)}$$

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– Otherwise ($t_1$ is equal to $t_2$), the following condition shall be true

average_bit_rate == 0 (D-7)

**average_frame_rate** indicates the average frame rate in units of frames/(256 seconds). All NAL units in the range of sub-sequence layers specified above are taken into account in the calculation. In the following, fTotal is the number of frames, complementary field pairs and non-paired fields between the current picture (inclusive) and the next sub-sequence layer characteristics SEI message (if present) or the end of the stream (otherwise). $t_1$ is the removal time (in seconds) of the current access unit, and $t_2$ is the removal time (in seconds) of the latest access unit (in decoding order) before the next sub-sequence layer characteristics SEI message (if present) or the end of the stream (otherwise).

When accurate_statistics_flag is equal to 1, the following conditions shall be fulfilled as follows.

– If $t_1$ is not equal to $t_2$, the following condition shall be true

average_frame_rate == Round( fTotal * 256 ÷ ( $t_2 - t_1$ ) ) (D-8)

– Otherwise ($t_1$ is equal to $t_2$), the following condition shall be true

average_frame_rate == 0 (D-9)

### D.2.13 Sub-sequence characteristics SEI message semantics

The sub-sequence characteristics SEI message indicates the characteristics of a sub-sequence. It also indicates inter prediction dependencies between sub-sequences. This message shall be contained in the first access unit in decoding order of the sub-sequence to which the sub-sequence characteristics SEI message applies. This sub-sequence is herein called the target sub-sequence.

**sub_seq_layer_num** identifies the sub-sequence layer number of the target sub-sequence. sub_seq_layer_num shall be in the range of 0 to 255, inclusive.

**sub_seq_id** identifies the target sub-sequence. sub_seq_id shall be in the range of 0 to 65535, inclusive.

**duration_flag** equal to 0 indicates that the duration of the target sub-sequence is not specified.

**sub_seq_duration** specifies the duration of the target sub-sequence in clock ticks of a 90-kHz clock.

**average_rate_flag** equal to 0 indicates that the average bit rate and the average frame rate of the target sub-sequence are unspecified.

**accurate_statistics_flag** indicates how reliable the values of average_bit_rate and average_frame_rate are. accurate_statistics_flag equal to 1, indicates that the average_bit_rate and the average_frame_rate are rounded from statistically correct values. accurate_statistics_flag equal to 0 indicates that the average_bit_rate and the average_frame_rate are estimates and may deviate from the statistically correct values.

**average_bit_rate** indicates the average bit rate in (1000 bits)/second of the target sub-sequence. All NAL units of the target sub-sequence are taken into account in the calculation. The average bit rate is derived according to the access unit removal time specified in subclause C.1.2. In the following, nB is the number of bits in all NAL units in the sub-sequence, $t_1$ is the removal time (in seconds) of the first access unit of the sub-sequence (in decoding order), and $t_2$ is the removal time (in seconds) of the last access unit of the sub-sequence (in decoding order).

When accurate_statistics_flag is equal to 1, the following conditions shall be fulfilled as follows.

– If $t_1$ is not equal to $t_2$, the following condition shall be true

average_bit_rate == Round( nB ÷ ( ( $t_2 - t_1$ ) * 1000 ) ) (D-10)

– Otherwise ($t_1$ is equal to $t_2$), the following condition shall be true

average_bit_rate == 0 (D-11)

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**average_frame_rate** indicates the average frame rate in units of frames/(256 seconds) of the target sub-sequence. All NAL units of the target sub-sequence are taken into account in the calculation. The average frame rate is derived according to the access unit removal time specified in subclause C.1.2. In the following, fC is the number of frames, complementary field pairs and non-paired fields in the sub-sequence. $t_1$ is the removal time (in seconds) of the first access unit of the sub-sequence (in decoding order), and $t_2$ is the removal time (in seconds) of the last access unit of the sub-sequence (in decoding order).

When accurate_statistics_flag is equal to 1, the following conditions shall be fulfilled as follows.

– If $t_1$ is not equal to $t_2$, the following condition shall be true

$$\text{average_frame_rate} == \text{Round}( fC * 256 \div ( t_2 - t_1 ) ) \quad \text{(D-12)}$$

– Otherwise ($t_1$ is equal to $t_2$), the following condition shall be true

$$\text{average_frame_rate} == 0 \quad \text{(D-13)}$$

**num_referenced_subseqs** specifies the number of sub-sequences that contain pictures that are used as reference pictures for inter prediction in the pictures of the target sub-sequence. num_referenced_subseqs shall be in the range of 0 to 255, inclusive.

**ref_sub_seq_layer_num, ref_sub_seq_id**, and **ref_sub_seq_direction** identify the sub-sequence that contains pictures that are used as reference pictures for inter prediction in the pictures of the target sub-sequence. Depending on ref_sub_seq_direction, the following applies.

– If ref_sub_seq_direction is equal to 0, a set of candidate sub-sequences consists of the sub-sequences whose sub_seq_id is equal to ref_sub_seq_id, which reside in the sub-sequence layer having sub_seq_layer_num equal to ref_sub_seq_layer_num, and whose first picture in decoding order precedes the first picture of the target sub-sequence in decoding order.

– Otherwise (ref_sub_seq_direction is equal to 1), a set of candidate sub-sequences consists of the sub-sequences whose sub_seq_id is equal to ref_sub_seq_id, which reside in the sub-sequence layer having sub_seq_layer_num equal to ref_sub_seq_layer_num, and whose first picture in decoding order succeeds the first picture of the target sub-sequence in decoding order.

The sub-sequence used as a reference for the target sub-sequence is the sub-sequence among the set of candidate sub-sequences whose first picture is the closest to the first picture of the target sub-sequence in decoding order.

### D.2.14 Full-frame freeze SEI message semantics

The full-frame freeze SEI message indicates that the current picture and any subsequent pictures in output order that meet specified conditions should not affect the content of the display. No more than one full-frame freeze SEI message shall be present in any access unit.

**full_frame_freeze_repetition_period** specifies the persistence of the full-frame freeze SEI message and may specify a picture order count interval within which another full-frame freeze SEI message or a full-frame freeze release SEI or the end of the coded video sequence shall be present in the bitstream. The value of full_frame_freeze_repetition_period shall be in the range of 0 to 16 384, inclusive.

full_frame_freeze_repetition_period equal to 0 specifies that the full-frame freeze SEI message applies to the current decoded picture only.

full_frame_freeze_repetition_period equal to 1 specifies that the full-frame freeze SEI message persists in output order until any of the following conditions are true.

- A new coded video sequence begins
- A picture in an access unit containing a full-frame freeze SEI message or a full-frame freeze release SEI message is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ).

full_frame_freeze_repetition_period greater than 1 specifies that the full-frame freeze SEI message persists until any of the following conditions are true.

- A new coded video sequence begins

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– A picture in an access unit containing a full-frame freeze SEI message or a full-frame freeze release SEI message is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ) and less than or equal to PicOrderCnt( CurrPic ) + full_frame_freeze_repetition_period.

full_frame_freeze_repetition_period greater than 1 indicates that another full-frame freeze SEI message or a full-frame freeze release SEI message shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ) and less than or equal to PicOrderCnt( CurrPic ) + full_frame_freeze_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

### D.2.15 Full-frame freeze release SEI message semantics

The full-frame freeze release SEI message cancels the effect of any full-frame freeze SEI message sent with pictures that precede the current picture in output order. The full-frame freeze release SEI message indicates that the current picture and subsequent pictures in output order should affect the contents of the display.

No more than one full-frame freeze release SEI message shall be present in any access unit. A full-frame freeze release SEI message shall not be present in an access unit containing a full-frame freeze SEI message. When a full-frame freeze SEI message is present in an access unit containing a field of a complementary field pair in which the values of PicOrderCnt( CurrPic ) for the two fields of the complementary field pair are equal to each other, a full-frame freeze release SEI message shall not be present in either of the two access units.

### D.2.16 Full-frame snapshot SEI message semantics

The full-frame snapshot SEI message indicates that the current frame is labelled for use as determined by the application as a still-image snapshot of the video content.

**snapshot_id** specifies a snapshot identification number. snapshot_id shall be in the range of 0 to $2^{32}$ - 1, inclusive.

Values of snapshot_id in the range of 0 to 255, inclusive, and in the range of 512 to $2^{31}$-1, inclusive, may be used as determined by the application. Values of snapshot_id in the range of 256 to 511, inclusive, and in the range of $2^{31}$ to $2^{32}$-1, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of snapshot_id in the range of 256 to 511, inclusive, or in the range of $2^{31}$ to $2^{32}$-1, inclusive, shall ignore (remove from the bitstream and discard) it.

### D.2.17 Progressive refinement segment start SEI message semantics

The progressive refinement segment start SEI message specifies the beginning of a set of consecutive coded pictures that is labelled as the current picture followed by a sequence of one or more pictures of refinement of the quality of the current picture, rather than as a representation of a continually moving scene.

The tagged set of consecutive coded pictures shall continue until one of the following conditions is true. When a condition below becomes true, the next slice to be decoded does not belong to the tagged set of consecutive coded pictures.

1. The next slice to be decoded belongs to an IDR picture.
2. num_refinement_steps_minus1 is greater than 0 and the frame_num of the next slice to be decoded is (currFrameNum + num_refinement_steps_minus1 + 1) % MaxFrameNum, where currFrameNum is the value of frame_num of the picture in the access unit containing the SEI message.
3. num_refinement_steps_minus1 is 0 and a progressive refinement segment end SEI message with the same progressive_refinement_id as the one in this SEI message is decoded.

The decoding order of picture within the tagged set of consecutive pictures should be the same as their output order. **progressive_refinement_id** specifies an identification number for the progressive refinement operation. progressive_refinement_id shall be in the range of 0 to $2^{32}$ - 1, inclusive.

Values of progressive_refinement_id in the range of 0 to 255, inclusive, and in the range of 512 to $2^{31}$ - 1, inclusive, may be used as determined by the application. Values of progressive_refinement_id in the range of 256 to 511, inclusive, and in the range of $2^{31}$ to $2^{32}$-1, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of progressive_refinement_id in the range of 256 to 511, inclusive, or in the range of $2^{31}$ to $2^{32}$ - 1, inclusive, shall ignore (remove from the bitstream and discard) it.

**num_refinement_steps_minus1** specifies the number of reference frames in the tagged set of consecutive coded pictures as follows.

– If num_refinement_steps_minus1 is equal to 0, the number of reference frames in the tagged set of consecutive coded pictures is unknown.

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– Otherwise, the number of reference frames in the tagged set of consecutive coded pictures is equal to num_refinement_steps_minus1 + 1.

num_refinement_steps_minus1 shall be in the range of 0 to MaxFrameNum - 1, inclusive.

### D.2.18 Progressive refinement segment end SEI message semantics

The progressive refinement segment end SEI message specifies the end of a set of consecutive coded pictures that has been labelled by use of a progressive refinement segment start SEI message as an initial picture followed by a sequence of one or more pictures of the refinement of the quality of the initial picture, and ending with the current picture.

**progressive_refinement_id** specifies an identification number for the progressive refinement operation. progressive_refinement_id shall be in the range of 0 to $2^{32}$ - 1, inclusive.

The progressive refinement segment end SEI message specifies the end of any progressive refinement segment previously started using a progressive refinement segment start SEI message with the same value of progressive_refinement_id.

Values of progressive_refinement_id in the range of 0 to 255, inclusive, and in the range of 512 to $2^{31}$ - 1, inclusive, may be used as determined by the application. Values of progressive_refinement_id in the range of 256 to 511, inclusive, and in the range of $2^{31}$ to $2^{32}$ - 1, inclusive, are reserved for future use by ITU-T | ISO/IEC. Decoders encountering a value of progressive_refinement_id in the range of 256 to 511, inclusive, or in the range of $2^{31}$ to $2^{32}$ - 1, inclusive, shall ignore (remove from the bitstream and discard) it.

### D.2.19 Motion-constrained slice group set SEI message semantics

This SEI message indicates that inter prediction over slice group boundaries is constrained as specified below. When present, the message shall only appear where it is associated, as specified in subclause 7.4.1.2.3, with an IDR access unit.

The target picture set for this SEI message contains all consecutive primary coded pictures in decoding order starting with the associated primary coded IDR picture (inclusive) and ending with the following primary coded IDR picture (exclusive) or with the very last primary coded picture in the bitstream (inclusive) in decoding order when there is no following primary coded IDR picture. The slice group set is a collection of one or more slice groups, identified by the slice_group_id[ i ] syntax element. When separate_colour_plane_flag is equal to 1, the term "primary coded pictures" represents the parts of the corresponding primary coded pictures that correspond to the NAL units having the same colour_plane_id.

This SEI message indicates that, for each picture in the target picture set, the inter prediction process is constrained as follows: No sample value outside the slice group set, and no sample value at a fractional sample position that is derived using one or more sample values outside the slice group set is used to inter predict any sample within the slice group set.

**num_slice_groups_in_set_minus1** + 1 specifies the number of slice groups in the slice group set. The allowed range of num_slice_groups_in_set_minus1 is 0 to num_slice_groups_minus1, inclusive. The allowed range of num_slice_groups_minus1 is specified in Annex A.

**slice_group_id[** i **]** identifies the slice group(s) contained within the slice group set. The allowed range is from 0 to num_slice_groups_in_set_minus1, inclusive. The size of the slice_group_id[ i ] syntax element is Ceil( Log2( num_slice_groups_minus1 + 1 ) ) bits.

**exact_sample_value_match_flag** equal to 0 indicates that, within the target picture set, when the macroblocks that do not belong to the slice group set are not decoded, the value of each sample in the slice group set need not be exactly the same as the value of the same sample when all the macroblocks are decoded. exact_sample_value_match_flag equal to 1 indicates that, within the target picture set, when the macroblocks that do not belong to the slice group set are not decoded, the value of each sample in the slice group set shall be exactly the same as the value of the same sample when all the macroblocks in the target picture set are decoded.

NOTE 1 – When disable_deblocking_filter_idc is equal to 2 in all slices in the target picture set, exact_sample_value_match_flag should be 1.

**pan_scan_rect_flag** equal to 0 specifies that pan_scan_rect_id is not present. pan_scan_rect_flag equal to 1 specifies that pan_scan_rect_id is present.

**pan_scan_rect_id** indicates that the specified slice group set covers at least the pan-scan rectangle identified by pan_scan_rect_id within the target picture set.

NOTE 2 – Multiple motion_constrained_slice_group_set SEI messages may be associated with the same IDR picture. Consequently, more than one slice group set may be active within a target picture set.

NOTE 3 – The size, shape, and location of the slice groups in the slice group set may change within the target picture set.

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### D.2.20 Film grain characteristics SEI message semantics

This SEI message provides the decoder with a parameterised model for film grain synthesis. For example, an encoder may use the film grain characteristics SEI message to characterise film grain that was present in the original source video material and was removed by pre-processing filtering techniques. Synthesis of simulated film grain on the decoded images for the display process is optional and does not affect the decoding process specified in this International Standard. If synthesis of simulated film grain on the decoded images for the display process is performed, there is no requirement that the method by which the synthesis is performed be the same as the parameterised model for the film grain as provided in the film grain characteristics SEI message.

NOTE 1 – The display process is not specified in this International Standard.

**film_grain_characteristics_cancel_flag** equal to 1 indicates that the SEI message cancels the persistence of any previous film grain characteristics SEI message in output order. film_grain_characteristics_cancel_flag equal to 0 indicates that film grain modelling information follows.

**model_id** identifies the film grain simulation model as specified in Table D-5. The value of model_id shall be in the range of 0 to 1, inclusive.

**Table D-5 – model_id values**

| Value | Description |
|---|---|
| 0 | frequency filtering |
| 1 | auto-regression |
| 2 | reserved |
| 3 | reserved |

**separate_colour_description_present_flag** equal to 1 indicates that a distinct colour space description for the film grain characteristics specified in the SEI message is present in the film grain characteristics SEI message syntax. separate_colour_description_present_flag equal to 0 indicates that the colour description for the film grain characteristics specified in the SEI message is the same as for the coded video sequence as specified in subclause E.2.1.

NOTE 2 – When separate_colour_description_present_flag is equal to 1, the colour space specified for the film grain characteristics specified in the SEI message may differ from the colour space specified for the coded video as specified in subclause E.2.1.

**film_grain_bit_depth_luma_minus8** plus 8 specifies the bit depth used for the luma component of the film grain characteristics specified in the SEI message. When film_grain_bit_depth_luma_minus8 is not present in the film grain characteristics SEI message, the value of film_grain_bit_depth_luma_minus8 shall be inferred to be equal to bit_depth_luma_minus8.

The value of filmGrainBitDepth[ 0 ] is derived as

$$filmGrainBitDepth[\ 0\ ] = film_grain_bit_depth_luma_minus8 + 8 \quad \text{(D-14)}$$

**film_grain_bit_depth_chroma_minus8** plus 8 specifies the bit depth used for the Cb and Cr components of the film grain characteristics specified in the SEI message. When film_grain_bit_depth_chroma_minus8 is not present in the film grain characteristics SEI message, the value of film_grain_bit_depth_chroma_minus8 shall be inferred to be equal to bit_depth_chroma_minus8.

The value of filmGrainBitDepth[ c ] for c = 1 and 2 is derived as

$$filmGrainBitDepth[\ c\ ] = film_grain_bit_depth_chroma_minus8 + 8 \quad \text{with } c = 1, 2 \quad \text{(D-15)}$$

**film_grain_full_range_flag** has the same semantics as specified in subclause E.2.1 for the video_full_range_flag syntax element, except as follows.

– film_grain_full_range_flag specifies the colour space of the film grain characteristics specified in the SEI message, rather than the colour space used for the coded video sequence.

– When film_grain_full_range_flag is not present in the film grain characteristics SEI message, the value of film_grain_full_range_flag shall be inferred to be equal to video_full_range_flag.

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**film_grain_colour_primaries** has the same semantics as specified in subclause E.2.1 for the colour_primaries syntax element, except as follows.

– film_grain_colour_primaries specifies the colour space of the film grain characteristics specified in the SEI message, rather than the colour space used for the coded video sequence.

– When film_grain_colour_primaries is not present in the film grain characteristics SEI message, the value of film_grain_colour_primaries shall be inferred to be equal to colour_primaries.

**film_grain_transfer_characteristics** has the same semantics as specified in subclause E.2.1 for the transfer_characteristics syntax element, except as follows.

– film_grain_transfer_characteristics specifies the colour space of the film grain characteristics specified in the SEI message, rather than the colour space used for the coded video sequence.

– When film_grain_transfer_characteristics is not present in the film grain characteristics SEI message, the value of film_grain_transfer_characteristics shall be inferred to be equal to transfer_characteristics.

**film_grain_matrix_coefficients** has the same semantics as specified in subclause E.2.1 for the matrix_coefficients syntax element, except as follows.

– film_grain_matrix_coefficients specifies the colour space of the film grain characteristics specified in the SEI message, rather than the colour space used for the coded video sequence.

– When film_grain_matrix_coefficients is not present in the film grain characteristics SEI message, the value of film_grain_matrix_coefficients shall be inferred to be equal to matrix_coefficients.

– The values allowed for film_grain_matrix_coefficients are not constrained by the value of chroma_format_idc.

The chroma_format_idc of the film grain characteristics specified in the film grain characteristics SEI message shall be inferred to be equal to 3 (4:4:4).

NOTE 3 – Because the use of a specific method is not required for performing film grain generation function used by the display process, a decoder may, if desired, down-convert the model information for chroma in order to simulate film grain for other chroma formats (4:2:0 or 4:2:2) rather than up-converting the decoded video (using a method not specified by this International Standard) before performing film grain generation.

**blending_mode_id** identifies the blending mode used to blend the simulated film grain with the decoded images as specified in Table D-6. blending_mode_id shall be in the range of 0 to 1, inclusive.

**Table D-6 – blending_mode_id values**

| Value | Description |
|---|---|
| 0 | additive |
| 1 | multiplicative |
| 2 | reserved |
| 3 | reserved |

Depending on blending_mode_id, the blending mode is specified as follows

– If blending_mode_id is equal to 0 the blending mode is additive as specified by

$$I_{grain}[ x, y, c ] = Clip3( 0, ( 1 << filmGrainBitDepth[ c ] ) – 1, I_{decoded}[ x, y, c ] + G[ x, y, c ] ) \quad (D\text{-}16)$$

– Otherwise (blending_mode_id is equal to 1), the blending mode is multiplicative as specified by

$$I_{grain}[ x, y, c ] = Clip3( 0, ( 1 << filmGrainBitDepth[ c ] ) – 1, I_{decoded}[ x, y, c ] * ( 1 + G[ x, y, c ] ) ) \quad (D\text{-}17)$$

where $I_{decoded}[ x, y, c ]$ represents the sample value at coordinates x, y of the colour component c of the decoded image $I_{decoded}$, $G[ x, y, c ]$ is the simulated film grain value at the same position and colour component, and filmGrainBitDepth[ c ] is the number of bits used for each sample in a fixed-length unsigned binary representation of the array $I_{grain}[ x, y, c ]$.

**log2_scale_factor** specifies a scale factor used in the film grain characterization equations.

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**comp_model_present_flag[** c ] equal to 0 indicates that film grain is not modelled on the c-th colour component, where c equal to 0 refers to the luma component, c equal to 1 refers to the Cb component, and c equal to 2 refers to the Cr component. comp_model_present_flag[ c ] equal to 1 indicates that syntax elements specifying modelling of film grain on colour component c are present in the SEI message.

**num_intensity_intervals_minus1**[ c ] plus 1 specifies the number of intensity intervals for which a specific set of model values has been estimated.

NOTE 4 – The intensity intervals may overlap in order to simulate multi-generational film grain.

**num_model_values_minus1**[ c ] plus 1 specifies the number of model values present for each intensity interval in which the film grain has been modelled. The value of num_model_values_minus1[ c ] shall be in the range of 0 to 5, inclusive.

**intensity_interval_lower_bound**[ c ][ i ] specifies the lower bound of the interval i of intensity levels for which the set of model values applies.

**intensity_interval_upper_bound**[ c ][ i ] specifies the upper bound of the interval i of intensity levels for which the set of model values applies.

Depending on model_id, the selection of the sets of model values is specified as follows.

– If model_id is equal to 0, the average value of each block b of 16x16 samples in $I_{decoded}$, referred as $b_{avg}$, is used to select the sets of model values with index s[ j ] that apply to all the samples in the block:

```
for( i = 0, j = 0; i <= num_intensity_intervals_minus1; i++ )
  if( bavg >= intensity_interval_lower_bound[ c ][ i ] && bavg <= intensity_interval_upper_bound[ c ][ i ] ) {
    s[ j ] = i                                                                    (D-18)
    j++
  }
```

– Otherwise (model_id is equal to 1), the sets of model values used to generate the film grain are selected for each sample value in $I_{decoded}$ as follows:

```
for( i = 0, j = 0; i <= num_intensity_intervals_minus1; i++ )
  if( Idecoded[ x, y, c ] >= intensity_interval_lower_bound[ c ][ i ] &&
      Idecoded[ x, y, c ] <= intensity_interval_upper_bound[ c ][ i ] ) {          (D-19)
    s[ j ] = i
    j++
  }
```

Samples that do not fall into any of the defined intervals are not modified by the grain generation function. Samples that fall into more than one interval will originate multi-generation grain. Multi-generation grain results from adding the grain computed independently for each intensity interval.

**comp_model_value**[ c ][ i ][ j ] represents each one of the model values present for the colour component c and the intensity interval i. The set of model values has different meaning depending on the value of model_id. The value of comp_model_value[ c ][ i ][ j ] shall be constrained as follows, and may be additionally constrained as specified elsewhere in this subclause.

– If model_id is equal to 0, comp_model_value[ c ][ i ][ j ] shall be in the range of 0 to $2^{filmGrainBitDepth[\,c\,]} - 1$, inclusive.

– Otherwise (model_id is equal to 1), comp_model_value[ c ][ i ][ j ] shall be in the range of $-2^{(\,filmGrainBitDepth[\,c\,]\,-\,1\,)}$ to $2^{(\,filmGrainBitDepth[\,c\,]\,-\,1\,)} - 1$, inclusive.

Depending on model_id, the synthesis of the film grain is modelled as follows.

– If model_id is equal to 0, a frequency filtering model enables simulating the original film grain for c = 0..2, x = 0..PicWidthInSamples$_L$, and y = 0..PicHeightInSamples$_L$ as specified by:

```
G[ x, y, c ] = ( comp_model_value[ c ][ s ][ 0 ] * Q[ x, y, c ] + comp_model_value[ c ][ s ][ 5 ] *
                                    G[ x, y, c-1 ] ) >> log2_scale_factor          (D-20)
```

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where Q[ c ] is a two-dimensional random process generated by filtering 16x16 blocks gaussRv with random-value elements $gaussRv_{ij}$ generated with a normalized Gaussian distribution (independent and identically distributed Gaussian random variable samples with zero mean and unity variance) and where the value of an element G[ x, y, c-1 ] used in the right-hand side of the equation is inferred to be equal to 0 when c-1 is less than 0.

NOTE 5 – A normalized Gaussian random value can be generated from two independent, uniformly distributed random values over the interval from 0 to 1 (and not equal to 0), denoted as $uRv_0$ and $uRv_1$, using the Box-Muller transformation specified by

$$gaussRv_{ij} = \sqrt{-2 * Ln( uRv_0 )} * Cos( 2 * \pi * uRv_1 ) \quad \text{(D-21)}$$

where Ln( x ) is the natural logarithm of x (the base-e logarithm, where e is natural logarithm base constant 2.718 281 828...), Cos( x ) is the trigonometric cosine function operating on an argument x in units of radians, and π is Archimedes' constant 3.141 592 653....

The band-pass filtering of blocks gaussRv may be performed in the discrete cosine transform (DCT) domain as follows:

```
for( y = 0; y < 16; y++ )
    for( x = 0; x < 16; x++ )
        if( ( x < comp_model_value[ c ][ s ][ 3 ]  &&  y < comp_model_value[ c ][ s ][ 4 ] )  ||
          x > comp_model_value[ c ][ s ][ 1 ]  ||  y > comp_model_value[ c ][ s ][ 2 ] )
            gaussRv[ x, y ] = 0
filteredRv = IDCT16x16( gaussRv )
```

(D-22)

where IDCT16x16( z ) refers to a unitary inverse discrete cosine transformation (IDCT) operating on a 16x16 matrix argument z as specified by

$$IDCT16x16( z ) = r * z * r^T \quad \text{(D-23)}$$

where the superscript T indicates a matrix transposition and r is the 16x16 matrix with elements $r_{ij}$ specified by

$$r_{ij} = \frac{( ( i == 0 ) ? 1 : \sqrt{2} )}{4} Cos\left( \frac{i * ( 2 * j + 1 ) * \pi}{32} \right) \quad \text{(D-24)}$$

where Cos( x ) is the trigonometric cosine function operating on an argument x in units of radians and π is Archimedes' constant 3.141 592 653.

Q[ c ] is formed by the frequency-filtered blocks filteredRv.

NOTE 6 – Coded model values are based on blocks of 16x16, but a decoder implementation may use other block sizes. For example, decoders implementing the IDCT on 8x8 blocks, should down-convert by a factor of two the set of coded model values comp_model_value[ c ][ s ][ i ] for i equal to 1..4.

NOTE 7 – To reduce the degree of visible blocks that can result from mosaicing the frequency-filtered blocks filteredRv, decoders may apply a low-pass filter to the boundaries between frequency-filtered blocks.

– Otherwise (model_id is equal to 1), an auto-regression model enables simulating the original film grain for c = 0..2, x = 0..$PicWidthInSamples_L$, and y = 0..$PicHeightInSamples_L$ as specified by

```
G[ x, y, c ] = ( comp_model_value[ c ][ s ][ 0 ] * n[ x, y, c ] +
    comp_model_value[ c ][ s ][ 1 ] * ( G[ x-1, y, c ] + ( ( comp_model_value[ c ][ s ][ 4 ] * G[ x, y-1, c ] )  >>
        log2_scale_factor ) ) +
    comp_model_value[ c ][ s ][ 3 ] * ( ( ( comp_model_value[ c ][ s ][ 4 ] * G[ x-1, y-1, c ] ) >>
        log2_scale_factor ) + G[ x+1, y-1, c ] ) +
    comp_model_value[ c ][ s ][ 5 ] * ( G[ x-2, y, c ] +
        ( ( comp_model_value[ c ][ s ][ 4 ] * comp_model_value[ c ][ s ][ 4 ] * G[ x, y-2, c ] ) >>
            ( 2 * log2_scale_factor ) ) ) +
    comp_model_value[ c ][ s ][ 2 ] * G[ x, y, c-1 ] ) >> log2_scale_factor
```

(D-25)

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where n[ x, y, c ] is a random value with normalized Gaussian distribution (independent and identically distributed Gaussian random variable samples with zero mean and unity variance for each value of x, y, and c) and where the value of an element G[ x, y, c ] used in the right-hand side of the equation is inferred to be equal to 0 when any of the following conditions are true:

– x is less than 0,
– y is less than 0,
– x is greater than or equal to $PicWidthInSamples_L$,
– c is less than 0.

**comp_model_value**[ c ][ i ][ 0 ] provides the first model value for the model as specified by model_id. comp_model_value[ c ][ i ][ 0 ] corresponds to the standard deviation of the Gaussian noise term in the generation functions specified in Equations D-20 through D-23.

**comp_model_value**[ c ][ i ][ 1 ] provides the second model value for the model as specified by model_id. comp_model_value[ c ][ i ][ 1 ] shall be greater than or equal to 0 and less than 16.

When not present in the film grain characteristics SEI message, comp_model_value[ c ][ i ][ 1 ] shall be inferred as follows.

– If model_id is equal to 0, comp_model_value[ c ][ i ][ 1 ] shall be inferred to be equal to 8.
– Otherwise (model_id is equal to 1), comp_model_value[ c ][ i ][ 1 ] shall be inferred to be equal to 0.

comp_model_value[ c ][ i ][ 1 ] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[ c ][ i ][ 1 ] indicates the horizontal high cut frequency to be used to filter the DCT of a block of 16x16 random values.
– Otherwise (model_id is equal to 1), comp_model_value[ c ][ i ][ 1 ] indicates the first order spatial correlation for neighbouring samples (x-1, y) and (x, y-1).

**comp_model_value**[ c ][ i ][ 2 ] provides the third model value for the model as specified by model_id. comp_model_value[ c ][ i ][ 2 ] shall be greater than or equal to 0 and less than 16.

When not present in the film grain characteristics SEI message, comp_model_value[ c ][ i ][ 2 ] shall be inferred as follows.

– If model_id is equal to 0, comp_model_value[ c ][ i ][ 2 ] shall be inferred to be equal to comp_model_value[ c ][ i ][ 1 ].
– Otherwise (model_id is equal to 0), comp_model_value[ c ][ i ][ 2 ] shall be inferred to be equal to 0.

comp_model_value[ c ][ i ][ 2 ] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[ c ][ i ][ 2 ] indicates the vertical high cut frequency to be used to filter the DCT of a block of 16x16 random values.
– Otherwise (model_id is equal to 1), comp_model_value[ c ][ i ][ 2 ] indicates the colour correlation between consecutive colour components.

**comp_model_value[** c ][ i ][ 3 ] provides the fourth model value for the model as specified by model_id. comp_model_value[ c ][ i ][ 3 ] shall be greater than or equal to 0 and less than or equal to comp_model_value[ c ][ i ][ 1 ].

When not present in the film grain characteristics SEI message, comp_model_value[ c ][ i ][ 3 ] shall be inferred to be equal to 0.

comp_model_value[ c ][ i ][ 3 ] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[ c ][ i ][ 3 ] indicates the horizontal low cut frequency to be used to filter the DCT of a block of 16x16 random values.
– Otherwise (model_id is equal to 1), comp_model_value[ c ][ i ][ 3 ] indicates the first order spatial correlation for neighbouring samples (x-1, y-1) and (x+1, y-1).

**comp_model_value**[ c ][ i ][ 4 ] provides the fifth model value for the model as specified by model_id. comp_model_value[ c ][ i ][ 4] shall be greater than or equal to 0 and less than or equal to comp_model_value[ c ][ i ][ 2 ].

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When not present in the film grain characteristics SEI message, comp_model_value[ c ][ i ][ 4 ] shall be inferred to be equal to model_id.

comp_model_value[ c ][ i ][ 4 ] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[ c ][ i ][ 4 ] indicates the vertical low cut frequency to be used to filter the DCT of a block of 16x16 random values.

– Otherwise (model_id is equal to 1), comp_model_value[ c ][ i ][ 4 ] indicates the aspect ratio of the modelled grain.

**comp_model_value**[ c ][ i ][ 5 ] provides the sixth model value for the model as specified by model_id. When not present in the film grain characteristics SEI message, comp_model_value[ c ][ i ][ 5 ] shall be inferred to be equal to 0.

comp_model_value[ c ][ i ][ 5 ] is interpreted as follows.

– If model_id is equal to 0, comp_model_value[ c ][ i ][ 5 ] indicates the colour correlation between consecutive colour components.

– Otherwise (model_id is equal to 1), comp_model_value[ c ][ i ][ 5 ] indicates the second order spatial correlation for neighbouring samples (x, y-2) and (x-2, y).

**film_grain_characteristics_repetition_period** specifies the persistence of the film grain characteristics SEI message and may specify a picture order count interval within which another film grain characteristics SEI message or the end of the coded video sequence shall be present in the bitstream. The value of film_grain_characteristics_repetition_period shall be in the range 0 to 16 384, inclusive.

film_grain_characteristics_repetition_period equal to 0 specifies that the film grain characteristics SEI message applies to the current decoded picture only.

film_grain_characteristics_repetition_period equal to 1 specifies that the film grain characteristics SEI message persists in output order until any of the following conditions are true.

– A new coded video sequence begins, or

– A picture in an access unit containing a film grain characteristics SEI message that is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ).

film_grain_characteristics_repetition_period greater than 1 specifies that the film grain characteristics SEI message persists until any of the following conditions are true.

– A new coded video sequence begins, or

– A picture in an access unit containing a film grain characteristics SEI message is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ) and less than or equal to PicOrderCnt( CurrPic ) + film_grain_characteristics_repetition_period.

film_grain_characteristics_repetition_period greater than 1 indicates that another film grain characteristics SEI message shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ) and less than or equal to PicOrderCnt( CurrPic ) + film_grain_characteristics_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

### D.2.21 Deblocking filter display preference SEI message semantics

This SEI message provides the decoder with an indication of whether the display of the cropped result of the deblocking filter process specified in subclause 8.7 or of the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.13 is preferred by the encoder for the display of each decoded picture that is output.

NOTE 1 – The display process is not specified in this International Standard. The means by which an encoder determines what to indicate as its preference expressed in a deblocking filter display preference SEI message is also not specified in this International Standard, and the expression of an expressed preference in a deblocking filter display preference SEI message does not impose any requirement on the display process.

**deblocking_display_preference_cancel_flag** equal to 1 indicates that the SEI message cancels the persistence of any previous deblocking filter display preference SEI message in output order. deblocking_display_preference_cancel_flag equal to 0 indicates that a display_prior_to_deblocking_preferred_flag and deblocking_display_preference_repetition_period follow.

NOTE 2 – In the absence of the deblocking filter display preference SEI message, or after the receipt of a deblocking filter display preference SEI message in which deblocking_display_preference_cancel_flag is equal to 1, the decoder should infer that the display of the cropped result of the deblocking filter process specified in subclause 8.7 is preferred over the display of the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.13 for the display of each decoded picture that is output.

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**display_prior_to_deblocking_preferred_flag** equal to 1 indicates that the encoder preference is for the display process (which is not specified in this International Standard) to display the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.13 rather than the cropped result of the deblocking filter process specified in subclause 8.7 for each picture that is cropped and output as specified in Annex C. display_prior_to_deblocking_preferred_flag equal to 0 indicates that the encoder preference is for the display process (which is not specified in this International Standard) to display the cropped result of the deblocking filter process specified in subclause 8.7 rather than the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.13 for each picture that is cropped and output as specified in Annex C.

NOTE 3 – The presence or absence of the deblocking filter display preference SEI message and the value of display_prior_to_deblocking_preferred_flag does not affect the requirements of the decoding process specified in this International Standard. Rather, it only provides an indication of when, in addition to fulfilling the requirements of this International Standard for the decoding process, enhanced visual quality might be obtained by performing the display process (which is not specified in this International Standard) in an alternative fashion. Encoders that use the deblocking filter display preference SEI message should be designed with an awareness that unless the encoder restricts its use of the DPB capacity specified in Annex A for the profile and level in use, some decoders may not have sufficient memory capacity for the storage of the result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.13 in addition to the storage of the result of the deblocking filter process specified in subclause 8.7 when reordering and delaying pictures for display, and such decoders would therefore not be able to benefit from the preference indication. By restricting its use of the DPB capacity, an encoder can be able to use at least half of the DPB capacity specified in Annex A while allowing the decoder to use the remaining capacity for storage of unfiltered pictures that have been indicated as preferable for display until the output time arrives for those pictures.

**dec_frame_buffering_constraint_flag** equal to 1 indicates that the use of the frame buffering capacity of the HRD decoded picture buffer (DPB) as specified by max_dec_frame_buffering has been constrained such that the coded video sequence will not require a decoded picture buffer with more than Max( 1, max_dec_frame_buffering ) frame buffers to enable the output of the decoded filtered or unfiltered pictures, as indicated by the deblocking filter display preference SEI messages, at the output times specified by the dpb_output_delay of the picture timing SEI messages. dec_frame_buffering_constraint_flag equal to 0 indicates that the use of the frame buffering capacity in the HRD may or may not be constrained in the manner that would be indicated by dec_frame_buffering_constraint_flag equal to 1.

For purposes of determining the constraint imposed when dec_frame_buffering_constraint_flag is equal to 1, the quantity of frame buffering capacity used at any given point in time by each frame buffer of the DPB that contains a picture shall be derived as follows:

- If both of the following criteria are satisfied for the frame buffer, the frame buffer is considered to use two frame buffers of capacity for its storage.
  - The frame buffer contains a frame or one or more fields that is marked as "used for reference", and
  - The frame buffer contains a picture for which both of the following criteria are fulfilled.
    - The HRD output time of the picture is greater than the given point in time, and
    - It has been indicated in a deblocking filter display preference SEI message that the encoder preference for the picture is for the display process to display the cropped result of the picture construction process prior to the deblocking filter process specified in subclause 8.5.13 rather than the cropped result of the deblocking filter process specified in subclause 8.7, and
- Otherwise, the frame buffer is considered to use one frame buffer of DPB capacity for its storage.

When dec_frame_buffering_constraint_flag is equal to 1, the frame buffering capacity used by all of the frame buffers in the DPB that contain pictures, as derived in this manner, shall not be greater than Max( 1, max_dec_frame_buffering ) during the operation of the HRD for the coded video sequence.

The value of dec_frame_buffering_constraint_flag shall be the same in all deblocking filter display preference SEI messages of the coded video sequence.

**deblocking_display_preference_repetition_period** specifies the persistence of the film grain characteristics SEI message and may specify a picture order count interval within which another film grain characteristics SEI message or the end of the coded video sequence shall be present in the bitstream. The value of deblocking_display_preference_repetition_period shall be in the range 0 to 16 384, inclusive.

deblocking_display_preference_repetition_period equal to 0 specifies that the deblocking filter display preference SEI message applies to the current decoded picture only.

deblocking_display_preference_repetition_period equal to 1 specifies that the deblocking filter display preference SEI message persists in output order until any of the following conditions are true.

- A new coded video sequence begins

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– A picture in an access unit containing a deblocking filter display preference SEI message that is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ).

deblocking_display_preference_repetition_period greater than 1 specifies that the deblocking filter display preference SEI message persists until any of the following conditions are true.

– A new coded video sequence begins

– A picture in an access unit containing a deblocking filter display preference SEI message is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ) and less than or equal to PicOrderCnt( CurrPic ) + deblocking_display_preference_repetition_period.

deblocking_display_preference_repetition_period greater than 1 indicates that another deblocking filter display preference SEI message shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ) and less than or equal to PicOrderCnt( CurrPic ) + deblocking_display_preference_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

### D.2.22 Stereo video information SEI message semantics

This SEI message provides the decoder with an indication that the entire coded video sequence consists of pairs of pictures forming stereo-view content.

The stereo video information SEI message shall not be present in any access unit of a coded video sequence unless a stereo video information SEI message is present in the first access unit of the coded video sequence.

**field_views_flag** equal to 1 indicates that all pictures in the current coded video sequence are fields and all fields of a particular parity are considered a left view and all fields of the opposite parity are considered a right view for stereo-view content. field_views_flag equal to 0 indicates that all pictures in the current coded video sequence are frames and alternating frames in output order represent a view of a stereo view. The value of field_views_flag shall be the same in all stereo video information SEI messages within a coded video sequence.

When the stereo video information SEI message is present and field_views_flag is equal to 1, the left view and right view of a stereo video pair shall be coded as a complementary field pair, the display time of the first field of the field pair in output order should be delayed to coincide with the display time of the second field of the field pair in output order, and the spatial locations of the samples in each individual field should be interpreted for display purposes as representing complete pictures as shown in Figure 6-1 rather than as spatially-distinct fields within a frame as shown in Figure 6-2.

NOTE – The display process is not specified in this International Standard.

**top_field_is_left_view_flag** equal to 1 indicates that the top fields in the coded video sequence represent a left view and the bottom fields in the coded video sequence represent a right view. top_field_is_left_view_flag equal to 0 indicates that the bottom fields in the coded video sequence represent a left view and the top fields in the coded video sequence represent a right view. When present, the value of top_field_is_left_view_flag shall be the same in all stereo video information SEI messages within a coded video sequence.

**current_frame_is_left_view_flag** equal to 1 indicates that the current picture is the left view of a stereo-view pair. current_frame_is_left_view_flag equal to 0 indicates that the current picture is the right view of a stereo-view pair.

**next_frame_is_second_view_flag** equal to 1 indicates that the current picture and the next picture in output order form a stereo-view pair, and the display time of the current picture should be delayed to coincide with the display time of the next picture in output order. next_frame_is_second_view_flag equal to 0 indicates that the current picture and the previous picture in output order form a stereo-view pair, and the display time of the current picture should not be delayed for purposes of stereo-view pairing.

**left_view_self_contained_flag** equal to 1 indicates that no inter prediction operations within the decoding process for the left-view pictures of the coded video sequence refer to reference pictures that are right-view pictures. left_view_self_contained_flag equal to 0 indicates that some inter prediction operations within the decoding process for the left-view pictures of the coded video sequence may or may not refer to reference pictures that are right-view pictures. Within a coded video sequence, the value of left_view_self_contained_flag in all stereo video information SEI messages shall be the same.

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**right_view_self_contained_flag** equal to 1 indicates that no inter prediction operations within the decoding process for the right-view pictures of the coded video sequence refer to reference pictures that are left-view pictures. right_view_self_contained_flag equal to 0 indicates that some inter prediction operations within the decoding process for the right-view pictures of the coded video sequence may or may not refer to reference pictures that are left-view pictures. Within a coded video sequence, the value of right_view_self_contained_flag in all stereo video information SEI messages shall be the same.

### D.2.23 Post-filter hint SEI message semantics

This SEI message provides the coefficients of a post-filter or correlation information for the design of a post-filter for potential use in post-processing of the output decoded pictures to obtain improved displayed quality.

**filter_hint_size_y** specifies the vertical size of the filter coefficient or correlation array. The value of filter_hint_size_y shall be in the range of 1 to 15, inclusive.

**filter_hint_size_x** specifies the horizontal size of the filter coefficient or correlation array. The value of filter_hint_size_x shall be in the range of 1 to 15, inclusive.

**filter_hint_type** identifies the type of the transmitted filter hints as specified in Table D-7. The value of filter_hint_type shall be in the range of 0 to 2, inclusive. Decoders that conform to this International Standard shall ignore post-filter hint SEI messages having filter_hint_type equal to the reserved value 3.

**Table D-7 – filter_hint_type values**

| Value | Description |
|---|---|
| 0 | coefficients of a 2D FIR filter |
| 1 | coefficients of two 1D FIR filters |
| 2 | cross-correlation matrix |
| 3 | Reserved |

**filter_hint[** colour_component **][** cy **][** cx **]** specifies a filter coefficient or an element of a cross-correlation matrix between original and decoded signal with 16-bit precision. colour_component specifies the related colour component. cy represents a counter in vertical direction, cx represents a counter in horizontal direction. Depending on filter_hint_type, the following applies.

– If filter_hint_type is equal to 0, the coefficients of a 2-dimensional FIR filter with the size of filter_hint_size_y * filter_hint_size_x are transmitted.

– Otherwise, if filter_hint_type is equal to 1, the filter coefficients of two 1-dimensional FIR filters are transmitted. In this case, filter_hint_size_y shall be equal to 2. The index cy = 0 specifies the filter coefficients of the horizontal filter and cy = 1 specifies the filter coefficients of the vertical filter. In the filtering process, the horizontal filter shall be applied first and the result shall be filtered by the vertical filter.

– Otherwise (filter_hint_type is equal to 2), the transmitted hints specify a cross-correlation matrix between the original signal s and the decoded signal s'.

NOTE 1 - The cross-correlation matrix for a related colour component with the size of filter_hint_size_y * filter_hint_size_x is defined as follows:

$$\text{filter_hint}(\text{cy},\text{cx}) = \frac{1}{h \cdot w} \sum_{m=0}^{h-1} \sum_{n=0}^{w-1} s(m,n) \cdot s'(m + \text{cy} - \mathit{offset_y}, n + \text{cx} - \mathit{offset_x}) \qquad \text{(D-26)}$$

where *s* denotes the original frame, *s'* denotes the decoded frame, *h* denotes the vertical height of the related colour component, *w* denotes the horizontal width of the related colour component, *offset_y* is equal to (filter_hint_size_y >> 1), *offset_x* is equal to (filter_hint_size_x >> 1), 0 <= cy < filter_hint_size_y and 0 <= cx < filter_hint_size_x.

NOTE 2 - A decoder can derive a Wiener post-filter from the cross-correlation matrix of original and decoded signal and the auto-correlation matrix of the decoded signal.

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**additional_extension_flag** equal to 0 indicates that no additional data follows within the post-filter hint SEI message. The value of additional_extension_flag shall be equal to 0. The value of 1 for additional_extension_flag is reserved for future use by ITU-T | ISO/IEC. Decoders that conform to this International Standard shall ignore all data that follows the value of 1 for additional_extension_flag in a post-filter hint SEI message.

### D.2.24 Tone mapping information SEI message semantics

This SEI message provides information to enable remapping of the colour samples of the output decoded pictures for customization to particular display environments. The remapping process maps coded sample values in the RGB colour space (specified in Annex E) to target sample values. All mappings are expressed in the RGB colour space and should be applied to each RGB component separately.

**tone_map_id** contains an identifying number that may be used to identify the purpose of the tone mapping model. The value of tone_map_id shall be in the range of 0 to $2^{32} - 1$, inclusive.

Values of tone_map_id from 0 to 255 and from 512 to $2^{31} - 1$ may be used as determined by the application. Values of tone_map_id from 256 to 511 and from $2^{31}$ to $2^{32} - 1$ are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore (remove from the bitstream and discard) all tone mapping information SEI messages containing a value of tone_map_id in the range of 256 to 511 or in the range of $2^{31}$ to $2^{32} - 1$, and bitstreams shall not contain such values.

NOTE 1 – The tone_map_id can be used to support tone mapping operations that are suitable for different display scenarios. For example, different values of tone_map_id may correspond to different display bit depths.

**tone_map_cancel_flag** equal to 1 indicates that the tone mapping information SEI message cancels the persistence of any previous tone mapping information SEI message in output order. tone_map_cancel_flag equal to 0 indicates that tone mapping information follows.

**tone_map_repetition_period** specifies the persistence of the tone mapping information SEI message and may specify a picture order count interval within which another tone mapping information SEI message with the same value of tone_map _id or the end of the coded video sequence shall be present in the bitstream. The value of tone_map_repetition_period shall be in the range of 0 to 16 384, inclusive.

tone_map_repetition_period equal to 0 specifies that the tone map information applies to the current decoded picture only.

tone_map_repetition_period equal to 1 specifies that the tone map information persists in output order until any of the following conditions are true.

– A new coded video sequence begins

– A picture in an access unit containing a tone mapping information SEI message with the same value of tone_map_id is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ).

tone_map_repetition_period equal to 0 or equal to 1 indicates that another tone mapping information SEI message with the same value of tone_map_id may or may not be present.

tone_map_repetition_period greater than 1 specifies that the tone map information persists until any of the following conditions are true.

– A new coded video sequence begins

– A picture in an access unit containing a tone mapping information SEI message with the same value of tone_map_id is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ) and less than or equal to PicOrderCnt( CurrPic ) + tone_map_repetition_period.

tone_map_repetition_period greater than 1 indicates that another tone mapping information SEI message with the same value of tone_map_id shall be present for a picture in an access unit that is output having PicOrderCnt( ) greater than PicOrderCnt( CurrPic ) and less than or equal to PicOrderCnt( CurrPic ) + tone_map_repetition_period; unless the bitstream ends or a new coded video sequence begins without output of such a picture.

**coded_data_bit_depth** specifies the $\text{BitDepth}_Y$ of the luma component of the coded video sequence. It is used to identify the tone mapping information SEI message that is intended for use with the coded video sequence. If tone mapping information SEI messages are present that have coded_data_bit_depth that is not equal to $\text{BitDepth}_Y$, these refer to the hypothetical result of a transcoding operation performed to convert the coded video to the $\text{BitDepth}_Y$ corresponding to the value of coded_data_bit_depth.

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The value of coded_data_bit_depth shall be in the range of 8 to 14, inclusive. Values of coded_data_bit_depth from 0 to 7 and from 15 to 255 are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore (remove from the bitstream and discard) all tone mapping SEI messages that contain a coded_data_bit_depth in the range of 0 to 7 or in the range of 15 to 255, and bitstreams shall not contain such values.

**target_bit_depth** specifies the bit depth of the output of the dynamic range mapping function (or tone mapping function) described by the tone mapping information SEI message. The tone mapping function specified with a particular target_bit_depth is suggested to be reasonable for all display bit depths that are equal to or less than the target_bit_depth.

The value of target_bit_depth shall be in the range of 1 to 16, inclusive. Values of target_bit_depth equal to 0 and in the range of 17 to 255 are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore (remove from the bitstream and discard) all tone mapping SEI messages that contain a value of target_bit_depth equal to 0 or in the range of 17 to 255, and bitstreams shall not contain such values.

**model_id** specifies the model utilized for mapping the coded data into the target_bit_depth range. Values greater than 3 are reserved for future use by ITU-T | ISO/IEC. Decoders shall ignore (remove from the bitstream and discard) all tone mapping SEI messages that contain a value of model_id greater than 3, and bitstreams shall not contain such values.

NOTE 2 – A model_id of 0 corresponds to a linear mapping with clipping; a model_id of 1 corresponds to a sigmoidal mapping; a model_id of 2 corresponds to a user-defined table mapping, and a model_id of 3 corresponds to a piece-wise linear mapping.

**min_value** specifies the RGB sample value in the coded data that maps to the minimum value in the signalled target_bit_depth. It is used in combination with the max_value parameter. All values in the coded data that are less than or equal to min_value are mapped to this minimum value in the target_bit_depth representation.

**max_value** specifies the RGB sample value in the coded data that maps to the maximum value in the signalled target_bit_depth. It is used in combination with the min_value parameter. All values in the coded data that are larger than or equal to max_value are mapped to this maximum value in the target_bit_depth representation.

**sigmoid_midpoint** specifies the RGB sample value of the coded data that is mapped to the center point of the target_bit_depth representation. It is used in combination with the sigmoid_width parameter.

**sigmoid_width** specifies the distance between two coded data values that approximately correspond to the 5% and 95% values of the target_bit_depth representation, respectively. It is used in combination with the sigmoid_midpoint parameter and is interpreted according to the following function:

$$f(i) = Round\left( \frac{2^{target_bit_depth} - 1}{1 + \exp\left( \frac{-6 * (i - sigmoid_midpoint)}{sigmoid_width} \right)} \right) \quad for\ i = 0, \cdots, (2^{coded_bit_depth} - 1) \qquad \text{(D-27)}$$

where *f*( i ) denotes the function that maps an RGB sample value i from the coded data to a resulting RGB sample value in the target_bit_depth representation.

**start_of_coded_interval**[ i ] specifies the beginning point of an interval in the coded data such that all RGB sample values that are greater than or equal to start_of_coded_interval[ i ] and less than start_of_coded_interval[ i + 1 ] are mapped to i in the target bit depth representation. The value of start_of_coded_interval[ $2^{target_bit_depth}$ ] is equal to $2^{coded_bit_depth}$. The number of bits used for the representation of the start_of_coded_interval is ( ( coded_data_bit_depth + 7 ) >> 3 ) << 3.

**num_pivots** specifies the number of pivot points in the piece-wise linear mapping function without counting the two default end points, (0, 0) and ($2^{coded_data_bit_depth} - 1$, $2^{target_bit_depth} - 1$) .

**coded_pivot_value**[ i ] specifies the value in the coded_bit_depth corresponding to the i-th pivot point. The number of bits used for the representation of the coded_pivot_value is ( ( coded_data_bit_depth + 7 ) >> 3 ) << 3.

**target_pivot_value**[ i ] specifies the value in the reference target_bit_depth corresponding to the i-th pivot point. The number of bits used for the representation of the target_pivot_value is ( ( target_bit_depth + 7 ) >> 3 ) << 3.

### D.2.25 Reserved SEI message semantics

This message consists of data reserved for future backward-compatible use by ITU-T | ISO/IEC. Encoders conforming to this International Standard shall not send reserved SEI messages until and unless the use of such messages has been specified by ITU-T | ISO/IEC. Decoders conforming to this International Standard that encounter reserved SEI messages shall discard their content without effect on the decoding process, except as specified in future Recommendations | International Standards specified by ITU-T | ISO/IEC.

**reserved_sei_message_payload_byte** is a byte reserved for future use by ITU-T | ISO/IEC.

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# Annex E
# Video usability information

(This annex forms an integral part of this International Standard)

This Annex specifies syntax and semantics of the VUI parameters of the sequence parameter sets.

VUI parameters are not required for constructing the luma or chroma samples by the decoding process. Conforming decoders are not required to process this information for output order conformance to this International Standard (see Annex C for the specification of conformance). Some VUI parameters are required to check bitstream conformance and for output timing decoder conformance.

In Annex E, specification for presence of VUI parameters is also satisfied when those parameters (or some subset of them) are conveyed to decoders (or to the HRD) by other means not specified by this International Standard. When present in the bitstream, VUI parameters shall follow the syntax and semantics specified in subclauses 7.3.2.1 and 7.4.2.1 and this annex. When the content of VUI parameters is conveyed for the application by some means other than presence within the bitstream, the representation of the content of the VUI parameters is not required to use the same syntax specified in this annex. For the purpose of counting bits, only the appropriate bits that are actually present in the bitstream are counted.

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## E.1 VUI syntax

### E.1.1 VUI parameters syntax

| vui_parameters( ) { | C | Descriptor |
|---|---|---|
| **aspect_ratio_info_present_flag** | 0 | u(1) |
| if( aspect_ratio_info_present_flag ) { | | |
| **aspect_ratio_idc** | 0 | u(8) |
| if( aspect_ratio_idc == Extended_SAR ) { | | |
| **sar_width** | 0 | u(16) |
| **sar_height** | 0 | u(16) |
| } | | |
| } | | |
| **overscan_info_present_flag** | 0 | u(1) |
| if( overscan_info_present_flag ) | | |
| **overscan_appropriate_flag** | 0 | u(1) |
| **video_signal_type_present_flag** | 0 | u(1) |
| if( video_signal_type_present_flag ) { | | |
| **video_format** | 0 | u(3) |
| **video_full_range_flag** | 0 | u(1) |
| **colour_description_present_flag** | 0 | u(1) |
| if( colour_description_present_flag ) { | | |
| **colour_primaries** | 0 | u(8) |
| **transfer_characteristics** | 0 | u(8) |
| **matrix_coefficients** | 0 | u(8) |
| } | | |
| } | | |
| **chroma_loc_info_present_flag** | 0 | u(1) |
| if( chroma_loc_info_present_flag ) { | | |
| **chroma_sample_loc_type_top_field** | 0 | ue(v) |
| **chroma_sample_loc_type_bottom_field** | 0 | ue(v) |
| } | | |
| **timing_info_present_flag** | 0 | u(1) |
| if( timing_info_present_flag ) { | | |
| **num_units_in_tick** | 0 | u(32) |
| **time_scale** | 0 | u(32) |
| **fixed_frame_rate_flag** | 0 | u(1) |
| } | | |
| **nal_hrd_parameters_present_flag** | 0 | u(1) |
| if( nal_hrd_parameters_present_flag ) | | |
| hrd_parameters( ) | | |
| **vcl_hrd_parameters_present_flag** | 0 | u(1) |
| if( vcl_hrd_parameters_present_flag ) | | |
| hrd_parameters( ) | | |
| if( nal_hrd_parameters_present_flag \|\| vcl_hrd_parameters_present_flag ) | | |
| **low_delay_hrd_flag** | 0 | u(1) |

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| | | |
|---|---|---|
| **pic_struct_present_flag** | 0 | u(1) |
| **bitstream_restriction_flag** | 0 | u(1) |
| if( bitstream_restriction_flag ) { | | |
| **motion_vectors_over_pic_boundaries_flag** | 0 | u(1) |
| **max_bytes_per_pic_denom** | 0 | ue(v) |
| **max_bits_per_mb_denom** | 0 | ue(v) |
| **log2_max_mv_length_horizontal** | 0 | ue(v) |
| **log2_max_mv_length_vertical** | 0 | ue(v) |
| **num_reorder_frames** | 0 | ue(v) |
| **max_dec_frame_buffering** | 0 | ue(v) |
| } | | |
| } | | |

### E.1.2 HRD parameters syntax

| hrd_parameters( ) { | C | Descriptor |
|---|---|---|
| **cpb_cnt_minus1** | 0 | ue(v) |
| **bit_rate_scale** | 0 | u(4) |
| **cpb_size_scale** | 0 | u(4) |
| for( SchedSelIdx = 0; SchedSelIdx <= cpb_cnt_minus1; SchedSelIdx++ ) { | | |
| **bit_rate_value_minus1[** SchedSelIdx **]** | 0 | ue(v) |
| **cpb_size_value_minus1[** SchedSelIdx **]** | 0 | ue(v) |
| **cbr_flag[** SchedSelIdx **]** | 0 | u(1) |
| } | | |
| **initial_cpb_removal_delay_length_minus1** | 0 | u(5) |
| **cpb_removal_delay_length_minus1** | 0 | u(5) |
| **dpb_output_delay_length_minus1** | 0 | u(5) |
| **time_offset_length** | 0 | u(5) |
| } | | |

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## E.2 VUI semantics

### E.2.1 VUI parameters semantics

**aspect_ratio_info_present_flag** equal to 1 specifies that aspect_ratio_idc is present. aspect_ratio_info_present_flag equal to 0 specifies that aspect_ratio_idc is not present.

**aspect_ratio_idc** specifies the value of the sample aspect ratio of the luma samples. Table E-1 shows the meaning of the code. When aspect_ratio_idc indicates Extended_SAR, the sample aspect ratio is represented by sar_width and sar_height. When the aspect_ratio_idc syntax element is not present, aspect_ratio_idc value shall be inferred to be equal to 0.


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**Table E-1 – Meaning of sample aspect ratio indicator**

| aspect_ratio_idc | Sample aspect ratio | (informative)<br>Examples of use |
|---|---|---|
| 0 | Unspecified | |
| 1 | 1:1<br>("square") | 1280x720 16:9 frame without horizontal overscan<br>1920x1080 16:9 frame without horizontal overscan (cropped from 1920x1088)<br>640x480 4:3 frame without horizontal overscan |
| 2 | 12:11 | 720x576 4:3 frame with horizontal overscan<br>352x288 4:3 frame without horizontal overscan |
| 3 | 10:11 | 720x480 4:3 frame with horizontal overscan<br>352x240 4:3 frame without horizontal overscan |
| 4 | 16:11 | 720x576 16:9 frame with horizontal overscan<br>528x576 4:3 frame without horizontal overscan |
| 5 | 40:33 | 720x480 16:9 frame with horizontal overscan<br>528x480 4:3 frame without horizontal overscan |
| 6 | 24:11 | 352x576 4:3 frame without horizontal overscan<br>480x576 16:9 frame with horizontal overscan |
| 7 | 20:11 | 352x480 4:3 frame without horizontal overscan<br>480x480 16:9 frame with horizontal overscan |
| 8 | 32:11 | 352x576 16:9 frame without horizontal overscan |
| 9 | 80:33 | 352x480 16:9 frame without horizontal overscan |
| 10 | 18:11 | 480x576 4:3 frame with horizontal overscan |
| 11 | 15:11 | 480x480 4:3 frame with horizontal overscan |
| 12 | 64:33 | 528x576 16:9 frame without horizontal overscan |
| 13 | 160:99 | 528x480 16:9 frame without horizontal overscan |
| 14 | 4:3 | 1440x1080 16:9 frame without horizontal overscan |
| 15 | 3:2 | 1280x1080 16:9 frame without horizontal overscan |
| 16 | 2:1 | 960x1080 16:9 frame without horizontal overscan |
| 17..254 | Reserved | |
| 255 | Extended_SAR | |

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**sar_width** indicates the horizontal size of the sample aspect ratio (in arbitrary units).

**sar_height** indicates the vertical size of the sample aspect ratio (in the same arbitrary units as sar_width).

sar_width and sar_height shall be relatively prime or equal to 0. When aspect_ratio_idc is equal to 0 or sar_width is equal to 0 or sar_height is equal to 0, the sample aspect ratio shall be considered unspecified by this International Standard.

**overscan_info_present_flag** equal to 1 specifies that the overscan_appropriate_flag is present. When overscan_info_present_flag is equal to 0 or is not present, the preferred display method for the video signal is unspecified.

**overscan_appropriate_flag** equal to 1 indicates that the cropped decoded pictures output are suitable for display using overscan. overscan_appropriate_flag equal to 0 indicates that the cropped decoded pictures output contain visually important information in the entire region out to the edges of the cropping rectangle of the picture, such that the cropped decoded pictures output should not be displayed using overscan. Instead, they should be displayed using either an exact match between the display area and the cropping rectangle, or using underscan.

NOTE 1 – For example, overscan_appropriate_flag equal to 1 might be used for entertainment television programming, or for a live view of people in a videoconference, and overscan_appropriate_flag equal to 0 might be used for computer screen capture or security camera content.

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**video_signal_type_present_flag** equal to 1 specifies that video_format, video_full_range_flag and colour_description_present_flag are present. video_signal_type_present_flag equal to 0, specify that video_format, video_full_range_flag and colour_description_present_flag are not present.

**video_format** indicates the representation of the pictures as specified in Table E-2, before being coded in accordance with this International Standard. When the video_format syntax element is not present, video_format value shall be inferred to be equal to 5.

**Table E-2 – Meaning of video_format**

| video_format | Meaning |
|---|---|
| 0 | Component |
| 1 | PAL |
| 2 | NTSC |
| 3 | SECAM |
| 4 | MAC |
| 5 | Unspecified video format |
| 6 | Reserved |
| 7 | Reserved |

**video_full_range_flag** indicates the black level and range of the luma and chroma signals as derived from $E'_Y$, $E'_{PB}$, and $E'_{PR}$ or $E'_R$, $E'_G$, and $E'_B$ analogue component signals.

When the video_full_range_flag syntax element is not present, the value of video_full_range_flag shall be inferred to be equal to 0.

**colour_description_present_flag** equal to 1 specifies that colour_primaries, transfer_characteristics and matrix_coefficients are present. colour_description_present_flag equal to 0 specifies that colour_primaries, transfer_characteristics and matrix_coefficients are not present.

**colour_primaries** indicates the chromaticity coordinates of the source primaries as specified in Table E-3 in terms of the CIE 1931 definition of x and y as specified by ISO/CIE 10527.

When the colour_primaries syntax element is not present, the value of colour_primaries shall be inferred to be equal to 2 (the chromaticity is unspecified or is determined by the application).

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**Table E-3 – Colour primaries**

| Value | Primaries | | | Informative Remark |
|---|---|---|---|---|
| 0 | Reserved | | | For future use by ITU-T \| ISO/IEC |
| 1 | primary<br>green<br>blue<br>red<br>white D65 | x<br>0.300<br>0.150<br>0.640<br>0.3127 | y<br>0.600<br>0.060<br>0.330<br>0.3290 | ITU-R Rec. BT.709-5<br>ITU-R Rec. BT.1361 conventional colour gamut system and extended colour gamut system<br>IEC 61966-2-4<br>Society of Motion Picture and Television Engineers RP 177 (1993) Annex B |
| 2 | Unspecified | | | Image characteristics are unknown or are determined by the application. |
| 3 | Reserved | | | For future use by ITU-T \| ISO/IEC |
| 4 | primary<br>green<br>blue<br>red<br>white C | x<br>0.21<br>0.14<br>0.67<br>0.310 | y<br>0.71<br>0.08<br>0.33<br>0.316 | ITU-R Rec. BT.470-6 System M (historical)<br>United States National Television System Committee 1953 Recommendation for transmission standards for colour television<br>United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20) |
| 5 | primary<br>green<br>blue<br>red<br>white D65 | x<br>0.29<br>0.15<br>0.64<br>0.3127 | y<br>0.60<br>0.06<br>0.33<br>0.3290 | ITU-R Rec. BT.470-6 System B, G (historical)<br>ITU-R Rec. BT.601-6 625<br>ITU-R Rec. BT.1358 625<br>ITU-R Rec. BT.1700 625 PAL and 625 SECAM |
| 6 | primary<br>green<br>blue<br>red<br>white D65 | x<br>0.310<br>0.155<br>0.630<br>0.3127 | y<br>0.595<br>0.070<br>0.340<br>0.3290 | ITU-R Rec. BT.601-6 525<br>ITU-R Rec. BT.1358 525<br>ITU-R Rec. BT.1700 NTSC<br>Society of Motion Picture and Television Engineers 170M (2004)<br>(functionally the same as the value 7) |
| 7 | primary<br>green<br>blue<br>red<br>white D65 | x<br>0.310<br>0.155<br>0.630<br>0.3127 | y<br>0.595<br>0.070<br>0.340<br>0.3290 | Society of Motion Picture and Television Engineers 240M (1999)<br>(functionally the same as the value 6) |
| 8 | primary<br>green<br>blue<br>red<br>white C | x<br>0.243<br>0.145<br>0.681<br>0.310 | y<br>0.692 (Wratten 58)<br>0.049 (Wratten 47)<br>0.319 (Wratten 25)<br>0.316 | Generic film (colour filters using Illuminant C) |
| 9-255 | Reserved | | | For future use by ITU-T \| ISO/IEC |

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**transfer_characteristics** indicates the opto-electronic transfer characteristic of the source picture as specified in Table E-4 as a function of a linear optical intensity input $L_c$ with an analogue range of 0 to 1.

When the transfer_characteristics syntax element is not present, the value of transfer_characteristics shall be inferred to be equal to 2 (the transfer characteristics are unspecified or are determined by the application).

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**Table E-4 – Transfer characteristics**

| Value | Transfer Characteristic | | Informative Remark |
|---|---|---|---|
| 0 | Reserved | | For future use by ITU-T \| ISO/IEC |
| 1 | $V = 1.099 * L_c^{0.45} - 0.099$<br>$V = 4.500 * L_c$ | for $1 >= L_c >= 0.018$<br>for $0.018 > L_c >= 0$ | ITU-R Rec. BT.709-5<br>ITU-R Rec. BT.1361 conventional colour gamut system<br>(functionally the same as the value 6) |
| 2 | Unspecified | | Image characteristics are unknown or are determined by the application. |
| 3 | Reserved | | For future use by ITU-T \| ISO/IEC |
| 4 | Assumed display gamma 2.2 | | ITU-R Rec. BT.470-6 System M (historical)<br>United States National Television System Committee 1953 Recommendation for transmission standards for colour television<br>United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20)<br>ITU-R Rec. BT.1700 (2007 revision) 625 PAL and 625 SECAM |
| 5 | Assumed display gamma 2.8 | | ITU-R Rec. BT.470-6 System B, G (historical) |
| 6 | $V = 1.099 * L_c^{0.45} - 0.099$<br>$V = 4.500 * L_c$ | for $1 >= L_c >= 0.018$<br>for $0.018 > L_c >= 0$ | ITU-R Rec. BT.601-6 525 or 625<br>ITU-R Rec. BT.1358 525 or 625<br>ITU-R Rec. BT.1700 NTSC<br>Society of Motion Picture and Television Engineers 170M (2004)<br>(functionally the same as the value 1) |
| 7 | $V = 1.1115 * L_c^{0.45} - 0.1115$<br>$V = 4.0 * L_c$ | for $1 >= L_c >= 0.0228$<br>for $0.0228 > L_c >= 0$ | Society of Motion Picture and Television Engineers 240M (1999) |
| 8 | $V = L_c$ | for $1 > L_c >= 0$ | Linear transfer characteristics |
| 9 | $V = 1.0 - \text{Log10}( L_c ) \div 2$<br>$V = 0.0$ | for $1 >= L_c >= 0.01$<br>for $0.01 > L_c >= 0$ | Logarithmic transfer characteristic (100:1 range) |
| 10 | $V = 1.0 - \text{Log10}( L_c ) \div 2.5$<br>$V = 0.0$ | for $1 >= L_c >= 0.0031622777$<br>for $0.0031622777 > L_c >= 0$ | Logarithmic transfer characteristic (316.22777:1 range) |
| 11 | $V = 1.099 * L_c^{0.45} - 0.099$<br>$V = 4.500 * L_c$<br>$V = -1.099 * ( -L_c )^{0.45} + 0.099$ | for $L_c >= 0.018$<br>for $0.018 > L_c > -0.018$<br>for $-0.018 >= L_c$ | IEC 61966-2-4 |
| 12 | $V = 1.099 * L_c^{0.45} - 0.099$<br>$V = 4.500 * L_c$<br>$V = ( 1.099 * ( -4 * L_c )^{0.45} - 0.099 ) \div 4$ | for $1.33 > L_c >= 0.018$<br>for $0.018 > L_c >= -0.0045$<br>for $-0.0045 > L_c >= -0.25$ | ITU-R Rec. BT.1361 extended colour gamut system |
| 13..255 | Reserved | | For future use by ITU-T \| ISO/IEC |

**matrix_coefficients** describes the matrix coefficients used in deriving luma and chroma signals from the green, blue, and red primaries, as specified in Table E-5.

matrix_coefficients shall not be equal to 0 unless both of the following conditions are true

– $\text{BitDepth}_C$ is equal to $\text{BitDepth}_Y$

– chroma_format_idc is equal to 3 (4:4:4)

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The specification of the use of matrix_coefficients equal to 0 under all other conditions is reserved for future use by ITU-T | ISO/IEC.

matrix_coefficients shall not be equal to 8 unless one of the following conditions are true

– $BitDepth_C$ is equal to $BitDepth_Y$

– $BitDepth_C$ is equal to $BitDepth_Y + 1$ and chroma_format_idc is equal to 3 (4:4:4)

The specification of the use of matrix_coefficients equal to 8 under all other conditions is reserved for future use by ITU-T | ISO/IEC.

When the matrix_coefficients syntax element is not present, the value of matrix_coefficients shall be inferred to be equal to 2 (unspecified).

The interpretation of matrix_coefficients is specified as follows.

– If transfer_characteristics is not equal to 11 or 12, $E'_R$, $E'_G$, and $E'_B$ are analog with values in the range of 0 to 1.

– Otherwise (transfer_characteristics is equal to 11 (IEC 61966-2-4) or 12 (ITU-R BT.1361 extended colour gamut system)), $E'_R$, $E'_G$ and $E'_B$ are analog with a larger range not specified in this Recommendation.

– Nominal white is specified as having $E'_R$ equal to 1, $E'_G$ equal to 1, and $E'_B$ equal to 1.

– Nominal black is specified as having $E'_R$ equal to 0, $E'_G$ equal to 0, and $E'_B$ equal to 0.

– If video_full_range_flag is equal to 0, the following equations apply.

  – If matrix_coefficients is equal to 1, 4, 5, 6, or 7, the following equations apply.

$$Y = Clip1_Y( Round( ( 1 << ( BitDepth_Y - 8 ) ) * ( 219 * E'_Y + 16 ) ) ) \quad (E\text{-}1)$$

$$Cb = Clip1_C( Round( ( 1 << ( BitDepth_C - 8 ) ) * ( 224 * E'_{PB} + 128 ) ) ) \quad (E\text{-}2)$$

$$Cr = Clip1_C( Round( ( 1 << ( BitDepth_C - 8 ) ) * ( 224 * E'_{PR} + 128 ) ) ) \quad (E\text{-}3)$$

  – Otherwise, if matrix_coefficients is equal to 0 or 8, the following equations apply.

$$R = Clip1_Y( ( 1 << ( BitDepth_Y - 8 ) ) * ( 219 * E'_R + 16 ) ) \quad (E\text{-}4)$$

$$G = Clip1_Y( ( 1 << ( BitDepth_Y - 8 ) ) * ( 219 * E'_G + 16 ) ) \quad (E\text{-}5)$$

$$B = Clip1_Y( ( 1 << ( BitDepth_Y - 8 ) ) * ( 219 * E'_B + 16 ) ) \quad (E\text{-}6)$$

  – Otherwise, if matrix_coefficients is equal to 2, the interpretation of the matrix_coefficients syntax element is unknown or is determined by the application.

  – Otherwise (matrix_coefficients is not equal to 0, 1, 2, 4, 5, 6, 7, or 8), the interpretation of the matrix_coefficients syntax element is reserved for future definition by ITU-T | ISO/IEC.

– Otherwise (video_full_range_flag is equal to 1), the following equations apply.

  – If matrix_coefficients is equal to 1, 4, 5, 6, or 7, the following equations apply.

$$Y = Clip1_Y( Round( ( ( 1 << BitDepth_Y ) - 1 ) * E'_Y ) ) \quad (E\text{-}7)$$

$$Cb = Clip1_C( Round( ( ( 1 << BitDepth_C ) - 1 ) * E'_{PB} + ( 1 << ( BitDepth_C - 1 ) ) ) ) \quad (E\text{-}8)$$

$$Cr = Clip1_C( Round( ( ( 1 << BitDepth_C ) - 1 ) * E'_{PR} + ( 1 << ( BitDepth_C - 1 ) ) ) ) \quad (E\text{-}9)$$

  – Otherwise, if matrix_coefficients is equal to 0 or 8, the following equations apply.

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$$R = Clip1_Y( ( ( 1 << BitDepth_Y ) – 1 ) * E'_R ) \quad \text{(E-10)}$$

$$G = Clip1_Y( ( ( 1 << BitDepth_Y ) – 1 ) * E'_G ) \quad \text{(E-11)}$$

$$B = Clip1_Y( ( ( 1 << BitDepth_Y ) – 1 ) * E'_B ) \quad \text{(E-12)}$$

  - Otherwise, if matrix_coefficients is equal to 2, the interpretation of the matrix_coefficients syntax element is unknown or is determined by the application.
  - Otherwise (matrix_coefficients is not equal to 0, 1, 2, 4, 5, 6, 7, or 8), the interpretation of the matrix_coefficients syntax element is reserved for future definition by ITU-T | ISO/IEC.

– If matrix_coefficients is not equal to 0 or 8, the following equations apply.

$$E'_Y = K_R * E'_R + ( 1 – K_R – K_B ) * E'_G + K_B * E'_B \quad \text{(E-13)}$$

$$E'_{PB} = 0.5 * ( E'_B – E'_Y ) \div ( 1 – K_B ) \quad \text{(E-14)}$$

$$E'_{PR} = 0.5 * ( E'_R – E'_Y ) \div ( 1 – K_R ) \quad \text{(E-15)}$$

NOTE 2 – $E'_Y$ is analog with the value 0 associated with nominal black and the value 1 associated with nominal white. $E'_{PB}$ and $E'_{PR}$ are analog with the value 0 associated with both nominal black and nominal white. When transfer_characteristics is not equal to 11 or 12, $E'_Y$ is analog with values in the range of 0 to 1. When transfer_characteristics is not equal to 11 or 12, $E'_{PB}$ and $E'_{PR}$ are analog with values in the range of –0.5 to 0.5. When transfer_characteristics is equal to 11 (IEC 61966-2-4), or 12 (ITU-R BT.1361 extended colour gamut system), $E'_Y$, $E'_{PB}$ and $E'_{PR}$ are analog with a larger range not specified in this Recommendation.

– Otherwise, if matrix_coefficients is equal to 0, the following equations apply.

$$Y = Round( G ) \quad \text{(E-16)}$$

$$Cb = Round( B ) \quad \text{(E-17)}$$

$$Cr = Round( R ) \quad \text{(E-18)}$$

– Otherwise (matrix_coefficients is equal to 8), the following applies.
  – If $BitDepth_C$ is equal to $BitDepth_Y$, the following equations apply.

$$Y = Round( 0.5 * G + 0.25 * ( R + B ) ) \quad \text{(E-19)}$$

$$Cb = Round( 0.5 * G – 0.25 * ( R + B ) ) + ( 1 << ( BitDepth_C – 1 ) ) \quad \text{(E-20)}$$

$$Cr = Round( 0.5 * (R – B ) ) + ( 1 << ( BitDepth_C – 1 ) ) \quad \text{(E-21)}$$

NOTE 3 – For purposes of the YCgCo nomenclature used in Table E-5, Cb and Cr of Equations E-20 and E-21 may be referred to as Cg and Co, respectively. The inverse conversion for the above three equations should be computed as.

$$t = Y – ( Cb – ( 1 << ( BitDepth_C – 1 ) ) ) \quad \text{(E-22)}$$

$$G = Clip1_Y( Y + ( Cb – ( 1 << ( BitDepth_C – 1 ) ) ) ) \quad \text{(E-23)}$$

$$B = Clip1_Y( t – ( Cr – ( 1 << ( BitDepth_C – 1 ) ) ) ) \quad \text{(E-24)}$$

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$$R = Clip1_Y( t + ( Cr - ( 1 << ( BitDepth_C - 1 ) ) ) ) \quad \text{(E-25)}$$

– Otherwise ($BitDepth_C$ is not equal to $BitDepth_Y$), the following equations apply.

$$Cr = Round( R ) - Round( B ) + ( 1 << ( BitDepth_C - 1 ) ) \quad \text{(E-26)}$$

$$t = Round( B ) + ( ( Cr - ( 1 << ( BitDepth_C - 1 ) ) ) >> 1 ) \quad \text{(E-27)}$$

$$Cb = Round( G ) - t + ( 1 << ( BitDepth_C - 1 ) ) \quad \text{(E-28)}$$

$$Y = t + ( ( Cb - ( 1 << ( BitDepth_C - 1 ) ) ) >> 1 ) \quad \text{(E-29)}$$

NOTE 4 – For purposes of the YCgCo nomenclature used in Table E-5, Cb and Cr of Equations E-28 and E-26 may be referred to as Cg and Co, respectively. The inverse conversion for the above four equations should be computed as.

$$t = Y - ( ( Cb - ( 1 << ( BitDepth_C - 1 ) ) ) >> 1 ) \quad \text{(E-30)}$$

$$G = Clip1_Y( t + ( Cb - ( 1 << ( BitDepth_C - 1 ) ) ) ) \quad \text{(E-31)}$$

$$B = Clip1_Y( t- ( ( Cr - ( 1 << ( BitDepth_C - 1 ) ) ) >> 1 ) ) \quad \text{(E-32)}$$

$$R = Clip1_Y( B + ( Cr - ( 1 << ( BitDepth_C - 1 ) ) ) ) \quad \text{(E-33)}$$

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**Table E-5 – Matrix coefficients**

| Value | Matrix | Informative remark |
|---|---|---|
| 0 | GBR | Typically referred to as RGB; see Equations E-16 to E-18 |
| 1 | $K_R = 0.2126$; $K_B = 0.0722$ | ITU-R Rec. BT.709-5<br>ITU-R Rec. BT.1361 conventional colour gamut system and extended colour gamut system<br>IEC 61966-2-4 $xvYCC_{709}$<br>Society of Motion Picture and Television Engineers RP 177 (1993) Annex B |
| 2 | Unspecified | Image characteristics are unknown or are determined by the application. |
| 3 | Reserved | For future use by ITU-T \| ISO/IEC |
| 4 | $K_R = 0.30$; $K_B = 0.11$ | United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20) |
| 5 | $K_R = 0.299$; $K_B = 0.114$ | ITU-R Rec. BT.470-6 System B, G (historical)<br>ITU-R Rec. BT.601-6 625<br>ITU-R Rec. BT.1358 625<br>ITU-R Rec. BT.1700 625 PAL and 625 SECAM<br>IEC 61966-2-4 $xvYCC_{601}$<br>(functionally the same as the value 6) |
| 6 | $K_R = 0.299$; $K_B = 0.114$ | ITU-R Rec. BT.601-6 525<br>ITU-R Rec. BT.1358 525<br>ITU-R Rec. BT.1700 NTSC<br>Society of Motion Picture and Television Engineers 170M (2004)<br>(functionally the same as the value 5) |
| 7 | $K_R = 0.212$; $K_B = 0.087$ | Society of Motion Picture and Television Engineers 240M (1999) |
| 8 | YCgCo | See Equations E-19 to E-33 |
| 9-255 | Reserved | For future use by ITU-T \| ISO/IEC |

**chroma_loc_info_present_flag** equal to 1 specifies that chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are present. chroma_loc_info_present_flag equal to 0 specifies that chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are not present.

**chroma_sample_loc_type_top_field** and **chroma_sample_loc_type_bottom_field** specify the location of chroma samples for the top field and the bottom field as shown in Figure E-1. The value of chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field shall be in the range of 0 to 5, inclusive. When the chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are not present, the values of chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field shall be inferred to be equal to 0.

NOTE 5 – When coding progressive source material, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should have the same value.

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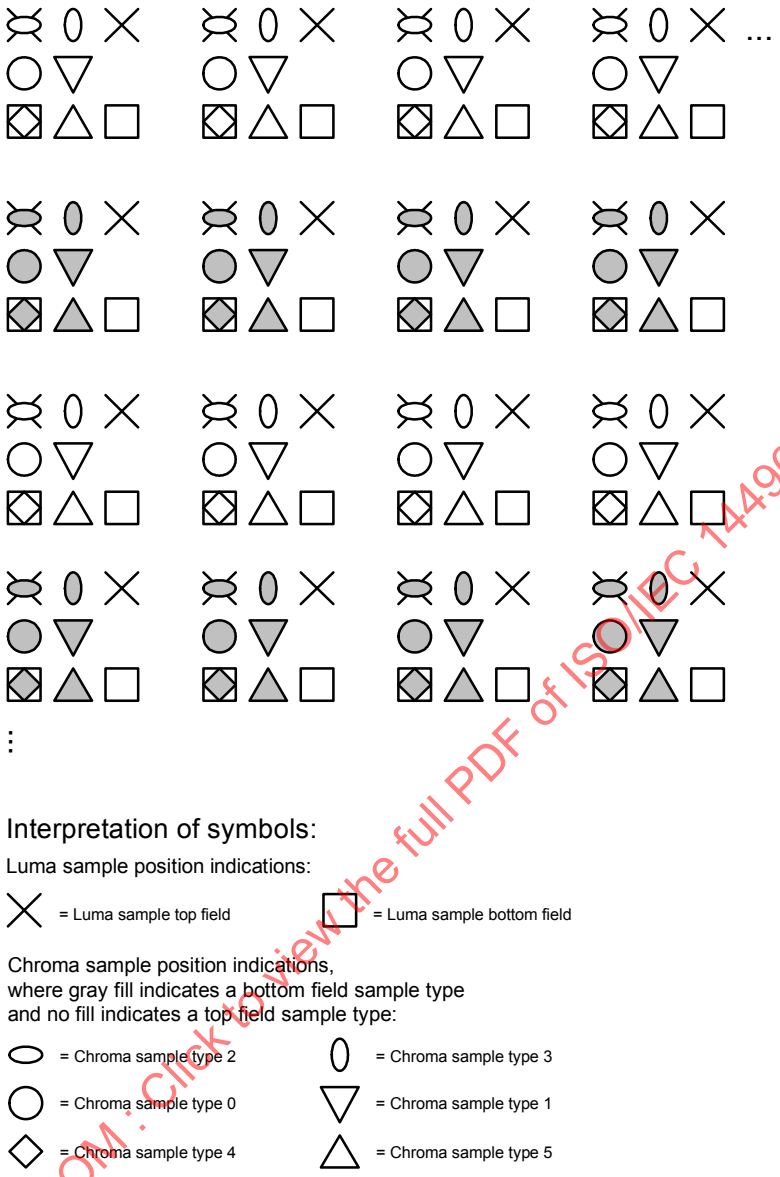


**Figure E-1 – Location of chroma samples for top and bottom fields as a function of chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field**

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**timing_info_present_flag** equal to 1 specifies that num_units_in_tick, time_scale and fixed_frame_rate_flag are present in the bitstream. timing_info_present_flag equal to 0 specifies that num_units_in_tick, time_scale and fixed_frame_rate_flag are not present in the bitstream.

**num_units_in_tick** is the number of time units of a clock operating at the frequency time_scale Hz that corresponds to one increment (called a clock tick) of a clock tick counter. num_units_in_tick shall be greater than 0. A clock tick is the minimum interval of time that can be represented in the coded data. For example, when the clock frequency of a video signal is 60 000 ÷ 1001 Hz, time_scale may be equal to 60 000 and num_units_in_tick may be equal to 1001. See Equation C-1.

**time_scale** is the number of time units that pass in one second. For example, a time coordinate system that measures time using a 27 MHz clock has a time_scale of 27 000 000. time_scale shall be greater than 0.

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**fixed_frame_rate_flag** equal to 1 indicates that the temporal distance between the HRD output times of any two consecutive pictures in output order is constrained as follows. fixed_frame_rate_flag equal to 0 indicates that no such constraints apply to the temporal distance between the HRD output times of any two consecutive pictures in output order.

For each picture n where n indicates the n-th picture (in output order) that is output and picture n is not the last picture in the bitstream (in output order) that is output, the value of $\Delta t_{fi,dpb}( n )$ is specified by

$$\Delta t_{fi,dpb}( n ) = \Delta t_{o,dpb}( n ) \div \text{DeltaTfiDivisor} \quad \text{(E-34)}$$

where $\Delta t_{o,dpb}( n )$ is specified in Equation C-13 and DeltaTfiDivisor is specified by Table E-6 based on the value of pic_struct_present_flag, field_pic_flag, and pic_struct for the coded video sequence containing picture n. Entries marked "-" in Table E-6 indicate a lack of dependence of DeltaTfiDivisor on the corresponding syntax element.

When fixed_frame_rate_flag is equal to 1 for a coded video sequence containing picture n, the value computed for $\Delta t_{fi,dpb}( n )$ shall be equal to $t_c$ as specified in Equation C-1 (using the value of $t_c$ for the coded video sequence containing picture n) when either or both of the following conditions are true for the following picture $n_n$ that is specified for use in Equation C-13.

– picture $n_n$ is in the same coded video sequence as picture n.

– picture $n_n$ is in a different coded video sequence and fixed_frame_rate_flag is equal to 1 in the coded video sequence containing picture $n_n$ and the value of num_units_in_tick ÷ time_scale is the same for both coded video sequences.

**Table E-6 – Divisor for computation of $\Delta t_{fi,dpb}( n )$**

| pic_struct_present_flag | field_pic_flag | pic_struct | DeltaTfiDivisor |
|---|---|---|---|
| 0 | 1 | - | 1 |
| 1 | - | 1 | 1 |
| 1 | - | 2 | 1 |
| 0 | 0 | - | 2 |
| 1 | - | 0 | 2 |
| 1 | - | 3 | 2 |
| 1 | - | 4 | 2 |
| 1 | - | 5 | 3 |
| 1 | - | 6 | 3 |
| 1 | - | 7 | 4 |
| 1 | - | 8 | 6 |

**nal_hrd_parameters_present_flag** equal to 1 specifies that NAL HRD parameters (pertaining to Type II bitstream conformance) are present. nal_hrd_parameters_present_flag equal to 0 specifies that NAL HRD parameters are not present.

NOTE 6 – When nal_hrd_parameters_present_flag is equal to 0, the conformance of the bitstream cannot be verified without provision of the NAL HRD parameters, including the NAL sequence HRD parameter information and all buffering period and picture timing SEI messages, by some means not specified in this International Standard.

When nal_hrd_parameters_present_flag is equal to 1, NAL HRD parameters (subclauses E.1.2 and E.2.2) immediately follow the flag.

The variable NalHrdBpPresentFlag is derived as follows.

– If any of the following is true, the value of NalHrdBpPresentFlag shall be set equal to 1.
  – nal_hrd_parameters_present_flag is present in the bitstream and is equal to 1
  – the need for presence of buffering periods for NAL HRD operation to be present in the bitstream in buffering period SEI messages is determined by the application, by some means not specified in this International Standard.

- Otherwise, the value of NalHrdBpPresentFlag shall be set equal to 0.

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**vcl_hrd_parameters_present_flag** equal to 1 specifies that VCL HRD parameters (pertaining to all bitstream conformance) are present. vcl_hrd_parameters_present_flag equal to 0 specifies that VCL HRD parameters are not present.

NOTE 7 – When vcl_hrd_parameters_present_flag is equal to 0, the conformance of the bitstream cannot be verified without provision of the VCL HRD parameters and all buffering period and picture timing SEI messages, by some means not specified in this International Standard.

When vcl_hrd_parameters_present_flag is equal to 1, VCL HRD parameters (subclauses E.1.2 and E.2.2) immediately follow the flag.

The variable VclHrdBpPresentFlag is derived as follows.

– If any of the following is true, the value of VclHrdBpPresentFlag shall be set equal to 1.
  – vcl_hrd_parameters_present_flag is present in the bitstream and is equal to 1
  – the need for presence of buffering periods for VCL HRD operation to be present in the bitstream in buffering period SEI messages is determined by the application, by some means not specified in this International Standard.
– Otherwise, the value of VclHrdBpPresentFlag shall be set equal to 0.

The variable CpbDpbDelaysPresentFlag is derived as follows.

– If any of the following is true, the value of CpbDpbDelaysPresentFlag shall be set equal to 1.
  – nal_hrd_parameters_present_flag is present in the bitstream and is equal to 1
  – vcl_hrd_parameters_present_flag is present in the bitstream and is equal to 1
  – the need for presence of CPB and DPB output delays to be present in the bitstream in picture timing SEI messages is determined by the application, by some means not specified in this International Standard.
– Otherwise, the value of CpbDpbDelaysPresentFlag shall be set equal to 0.

**low_delay_hrd_flag** specifies the HRD operational mode as specified in Annex C. When fixed_frame_rate_flag is equal to 1, low_delay_hrd_flag shall be equal to 0.

NOTE 8 – When low_delay_hrd_flag is equal to 1, "big pictures" that violate the nominal CPB removal times due to the number of bits used by an access unit are permitted. It is expected, but not required, that such "big pictures" occur only occasionally.

**pic_struct_present_flag** equal to 1 specifies that picture timing SEI messages (subclause D.2.2) are present that include the pic_struct syntax element. pic_struct_present_flag equal to 0 specifies that the pic_struct syntax element is not present in picture timing SEI messages. When pic_struct_present_flag is not present, its value shall be inferred to be equal to 0.

**bitstream_restriction_flag** equal to 1, specifies that the following coded video sequence bitstream restriction parameters are present. bitstream_restriction_flag equal to 0, specifies that the following coded video sequence bitstream restriction parameters are not present.

**motion_vectors_over_pic_boundaries_flag** equal to 0 indicates that no sample outside the picture boundaries and no sample at a fractional sample position whose value is derived using one or more samples outside the picture boundaries is used to inter predict any sample. motion_vectors_over_pic_boundaries_flag equal to 1 indicates that one or more samples outside picture boundaries may be used in inter prediction. When the motion_vectors_over_pic_boundaries_flag syntax element is not present, motion_vectors_over_pic_boundaries_flag value shall be inferred to be equal to 1.

**max_bytes_per_pic_denom** indicates a number of bytes not exceeded by the sum of the sizes of the VCL NAL units associated with any coded picture in the coded video sequence.

The number of bytes that represent a picture in the NAL unit stream is specified for this purpose as the total number of bytes of VCL NAL unit data (i.e., the total of the NumBytesInNALunit variables for the VCL NAL units) for the picture. The value of max_bytes_per_pic_denom shall be in the range of 0 to 16, inclusive.

Depending on max_bytes_per_pic_denom the following applies.

– If max_bytes_per_pic_denom is equal to 0, no limits are indicated.
– Otherwise (max_bytes_per_pic_denom is not equal to 0), no coded picture shall be represented in the coded video sequence by more than the following number of bytes.

$$( \text{PicSizeInMbs} * \text{RawMbBits} ) \div ( 8 * \text{max_bytes_per_pic_denom} ) \quad \text{(E-35)}$$

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When the max_bytes_per_pic_denom syntax element is not present, the value of max_bytes_per_pic_denom shall be inferred to be equal to 2.

**max_bits_per_mb_denom** indicates the maximum number of coded bits of macroblock_layer( ) data for any macroblock in any picture of the coded video sequence. The value of max_bits_per_mb_denom shall be in the range of 0 to 16, inclusive.

Depending on max_bits_per_mb_denom the following applies.

– If max_bits_per_mb_denom is equal to 0, no limit is specified.

– Otherwise (max_bits_per_mb_denom is not equal to 0), no coded macroblock_layer( ) shall be represented in the bitstream by more than the following number of bits.

$$( 128 + \text{RawMbBits} ) \div \text{max_bits_per_mb_denom} \quad \text{(E-36)}$$

Depending on entropy_coding_mode_flag, the bits of macroblock_layer( ) data are counted as follows.

– If entropy_coding_mode_flag is equal to 0, the number of bits of macroblock_layer( ) data is given by the number of bits in the macroblock_layer( ) syntax structure for a macroblock.

– Otherwise (entropy_coding_mode_flag is equal to 1), the number of bits of macroblock_layer( ) data for a macroblock is given by the number of times read_bits( 1 ) is called in subclauses 9.3.3.2.2 and 9.3.3.2.3 when parsing the macroblock_layer( ) associated with the macroblock.

When the max_bits_per_mb_denom is not present, the value of max_bits_per_mb_denom shall be inferred to be equal to 1.

**log2_max_mv_length_horizontal** and **log2_max_mv_length_vertical** indicate the maximum absolute value of a decoded horizontal and vertical motion vector component, respectively, in ¼ luma sample units, for all pictures in the coded video sequence. A value of n asserts that no value of a motion vector component shall exceed the range from $-2^n$ to $2^n-1$, inclusive, in units of ¼ luma sample displacement. The value of log2_max_mv_length_horizontal shall be in the range of 0 to 16, inclusive. The value of log2_max_mv_length_vertical shall be in the range of 0 to 16, inclusive. When log2_max_mv_length_horizontal is not present, the values of log2_max_mv_length_horizontal and log2_max_mv_length_vertical shall be inferred to be equal to 16.

NOTE 9 – The maximum absolute value of a decoded vertical or horizontal motion vector component is also constrained by profile and level limits as specified in Annex A.

**num_reorder_frames** indicates the maximum number of frames, complementary field pairs, or non-paired fields that precede any frame, complementary field pair, or non-paired field in the coded video sequence in decoding order and follow it in output order. The value of num_reorder_frames shall be in the range of 0 to max_dec_frame_buffering, inclusive. When the num_reorder_frames syntax element is not present, the value of num_reorder_frames value shall be inferred as follows.

– If profile_idc is equal to 44, 86, 100, 110, 122, or 244 and constraint_set3_flag is equal to 1, the value of num_reorder_frames shall be inferred to be equal to 0.

– Otherwise (profile_idc is not equal to 44, 86, 100, 110, 122, or 244 or constraint_set3_flag is equal to 0), the value of num_reorder_frames shall be inferred to be equal to MaxDpbSize.

**max_dec_frame_buffering** specifies the required size of the HRD decoded picture buffer (DPB) in units of frame buffers. The coded video sequence shall not require a decoded picture buffer with size of more than Max( 1, max_dec_frame_buffering ) frame buffers to enable the output of decoded pictures at the output times specified by dpb_output_delay of the picture timing SEI messages. The value of max_dec_frame_buffering shall be in the range of num_ref_frames to MaxDpbSize (as specified in subclause A.3.1 or A.3.2), inclusive. When the max_dec_frame_buffering syntax element is not present, the value of max_dec_frame_buffering shall be inferred as follows.

– If profile_idc is equal to 44 or 244 and constraint_set3_flag is equal to 1, the value of max_dec_frame_buffering shall be inferred to be equal to 0.

– Otherwise (profile_idc is not equal to 44 or 244 or constraint_set3_flag is equal to 0), the value of max_dec_frame_buffering shall be inferred to be equal to MaxDpbSize.

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### E.2.2 HRD parameters semantics

**cpb_cnt_minus1** plus 1 specifies the number of alternative CPB specifications in the bitstream. The value of cpb_cnt_minus1 shall be in the range of 0 to 31, inclusive. When low_delay_hrd_flag is equal to 1, cpb_cnt_minus1 shall be equal to 0. When cpb_cnt_minus1 is not present, it shall be inferred to be equal to 0.

**bit_rate_scale** (together with bit_rate_value_minus1[ SchedSelIdx ]) specifies the maximum input bit rate of the SchedSelIdx-th CPB.

**cpb_size_scale** (together with cpb_size_value_minus1[ SchedSelIdx ]) specifies the CPB size of the SchedSelIdx-th CPB.

**bit_rate_value_minus1[** SchedSelIdx **]** (together with bit_rate_scale) specifies the maximum input bit rate for the SchedSelIdx-th CPB. bit_rate_value_minus1[ SchedSelIdx ] shall be in the range of 0 to $2^{32}$ - 2, inclusive. For any SchedSelIdx > 0, bit_rate_value_minus1[ SchedSelIdx ] shall be greater than bit_rate_value_minus1[ SchedSelIdx - 1 ]. The bit rate in bits per second is given by

$$BitRate[ SchedSelIdx ] = ( bit_rate_value_minus1[ SchedSelIdx ] + 1 ) * 2^{(6 + bit_rate_scale)} \quad (E\text{-}37)$$

When the bit_rate_value_minus1[ SchedSelIdx ] syntax element is not present, the value of BitRate[ SchedSelIdx ] shall be inferred as follows.

- If profile_idc is equal to 66, 77, or 88, BitRate[ SchedSelIdx ] shall be inferred to be equal to 1000 * MaxBR for VCL HRD parameters and to be equal to 1200 * MaxBR for NAL HRD parameters, where MaxBR is specified in subclause A.3.1.
- Otherwise, BitRate[ SchedSelIdx ] shall be inferred to be equal to cpbBrVclFactor * MaxBR for VCL HRD parameters and to be equal to cpbBrNalFactor * MaxBR for NAL HRD parameters, where cpbBrVclFactor, cpbBrNalFactor, and MaxBR are specified in subclause A.3.3.

**cpb_size_value_minus1[** SchedSelIdx **]** is used together with cpb_size_scale to specify the SchedSelIdx-th CPB size. cpb_size_value_minus1[ SchedSelIdx ] shall be in the range of 0 to $2^{32}$ - 2, inclusive. For any SchedSelIdx greater than 0, cpb_size_value_minus1[ SchedSelIdx ] shall be less than or equal to cpb_size_value_minus1[ SchedSelIdx -1 ].

The CPB size in bits is given by

$$CpbSize[ SchedSelIdx ] = ( cpb_size_value_minus1[ SchedSelIdx ] + 1 ) * 2^{(4 + cpb_size_scale)} \quad (E\text{-}38)$$

When the cpb_size_value_minus1[ SchedSelIdx ] syntax element is not present, the value of CpbSize[ SchedSelIdx ] shall be inferred as follows.

- If profile_idc is equal to 66, 77, or 88, CpbSize[ SchedSelIdx ] shall be inferred to be equal to 1000 * MaxCPB for VCL HRD parameters and to be equal to 1200 * MaxCPB for NAL HRD parameters, where MaxCPB is specified in subclause A.3.1.
- Otherwise, CpbSize[ SchedSelIdx ] shall be inferred to be equal to cpbBrVclFactor * MaxCPB for VCL HRD parameters and to be equal to cpbBrNalFactor * MaxCPB for NAL HRD parameters, where cpbBrVclFactor, cpbBrNalFactor, and MaxCPB are specified in subclause A.3.3.

**cbr_flag[** SchedSelIdx **]** equal to 0 specifies that to decode this bitstream by the HRD using the SchedSelIdx-th CPB specification, the hypothetical stream delivery scheduler (HSS) operates in an intermittent bit rate mode. cbr_flag[ SchedSelIdx ] equal to 1 specifies that the HSS operates in a constant bit rate (CBR) mode. When the cbr_flag[ SchedSelIdx ] syntax element is not present, the value of cbr_flag shall be inferred to be equal to 0.

**initial_cpb_removal_delay_length_minus1** specifies the length in bits of the initial_cpb_removal_delay[ SchedSelIdx ] and initial_cpb_removal_delay_offset[ SchedSelIdx ] syntax elements of the buffering period SEI message. The length of initial_cpb_removal_delay[ SchedSelIdx ] and of initial_cpb_removal_delay_offset[ SchedSelIdx ] is initial_cpb_removal_delay_length_minus1 + 1. When the initial_cpb_removal_delay_length_minus1 syntax element is present in more than one hrd_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the initial_cpb_removal_delay_length_minus1 parameters shall be equal in both hrd_parameters( ) syntax structures. When the initial_cpb_removal_delay_length_minus1 syntax element is not present, it shall be inferred to be equal to 23.

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**cpb_removal_delay_length_minus1** specifies the length in bits of the cpb_removal_delay syntax element. The length of the cpb_removal_delay syntax element of the picture timing SEI message is cpb_removal_delay_length_minus1 + 1. When the cpb_removal_delay_length_minus1 syntax element is present in more than one hrd_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the cpb_removal_delay_length_minus1 parameters shall be equal in both hrd_parameters( ) syntax structures. When the cpb_removal_delay_length_minus1 syntax element is not present, it shall be inferred to be equal to 23.

**dpb_output_delay_length_minus1** specifies the length in bits of the dpb_output_delay syntax element. The length of the dpb_output_delay syntax element of the picture timing SEI message is dpb_output_delay_length_minus1 + 1. When the dpb_output_delay_length_minus1 syntax element is present in more than one hrd_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the dpb_output_delay_length_minus1 parameters shall be equal in both hrd_parameters( ) syntax structures. When the dpb_output_delay_length_minus1 syntax element is not present, it shall be inferred to be equal to 23.

**time_offset_length** greater than 0 specifies the length in bits of the time_offset syntax element. time_offset_length equal to 0 specifies that the time_offset syntax element is not present. When the time_offset_length syntax element is present in more than one hrd_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the time_offset_length parameters shall be equal in both hrd_parameters( ) syntax structures. When the time_offset_length syntax element is not present, it shall be inferred to be equal to 24.

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# Annex F
# Patent Rights

(This annex does not form an integral part of this Recommendation | International Standard)

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**Table F-1 – Organizations providing patent rights licensing notices**

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# Annex G
# Scalable video coding

(This annex forms an integral part of this International Standard)

This annex specifies scalable video coding, referred to as SVC.

## G.1 Scope

Bitstreams and decoders conforming to one or more of the profiles specified in this Annex are completely specified in this Annex with reference made to clauses 2-9 and Annexes A-E.

## G.2 Normative References

The specifications in clause 2 apply with the following additions.

- ISO/IEC 10646:2003, Information technology − Universal Multiple-Octet Coded Character Set (UCS).
- IETF RFC 3986 (2005), Uniform Resource Identifiers (URI): Generic Syntax.

## G.3 Definitions

For the purpose of this Annex, the following definitions apply in addition to the definitions in clause 3. These definitions are either not present in clause 3 or replace definitions in clause 3.

**G.3.1** **arbitrary slice order (ASO)**: A *decoding order* of *slices* in which the *macroblock address* of the first *macroblock* of some *slice* of a *slice group* within a *layer representation* may be less than the *macroblock address* of the first *macroblock* of some other preceding *slice* of the same *slice group* within the same *layer representation* or in which the *slices* of a *slice group* within a *layer representation* may be interleaved with the *slices* of one or more other *slices groups* within the same *layer representation*.

**G.3.2** **associated NAL unit**: A *NAL unit* that directly succeeds a *prefix NAL unit* in *decoding order*.

**G.3.3** **B slice**: A *slice* that may be decoded using *intra-layer intra prediction* or *inter prediction* using at most two *motion vectors* and *reference indices* to *predict* the sample values of each *block*.

**G.3.4** **base layer**: A *bitstream subset* that contains all the *NAL units* with the nal_unit_type *syntax element* equal to 1 and 5 of the *bitstream* and does not contain any *NAL unit* with the nal_unit_type *syntax element* equal to 14, 15, or 20 and conforms to one or more of the profiles specified in Annex A.

**G.3.5** **base quality layer representation**: The *layer representation* of the *target dependency representation* of an *access unit* that is associated with the quality_id *syntax element* equal to 0.

**G.3.6** **bitstream subset**: A *bitstream* that is derived as a *subset* from a *bitstream* by discarding zero or more *NAL units*. A *bitstream subset* is also referred to as *sub-bitstream*.

**G.3.7** **bottom macroblock (of a macroblock pair)**: The *macroblock* within a *macroblock pair* that contains the samples in the bottom row of samples for the *macroblock pair*. For a *field macroblock pair*, the bottom macroblock represents the samples from the region of the *bottom field* or *layer bottom field* of the *frame* or *layer frame*, respectively, that lie within the spatial region of the *macroblock pair*. For a *frame macroblock pair*, the bottom macroblock represents the samples of the *frame* or *layer frame* that lie within the bottom half of the spatial region of the *macroblock pair*.

**G.3.8** **coded slice in scalable extension NAL unit**: A *coded slice NAL unit* that contains an *EI slice*, *EP slice*, or an *EB slice*.

**G.3.9** **complementary reference field pair**: A collective term for two *reference fields* that are in consecutive *access units* in *decoding order* as two *coded fields*, where the *target dependency representations* of the *access units* share the same value of the frame_num *syntax element* and where the second *field* in *decoding order* is not an *IDR picture* and the *target dependency representation* of the second *access unit* does not include a memory_management_control_operation *syntax element* equal to 5, or a *complementary reference base field pair*.

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**G.3.10** **complementary reference base field pair**: Two *reference base fields* that are constructed from consecutive *access units* in *decoding order*, where the *target dependency representations* of the *access units* share the same value of the frame_num *syntax element* and where the second *access unit* in *decoding order* is not an *IDR access unit* and the *target dependency representation* of the second *access unit* does not include a memory_management_control_operation *syntax element* equal to 5. A *complementary reference base field pair* is a *complementary reference field pair*.

**G.3.11** **dependency representation**: A *subset* of *VCL NAL units* within an *access unit* that are associated with the same value of the dependency_id *syntax element*, which is provided as part of the *NAL unit* header or by an associated *prefix NAL unit*. A *dependency representation* consist of one or more *layer representations*.

**G.3.12** **EB slice**: A *slice* that may be decoded using *intra prediction* or *inter prediction* or *inter-layer prediction* from *syntax elements* and derived variables of the *reference layer representation*. For *inter-prediction* of EB slices at most two *motion vectors* and *reference indices* are used to *predict* the sample values of each *block*.

**G.3.13** **EI slice**: A *slice* that is not an *I slice* or *SI slice* that is decoded using *intra prediction* only.

**G.3.14** **EP slice**: A *slice* that may be decoded using *intra prediction* or *inter prediction* or *inter-layer prediction* from *syntax elements* and derived variables of the *reference layer representation*. For *inter-prediction* of EP slices at most one *motion vector* and *reference index* is used to *predict* the sample values of each *block*.

**G.3.15** **field macroblock**: A *macroblock* containing samples from a single *field* or *layer field*.

**G.3.16** **filler prefix NAL unit**: A *prefix NAL unit* with an *associated NAL unit* that is a filler data *NAL unit*.

**G.3.17** **frame macroblock**: A *macroblock* containing samples from the two *fields* or *layer fields* of a *frame* or *layer frame*, respectively.

**G.3.18** **I slice**: A *slice* that is decoded using *intra-layer intra prediction* only.

**G.3.19** **instantaneous decoding refresh (IDR) picture**: A *coded picture* in which all *slices* of the *target dependency representation* within the access unit are *I or EI slices* that causes the *decoding process* to mark all *reference pictures* as "unused for reference" immediately after decoding the IDR picture. After the decoding of an IDR picture all following *coded pictures* in *decoding order* can be decoded without *inter prediction* from any *picture* decoded prior to the IDR picture. The first *picture* of each *coded video sequence* is an IDR picture.

**G.3.20** **inter-layer intra prediction**: An *inter-layer prediction* derived from decoded samples of *intra-coded macroblocks* of the *reference layer representation*.

**G.3.21** **inter-layer prediction**: A *prediction* derived from *syntax elements*, derived variables, or decoded samples of the *reference layer representation*.

**G.3.22** **intra-layer intra prediction**: A *prediction* derived from decoded samples of the same decoded *slice*.

**G.3.23** **intra prediction**: A collective term for *intra-layer intra prediction* or *inter-layer intra prediction* or a combination of *intra-layer intra prediction* together with *inter-layer prediction* from *syntax elements* and derived variables of the *reference layer representation*.

**G.3.24** **intra slice**: A collective term for *I slice* or *EI slice*.

**G.3.25** **layer bottom field**: One of two *layer fields* that comprise a *layer frame*. Each row of a layer bottom field is spatially located immediately below a corresponding row of a *layer top field*.

**G.3.26** **layer field**: An assembly of alternate rows of a *layer frame*. A *layer frame* is composed of two *layer fields*, a *layer top field* and a *layer bottom field*.

**G.3.27** **layer frame**: A *layer frame* contains an array of *luma* samples that represents an intermediate decoding result for a *field* or a *frame* in monochrome format or an array of *luma* samples and two corresponding arrays of *chroma* samples that represent an intermediate decoding result for a *field* or a *frame* in 4:2:0, 4:2:2, and 4:4:4 colour format. A *layer frame* consists of two *layer fields*, a *layer top field* and a *layer bottom field*.

**G.3.28** **layer picture**: A collective term for a *layer field* or a *layer frame*.

**G.3.29** **layer top field**: One of two *layer fields* that comprise a *layer frame*. Each row of a *layer top field* is spatially located immediately above a corresponding row of a *layer bottom field*.

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**G.3.30** **layer representation**: A subset of *VCL NAL units* within an *access unit* that are associated with the same values of the dependency_id and quality_id *syntax elements*, which are provided as part of the *VCL NAL unit* header or by an associated *prefix NAL unit*. One or more *layer representations* represent a *dependency representation*.

**G.3.31** **layer representation identifier**: An integer value by which a particular *layer representation* inside an *access unit* is uniquely identified.

**G.3.32** **macroblock**: A 16x16 *block* of *luma* samples and two corresponding *blocks* of *chroma* samples of a *picture* or *layer picture* that has three sample arrays, or a 16x16 *block* of samples of a monochrome *picture* or *layer picture*. The division of a *slice* or a *macroblock pair* into macroblocks is a *partitioning*.

**G.3.33** **macroblock-adaptive frame/field decoding**: A *decoding process* for *coded frames* or *layer representations* in which some *macroblocks* may be decoded as *frame macroblocks* and others may be decoded as *field macroblocks*.

**G.3.34** **macroblock address**: When *macroblock-adaptive frame/field decoding* is not in use, a macroblock address is the index of a macroblock in a *macroblock raster scan* of the *picture* or *layer picture* starting with zero for the top-left *macroblock* in a *picture* or *layer picture*. When *macroblock-adaptive frame/field decoding* is in use, the macroblock address of the *top macroblock* of a *macroblock pair* is two times the index of the *macroblock pair* in a *macroblock pair raster scan* of the *picture* or *layer picture*, and the macroblock address of the *bottom macroblock* of a *macroblock pair* is the macroblock address of the corresponding *top macroblock* plus 1. The macroblock address of the *top macroblock* of each *macroblock pair* is an even number and the macroblock address of the *bottom macroblock* of each *macroblock pair* is an odd number.

**G.3.35** **macroblock location**: The two-dimensional coordinates of a *macroblock* in a *picture* or *layer picture* denoted by ( x, y ). For the top left *macroblock* of the *picture* or *layer picture* ( x, y ) is equal to ( 0, 0 ). x is incremented by 1 for each *macroblock* column from left to right. When *macroblock-adaptive frame/field decoding* is not in use, y is incremented by 1 for each *macroblock* row from top to bottom. When *macroblock-adaptive frame/field decoding* is in use, y is incremented by 2 for each *macroblock pair* row from top to bottom, and is incremented by an additional 1 when a macroblock is a *bottom macroblock*.

**G.3.36** **macroblock pair**: A pair of vertically contiguous *macroblocks* in a *frame* or *layer frame* that is coupled for use in *macroblock-adaptive frame/field decoding*. The division of a *slice* into macroblock pairs is a *partitioning*.

**G.3.37** **macroblock to slice group map**: A means of mapping *macroblocks* of a *picture* or *layer picture* into *slice groups*. The macroblock to slice group map consists of a list of numbers, one for each coded *macroblock*, specifying the *slice group* to which each coded *macroblock* belongs.

**G.3.38** **map unit to slice group map**: A means of mapping *slice group map units* of a *picture* or *layer picture* into *slice groups*. The map unit to slice group map consists of a list of numbers, one for each *slice group map unit*, specifying the *slice group* to which each coded *slice group map unit* belongs to.

**G.3.39** **non-paired reference base field**: A *reference base field* that is not part of a *complementary reference base field pair*. A *non-paired reference base field* is a *non-paired reference field*.

**G.3.40** **P slice**: A *slice* that may be decoded using *intra-layer intra prediction* or inter *prediction* using at most one *motion vector* and *reference index* to *predict* the sample values of each *block*.

**G.3.41** **parameter**: A *syntax element* of an *SVC sequence parameter set* or a *picture parameter set*. Parameter is also used as part of the defined term *quantisation parameter*.

**G.3.42** **picture parameter set**: A *syntax structure* containing *syntax elements* that apply to zero or more *layer representations* as determined by the pic_parameter_set_id *syntax element* found in each *slice header*.

**G.3.43** **prefix NAL unit**: A *NAL unit* with nal_unit_type equal to 14 that immediately precedes in *decoding order* a *NAL unit* with nal_unit_type equal to 1, 5, or 12. The *NAL unit* that immediately succeeds in *decoding order* the *prefix NAL unit* is referred to as the *associated NAL unit*. The *prefix NAL unit* contains data associated with the *associated NAL unit*, which are considered to be part of the *associated NAL unit*.

**G.3.44** **reference base field**: A *reference field* that is obtained by decoding a *base quality layer representation* with the nal_ref_idc *syntax element* not equal to 0, the store_ref_base_pic_flag *syntax element* equal to 1, and the field_pic_flag *syntax element* equal to 1 of an access unit and all *layer representations* of the *access unit* that are referred to by *inter-layer prediction* of the *base quality layer representation*. A *reference base field* is not an output of the *decoding process*, but may be used for *inter prediction* when *P*, *B*, *EP*, and *EB slices* of a *coded field* or *field macroblock* of a *coded frame* are decoded. See also *reference base picture*.

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**G.3.45** **reference base frame**: A *reference frame* that is obtained by decoding a *base quality layer representation* with the nal_ref_idc *syntax element* not equal to 0, the store_ref_base_pic_flag *syntax element* equal to 1, and the field_pic_flag *syntax element* equal to 0 of an access unit and all *layer representations* of the *access unit* that are referred to by *inter-layer prediction* of the *base quality layer representation*. A *reference base frame* is not an output of the *decoding process*, but may be used for *inter prediction* when *P*, *B*, *EP*, and *EB slices* of a *coded frame* are decoded. See also *reference base picture*.

**G.3.46** **reference base picture**: A *reference picture* that is obtained by decoding a *base quality layer representation* with the nal_ref_idc *syntax element* not equal to 0 and the store_ref_base_pic_flag *syntax element* equal to 1 of an access unit and all *layer representations* of the *access unit* that are referred to by *inter-layer prediction* of the *base quality layer representation*. A *reference base picture* is not an output of the *decoding process*, but the samples of a *reference base picture* may be used for *inter prediction* in the *decoding process* of subsequent *pictures* in *decoding order*. *Reference base picture* is a collective term for a *reference base field* or a *reference base frame*.

**G.3.47** **reference field**: A *reference field* may be used for *inter prediction* when *P*, *B, EP,* or *EB slices* of a *coded field* or *field macroblocks* of a *coded frame* are decoded. See also *reference picture*.

**G.3.48** **reference frame**: A *reference frame* may be used for *inter prediction* when *P*, *B, EP,* or *EB slices* of a *coded frame* are decoded. See also *reference picture*.

**G.3.49** **reference layer macroblock**: A *macroblock* of a *reference layer representation*.

**G.3.50** **reference layer representation**: A *reference layer representation* for a particular *layer representation* of an *access unit* is the *layer representation* that is used for *inter-layer prediction* of the particular *layer representation*. The *reference layer representation* is in the same *access unit* as the *layer representation* that uses the *reference layer representation* for *inter-layer prediction*.

**G.3.51** **reference picture**: A collective term for a *decoded picture* that is obtained by decoding an *access unit* for that the nal_ref_idc *syntax element* that is associated with the *target dependency representation* is not equal to 0 or a *reference base picture*. A *reference picture* contains samples that may be used for *inter prediction* in the *decoding process* of subsequent *pictures* in *decoding order*.

**G.3.52** **reference picture list**: A list of *reference pictures* that is used for *inter prediction* of a *P, B, EP,* or *EB slice.* For the *decoding process* of a *P* or *EP slice,* there is one reference picture list. For the *decoding process* of a *B* or *EB slice*, there are two reference picture lists.

**G.3.53** **reference picture list 0**: A *reference picture list* used for *inter prediction* of a *P*, *B*, *EP,* or *EB slice*. All *inter prediction* used for *P* and *EP slices* uses reference picture list 0. Reference picture list 0 is one of two *reference picture lists* used for *inter prediction* for a *B* or *EB slice*, with the other being *reference picture list 1*.

**G.3.54** **reference picture list 1**: A *reference picture list* used for *inter prediction* of a *B* or *EB slice*. Reference picture list 1 is one of two *reference picture lists* used for *inter prediction* for a *B* or *EB slice*, with the other being *reference picture list 0*.

**G.3.55** **scalable bitstream**: A *bitstream* with the property that one or more *bitstream subsets* that are not identical to the *scalable bitstream* form another *bitstream* that conforms to this specification.

**G.3.56** **sequence parameter set**: A *syntax structure* containing *syntax elements* that apply to zero or more *layer representations* with the dependency_id *syntax element* equal to 0 and the quality_id *syntax element* equal to 0 as determined by the content of a seq_parameter_set_id *syntax element* found in the *picture parameter set* referred to by the pic_parameter_set_id *syntax element* found in each *slice header* of *I*, *P*, and *B slices.*

**G.3.57** **slice**: An integer number of *macroblocks* or *macroblock pairs* ordered consecutively in the *raster scan* within a particular *slice group*. For a *picture* or *layer picture*, the division of each *slice group* into slices is a partitioning. Although a slice contains *macroblocks* or *macroblock pairs* that are consecutive in the *raster scan* within a *slice group*, these *macroblocks* or *macroblock pairs* are not necessarily consecutive in the *raster scan* within the *picture* or *layer picture*. The *macroblock addresses* are derived from the first *macroblock address* in a slice (as represented in the *slice header*) and the *macroblock to slice group map.*

**G.3.58** **slice group**: A subset of the *macroblocks* or *macroblock pairs* of a *picture* or *layer picture*. The division of the *picture* or *layer picture* into slice groups is a *partitioning* of the *picture* or *layer picture.* The partitioning is specified by the *macroblock to slice group map.*

**G.3.59** **spatial intra prediction**: See *intra-layer intra prediction*.

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**G.3.60 sub-bitstream**: A *subset* of a *bitstream*. A *sub-bitstream* is also referred to as *bitstream subset*.

**G.3.61 subset**: A subset contains only elements that are also contained in the set from which the subset is derived. The subset may be identical to the set from which it is derived.

**G.3.62 subset sequence parameter set**: A *syntax structure* containing *syntax elements* that apply to zero or more *layer representations* with the dependency_id *syntax element* not equal to 0 or the quality_id *syntax element* not equal to 0 as determined by the content of a seq_parameter_set_id *syntax element* found in the *picture parameter set* referred to by the pic_parameter_set_id *syntax element* found in each *slice header* of *EI*, *EP*, and *EB slices*.

**G.3.63 SVC sequence parameter set**: A collective term for *sequence parameter set* or *subset sequence parameter set*.

**G.3.64 SVC sequence parameter set RBSP**: A collective term for sequence parameter set RBSP or subset sequence parameter set RBSP.

**G.3.65 target dependency representation**: The *dependency representation* of an *access unit* that is associated with the largest value of the dependency_id *syntax element* for all *dependency representations* of the *access unit*.

**G.3.66 target layer representation**: The *layer representation* of the *target dependency representation* of an *access unit* that is associated with the largest value of the quality_id *syntax element* for all *layer representations* of the *target dependency representation* of the *access unit*.

**G.3.67 top macroblock (of a macroblock pair)**: The *macroblock* within a *macroblock pair* that contains the samples in the top row of samples for the *macroblock pair*. For a *field macroblock pair*, the top macroblock represents the samples from the region of the *top field* or *layer top field* of the *frame* or *layer frame* that lie within the spatial region of the *macroblock pair*. For a *frame macroblock pair*, the top macroblock represents the samples of the *frame* or *layer frame* that lie within the top half of the spatial region of the *macroblock pair*.

**G.3.68 VCL NAL unit**: A collective term for *coded slice NAL units* and *VCL prefix NAL units*.

**G.3.69 VCL prefix NAL unit**: A *prefix NAL unit* with an *associated NAL unit* that has nal_unit_type equal to 1 or 5.

## G.4 Abbreviations

The specifications in clause 4 apply.

## G.5 Conventions

The specifications in clause 5 apply.

## G.6 Source, coded, decoded and output data formats, scanning processes, neighbouring and reference layer relationships

The specifications in clause 6 apply with substituting SVC sequence parameter set for sequence parameter set. Additionally, the following process is specified.

### G.6.1 Derivation process for reference layer macroblocks

This process is only invoked when no_inter_layer_pred_flag is equal to 0.

Inputs to this process are

– a luma location ( xP, yP ) relative to the upper-left luma sample of the current macroblock,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying macroblock types for the macroblocks of the reference layer representation.

Outputs of this process are

– the macroblock address mbAddrRefLayer specifying the reference layer macroblock,

– a luma location ( xB, yB ) relative to the upper-left luma sample of the reference layer macroblock.

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The variables shiftX, shiftY, scaleX, scaleY, offsetX, and offsetY are derived as specified in the following ordered steps.

NOTE 1 – These variables do not depend on the luma location ( xP, yP ), the variable fieldMbFlag, or the current macroblock.

1. The variables refW, refH, scaledW, scaledH, offsetX, and offsetY are derived by

$$refW = RefLayerPicWidthInSamples_L \quad (G\text{-}1)$$
$$refH = RefLayerPicHeightInSamples_L \quad (G\text{-}2)$$
$$scaledW = ScaledRefLayerPicWidthInSamples_L \quad (G\text{-}3)$$
$$scaledH = ScaledRefLayerPicHeightInSamples_L \quad (G\text{-}4)$$
$$offsetX = ScaledRefLayerLeftOffset \quad (G\text{-}5)$$
$$offsetY = ScaledRefLayerTopOffset / ( 1 + field_pic_flag ) \quad (G\text{-}6)$$

2. The variables shiftX and shiftY are derived by

$$shiftX = ( ( level_idc <= 30 ) \ ? \ 16 \ : \ ( 31 - Ceil( Log2( refW ) ) ) ) \quad (G\text{-}7)$$
$$shiftY = ( ( level_idc <= 30 ) \ ? \ 16 \ : \ ( 31 - Ceil( Log2( refH ) ) ) ) \quad (G\text{-}8)$$

3. The variables scaleX and scaleY are derived by

$$scaleX = ( ( refW << shiftX ) + ( scaledW >> 1 ) ) / scaledW \quad (G\text{-}9)$$
$$scaleY = ( ( refH << shiftY ) + ( scaledH >> 1 ) ) / scaledH \quad (G\text{-}10)$$

The reference layer luma location ( xRef, yRef ) relative to the upper-left sample of the reference layer picture is derived as specified by the following ordered steps.

1. The inverse macroblock scanning process as specified in subclause 6.4.1 is invoked with CurrMbAddr as the input and the output is assigned to ( xM, yM ). For this invocation of the process in subclause 6.4.1, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1, and it is treated as frame macroblock when fieldMbFlag is equal to 0.
2. The luma location ( xC, yC ) is derived by

$$xC = xM + xP \quad (G\text{-}11)$$
$$yC = yM + yP * ( 1 + fieldMbFlag - field_pic_flag ) \quad (G\text{-}12)$$

3. The reference layer luma location is derived by

$$xRef = ( ( xC - offsetX ) * scaleX + ( 1 << ( shiftX - 1 ) ) ) >> shiftX \quad (G\text{-}13)$$
$$yRef = ( ( yC - offsetY ) * scaleY + ( 1 << ( shiftY - 1 ) ) ) >> shiftY \quad (G\text{-}14)$$

The reference layer macroblock address mbAddrRefLayer and a luma location ( xB, yB ) relative to the upper-left sample of the reference layer macroblock mbAddrRefLayer are derived as follows.

– If MbaffFrameFlag is equal to 0 and RefLayerMbaffFrameFlag is equal to 0, the following ordered steps are specified.

1. The reference layer macroblock address mbAddrRefLayer is derived as follows.
   – If any of the following conditions is true, mbAddrRefLayer is marked as not available.
     – xRef is less than 0 or xRef is greater than or equal to $RefLayerPicWidthInSamples_L$
     – yRef is less than 0 or yRef is greater than or equal to $RefLayerPicHeightInSamples_L$
   – Otherwise, the macroblock address mbAddrRefLayer is derived by

$$mbAddrRefLayer = ( yRef / 16 ) * RefLayerPicWidthInMbs + ( xRef / 16 ) \quad (G\text{-}15)$$

2. The luma location ( xB, yB ) is derived as follows.
   – If mbAddrRefLayer is not available, ( xB, yB ) is marked as not available.

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- Otherwise (mbAddrRefLayer is available), ( xB, yB ) is set equal to ( xRef % 16, yRef % 16 ).

– Otherwise (MbaffFrameFlag is equal to 1 or RefLayerMbaffFrameFlag is equal to 1), the following ordered steps are specified.

NOTE 2 – When MbaffFrameFlag is equal to 1 or RefLayerMbaffFrameFlag is equal to 1, field_pic_flag and RefLayerFieldPicFlag are both equal to 0 (see subclause G.7.4.3.4).

1. A virtual reference layer macroblock address virtMbAddrRefLayer is derived as follows.
   - If any of the following conditions is true, virtMbAddrRefLayer is marked as not available.
     - xRef is less than 0 or xRef is greater than or equal to $RefLayerPicWidthInSamples_L$
     - yRef is less than 0 or yRef is greater than or equal to $RefLayerPicHeightInSamples_L$
   - Otherwise, the following applies.
     - If RefLayerMbaffFrameFlag is equal to 1, virtMbAddrRefLayer is derived by

$$virtMbAddrRefLayer = 2 * ( ( yRef / 32 ) * RefLayerPicWidthInMbs + ( xRef / 16 ) ) + ( yRef \% 32 ) / 16 \quad (G\text{-}16)$$

     - Otherwise (RefLayerMbaffFrameFlag is equal to 0), virtMbAddrRefLayer is derived by

$$virtMbAddrRefLayer = ( yRef / 16 ) * RefLayerPicWidthInMbs + ( xRef / 16 ) \quad (G\text{-}17)$$

2. The reference layer macroblock address mbAddrRefLayer and the luma location ( xB, yB ) are derived as follows.
   - If virtMbAddrRefLayer is not available, the reference layer macroblock address mbAddrRefLayer and the luma location ( xB, yB ) are marked as not available.
   - Otherwise, if fieldMbFlag is equal to 0 and refLayerFieldMbRef[ virtMbAddrRefLayer ] is equal to 1, the field-to-frame reference layer macroblock conversion process as specified in subclause G.6.1.1 is invoked with virtMbAddrRefLayer, ( xRef, yRef ), and refLayerMbType as the inputs and the outputs are assigned to mbAddrRefLayer and ( xB, yB ).
   - Otherwise, if fieldMbFlag is equal to 1 and refLayerFieldMbRef[ virtMbAddrRefLayer ] is equal to 0, the frame-to-field reference layer macroblock conversion process as specified in subclause G.6.1.2 is invoked with virtMbAddrRefLayer and ( xRef, yRef ) as the inputs and the outputs are assigned to mbAddrRefLayer and ( xB, yB ).
   - Otherwise (virtMbAddrRefLayer is available and fieldMbFlag is equal to refLayerFieldMbRef[ virtMbAddrRefLayer ]), mbAddrRefLayer and ( xB, yB ) are derived as follows.

$$mbAddrRefLayer = ( ( virtMbAddrRefLayer >> fieldMbFlag ) << fieldMbFlag ) + ( CurrMbAddr \% 2 ) * fieldMbFlag \quad (G\text{-}18)$$

$$xB = ( xRef \% 16 ) \quad (G\text{-}19)$$

$$yB = ( yRef \% ( 16 << fieldMbFlag ) ) >> fieldMbFlag \quad (G\text{-}20)$$

### G.6.1.1 Field-to-frame reference layer macroblock conversion process

Inputs to this process are

– a virtual reference layer macroblock address virtMbAddrRefLayer,

– a reference layer luma location ( xRef, yRef ) relative to the upper-left luma sample of the reference layer picture,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying macroblock types for the macroblocks of the reference layer representation.

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Outputs of this process are

– the macroblock address mbAddrRefLayer of the reference layer macroblock,

– a luma location ( xB, yB ) relative to the upper-left luma sample of the reference layer macroblock.

The macroblock addresses mbAddrRefLayerTop and mbAddrRefLayerBot are derived by

mbAddrRefLayerTop = virtMbAddrRefLayer – ( virtMbAddrRefLayer % 2 ) (G-21)
mbAddrRefLayerBot = mbAddrRefLayerTop + 1 (G-22)

The reference layer macroblock address mbAddrRefLayer is derived as follows.

– If refLayerMbType[ mbAddrRefLayerTop ] is equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL, mbAddrRefLayer is set equal to mbAddrRefLayerBot.

– Otherwise (refLayerMbType[ mbAddrRefLayerTop ] is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL), mbAddrRefLayer is set equal to mbAddrRefLayerTop.

The luma location ( xB, yB ) is derived by

xB = xRef % 16 (G-23)
yB = 8 * ( ( yRef / 16 ) % 2 ) + 4 * ( ( yRef % 16 ) / 8 ) (G-24)

#### G.6.1.2 Frame-to-field reference layer macroblock conversion process

Inputs to this process are

– a virtual reference layer macroblock address virtMbAddrRefLayer,

– a virtual reference layer luma location ( xRef, yRef ) relative to the upper-left luma sample of the reference layer picture.

Outputs of this process are

– the macroblock address mbAddrRefLayer of the reference layer macroblock,

– a luma location ( xB, yB ) relative to the upper-left luma sample of the reference layer macroblock.

The macroblock addresses mbAddrRefLayerTop and mbAddrRefLayerBot are derived as follows.

– If RefLayerMbaffFrameFlag is equal to 1, mbAddrRefLayerTop and mbAddrRefLayerBot are derived by

mbAddrRefLayerTop = virtMbAddrRefLayer – ( virtMbAddrRefLayer % 2 ) (G-25)
mbAddrRefLayerBot = mbAddrRefLayerTop + 1 (G-26)

– Otherwise (RefLayerMbaffFrameFlag is equal to 0), mbAddrRefLayerTop and mbAddrRefLayerBot are derived by

mbAddrRefLayerTop = virtMbAddrRefLayer – ( ( yRef / 16 ) % 2 ) * RefLayerPicWidthInMbs (G-27)
mbAddrRefLayerBot = mbAddrRefLayerTop + RefLayerPicWidthInMbs (G-28)

The reference layer macroblock address is derived as follows.

– If ( yRef % 16) is less than 8, mbAddrRefLayer is set equal to mbAddrRefLayerTop.

– Otherwise (( yRef % 16 ) is greater than or equal to 8), mbAddrRefLayer is set equal to mbAddRefLayerBot.

The luma location ( xB, yB ) is derived by

xB = xRef % 16 (G-29)
yB = 8 * ( ( ( yRef % 16 ) / 4 ) % 2 ) + 4 * ( ( yRef / 16 ) % 2 ) (G-30)

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### G.6.2 Derivation process for reference layer partitions

This process is only invoked when no_inter_layer_pred_flag is equal to 0.

Inputs to this process are

– a luma location ( xP, yP ) relative to the upper-left luma sample of the current macroblock,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblocks,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying macroblock types for the macroblocks of the reference layer representation,

– a (RefLayerPicSizeInMbs)x4 array refLayerSubMbType specifying the sub-macroblock types for the macroblocks of the reference layer representation.

Outputs of this process are

– the macroblock address mbAddrRefLayer specifying the reference layer macroblock,

– the macroblock partition index mbPartIdxRefLayer specifying the reference layer macroblock partition inside the reference layer macroblock mbAddrRefLayer,

– the sub-macroblock partition index subMbPartIdxRefLayer specifying the reference layer sub-macroblock partition inside the macroblock partition mbPartIdxRefLayer of the reference layer macroblock mbAddrRefLayer.

The derivation process for reference layer macroblocks as specified in subclause G.6.1 is invoked with the luma location ( xP, yP ), fieldMbFlag, refLayerFieldMbFlag, and refLayerMbType as the input and the outputs are assigned to mbAddrRefLayer and ( xB, yB ).

The reference layer macroblock partition index mbPartIdxRefLayer and the reference layer sub-macroblock partition index subMbPartIdxRefLayer are derived as follows.

– If mbAddrRefLayer is not available, mbPartIdxRefLayer and subMbPartIdxRefLayer are marked as not available.

– Otherwise, if refLayerMbType[ mbAddrRefLayer ] is equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL, mbPartIdxRefLayer and subMbPartIdxRefLayer are set equal to 0.

– Otherwise, if refLayerMbType[ mbAddrRefLayer ] is equal to B_Skip or B_Direct_16x16, the following applies.

  – If ref_layer_dq_id is greater than 0, mbPartIdxRefLayer and subMbPartIdxRefLayer are set equal to 0.

  – Otherwise (ref_layer_dq_id is equal to 0), mbPartIdxRefLayer and subMbPartIdxRefLayer are derived by

$$mbPartIdxRefLayer = 2 * ( yB / 8 ) + ( xB / 8 ) \quad \text{(G-31)}$$

$$subMbPartIdxRefLayer = 2 * ( ( yB \% 8 ) / 4 ) + ( ( xB \% 8 ) / 4 ) \quad \text{(G-32)}$$

– Otherwise (mbAddrRefLayer is available and refLayerMbType[ mbAddrRefLayer ] is not equal to I_PCM, I_16x16, I_8x8, I_4x4, I_BL, B_Skip, or B_Direct_16x16), the following ordered steps are specified.

1. The reference layer macroblock partition index mbPartIdxRefLayer is set equal to the macroblock partition index of the macroblock partition inside the reference layer macroblock mbAddrRefLayer that covers the luma location ( xB, yB ). The macroblock partitioning of the reference layer macroblock mbAddrRefLayer is given by the macroblock type refLayerMbType[ mbAddrRefLayer ] and the specification in subclause G.8.4.1.

2. The reference layer sub-macroblock partition index subMbPartIdxRefLayer is derived as follows.

   – If NumMbPart( refLayerMbType[ mbAddrRefLayer ] ) is less than 4, subMbPartIdxRefLayer is set equal to 0.

   – Otherwise (NumMbPart( refLayerMbType[ mbAddrRefLayer ] ) is equal to 4), the following applies.

     – If refLayerSubMbType[ mbAddrRefLayer ][ mbPartIdxRefLayer ] is equal to B_Direct_8x8, the following applies.

       – If ref_layer_dq_id is greater than 0, subMbPartIdxRefLayer is set equal to 0.

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– Otherwise (ref_layer_dq_id is equal to 0), subMbPartIdxRefLayer is derived by

subMbPartIdxRefLayer = 2 * ( ( yB % 8 ) / 4 ) + ( ( xB % 8 ) / 4 ) (G-33)

– Otherwise (refLayerSubMbType[ mbAddrRefLayer ][ mbPartIdxRefLayer ] is not equal to B_Direct_8x8), the reference layer sub-macroblock partition index subMbPartIdxRefLayer is set equal to the sub-macroblock partition index of the sub-macroblock partition inside the macroblock partition mbPartIdxRefLayer of the reference layer macroblock mbAddrRefLayer that covers the luma location ( xB, yB ). The sub-macroblock partitioning of the reference layer macroblock partition mbPartIdxRefLayer inside the reference layer macroblock mbAddrRefLayer is given by the sub-macroblock type refLayerSubMbType[ mbAddrRefLayer ][ mbPartIdxRefLayer ] and the specification in subclause G.8.4.1.

### G.6.3 Derivation process for reference layer sample locations in resampling

Inputs to this process are

– a variable chromaFlag specifying whether the luma or a chroma component is subject to the resampling process,

– a sample location ( xP, yP ) relative to the upper-left sample of the current macroblock,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable botFieldFlag specifying whether a top or a bottom field is subject to the resampling process (when RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 0).

Output of this process is a reference layer sample location ( xRef16, yRef16 ), which specifies the following.

– If RefLayerFrameMbsOnlyFlag is equal to 1 or RefLayerFieldPicFlag is equal to 1, ( xRef16, yRef16 ) specifies the reference layer sample location in units of 1/16-th sample relative to the upper-left sample of the reference layer picture.

– Otherwise (RefLayerFrameMbsOnlyFlag is equal to 0 and RefLayerFieldPicFlag is equal to 0), ( xRef16, yRef16 ) specifies the reference layer sample location in units of 1/16-th field sample relative to the upper-left sample of the field specified by botFieldFlag of the reference layer picture.

The variables subW, subH, shiftX, shiftY, scaleX, scaleY, offsetX, offsetY, addX, addY, deltaX, and deltaY are derived as specified in the following ordered steps.

NOTE – These variables do not depend on the input sample location ( xP, yP ), the input variable fieldMbFlag, or the current macroblock address CurrMbAddr.

1. With Z being replaced by L for chromaFlag equal to 0 and C for chromaFlag equal to 1, the variables refW, refH, scaledW, and scaledH are derived by

$$refW = RefLayerPicWidthInSamples_Z \quad (G\text{-}34)$$
$$refH = RefLayerPicHeightInSamples_Z * ( 1 + RefLayerFieldPicFlag ) \quad (G\text{-}35)$$
$$scaledW = ScaledRefLayerPicWidthInSamples_Z \quad (G\text{-}36)$$
$$scaledH = ScaledRefLayerPicHeightInSamples_Z * ( 1 + field_pic_flag ) \quad (G\text{-}37)$$

2. When frame_mbs_only_flag is equal to 0 and RefLayerFrameMbsOnlyFlag is equal to 1, the variable scaledH is modified by

$$scaledH = scaledH / 2 \quad (G\text{-}38)$$

3. The variables refPhaseX, refPhaseY, phaseX, phaseY, subW, and subH are derived by

$$refPhaseX = ( ( chromaFlag == 0 ) ? 0 : ( ref_layer_chroma_phase_x_plus1_flag - 1 ) ) \quad (G\text{-}39)$$
$$refPhaseY = ( ( chromaFlag == 0 ) ? 0 : ( ref_layer_chroma_phase_y_plus1 - 1 ) ) \quad (G\text{-}40)$$
$$phaseX = ( ( chromaFlag == 0 ) ? 0 : ( chroma_phase_x_plus1_flag - 1 ) ) \quad (G\text{-}41)$$
$$phaseY = ( ( chromaFlag == 0 ) ? 0 : ( chroma_phase_y_plus1 - 1 ) ) \quad (G\text{-}42)$$
$$subW = ( ( chromaFlag == 0 ) ? 1 : SubWidthC ) \quad (G\text{-}43)$$
$$subH = ( ( chromaFlag == 0 ) ? 1 : SubHeightC ) \quad (G\text{-}44)$$

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4. When RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 0, the following applies.
   - The variable phaseY is modified by

$$phaseY = phaseY + 4 * botFieldFlag \quad \text{(G-45)}$$

   - The variable refPhaseY is modified as follows.
     - If RefLayerFrameMbsOnlyFlag is equal to 1, the variable refPhaseY is modified by

$$refPhaseY = 2 * refPhaseY + 2 \quad \text{(G-46)}$$

     - Otherwise (RefLayerFrameMbsOnlyFlag is equal to 0), the variable refPhaseY is modified by

$$refPhaseY = refPhaseY + 4 * botFieldFlag \quad \text{(G-47)}$$

5. The variables shiftX and shiftY are derived by

$$shiftX = ( ( level_idc <= 30 ) \ ? \ 16 \ : \ ( 31 - Ceil( Log2( refW ) ) ) ) \quad \text{(G-48)}$$
$$shiftY = ( ( level_idc <= 30 ) \ ? \ 16 \ : \ ( 31 - Ceil( Log2( refH ) ) ) ) \quad \text{(G-49)}$$

6. The variables scaleX and scaleY are derived by

$$scaleX = ( ( refW << shiftX ) + ( scaledW >> 1 ) ) / scaledW \quad \text{(G-50)}$$
$$scaleY = ( ( refH << shiftY ) + ( scaledH >> 1 ) ) / scaledH \quad \text{(G-51)}$$

7. The variables offsetX, addX, and deltaX are derived by

$$offsetX = ScaledRefLayerLeftOffset / subW \quad \text{(G-52)}$$
$$addX = ( ( ( refW * ( 2 + phaseX ) ) << ( shiftX - 2 ) ) + ( scaledW >> 1 ) ) / scaledW + ( 1 << ( shiftX - 5 ) ) \quad \text{(G-53)}$$
$$deltaX = 4 * ( 2 + refPhaseX ) \quad \text{(G-54)}$$

8. The variables offsetY, addY, and deltaY are derived as follows.
   - If RefLayerFrameMbsOnlyFlag is equal to 1 and frame_mbs_only_flag is equal to 1, the variables offsetY, addY, and deltaY are derived by

$$offsetY = ScaledRefLayerTopOffset / subH \quad \text{(G-55)}$$
$$addY = ( ( ( refH * ( 2 + phaseY ) ) << ( shiftY - 2 ) ) + ( scaledH >> 1 ) ) / scaledH + ( 1 << ( shiftY - 5 ) ) \quad \text{(G-56)}$$
$$deltaY = 4 * ( 2 + refPhaseY ) \quad \text{(G-57)}$$

   Otherwise (RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 0), the variables offsetY, addY, and deltaY are derived by

$$offsetY = ScaledRefLayerTopOffset / ( 2 * subH ) \quad \text{(G-58)}$$
$$addY = ( ( ( refH * ( 2 + phaseY ) ) << ( shiftY - 3 ) ) + ( scaledH >> 1 ) ) / scaledH + ( 1 << ( shiftY - 5 ) ) \quad \text{(G-59)}$$
$$deltaY = 2 * ( 2 + refPhaseY ) \quad \text{(G-60)}$$

The sample location ( xC, yC ) is derived as specified in the following ordered steps.

1. The inverse macroblock scanning process as specified in subclause 6.4.1 is invoked with CurrMbAddr as input and the output is assigned to ( xM, yM ). For this invocation of the process in subclause 6.4.1, the current macroblock is treated as field macroblock when fieldMbFlag is equal to 1 and it is treated as frame macroblock when fieldMbFlag is equal to 0.

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2. The sample location ( xC, yC ) is derived by

$$xC = xP + ( xM >> ( subW - 1 ) ) \quad \text{(G-61)}$$
$$yC = yP + ( yM >> ( subH - 1 + fieldMbFlag - field_pic_flag ) ) \quad \text{(G-62)}$$

3. When RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 0, the vertical component of the sample location ( xC, yC ) is modified by

$$yC = yC >> ( 1 - fieldMbFlag ) \quad \text{(G-63)}$$

The reference layer sample location ( xRef16 yRef16 ) is derived by

$$xRef16 = ( ( ( xC - offsetX ) * scaleX + addX ) >> ( shiftX - 4 ) ) - deltaX \quad \text{(G-64)}$$
$$yRef16 = ( ( ( yC - offsetY ) * scaleY + addY ) >> ( shiftY - 4 ) ) - deltaY \quad \text{(G-65)}$$

## G.7 Syntax and semantics

This clause specifies syntax and semantics for coded video sequences that conform to one or more of the profiles specified in this Annex.

### G.7.1 Method of specifying syntax in tabular form

The specifications in subclause 7.1 apply.

### G.7.2 Specification of syntax functions, categories, and descriptors

The specifications in subclauses 7.2 apply. Additionally, the following syntax function is specified.

in_crop_window( mbAddr ) is specified by the following ordered steps.

1. The variables mbX is set equal to (mbAddr % PicWidthInMbs).
2. The variables mbY0 and mbY1 are derived as follows.
   - If MbaffFrameFlag is equal to 0, mbY0 and mbY1 are set equal to (mbAddr / PicWidthInMbs).
   - Otherwise (MbaffFrameFlag is equal to 1), mbY0 is set equal to (2 * ( ( mbAddr / PicWidthInMbs ) / 2 )) and mbIdxY1 is set equal to (mbIdxY0 + 1).
3. The variable scalMbH is set equal to (16 * ( 1 + field_pic_flag )).
4. The return value of in_crop_window ( mbAddr ) is derived as follows.
   - If all of the following conditions are true, the return value of in_crop_window( mbAddr ) is equal to TRUE.
     - no_inter_layer_pred_flag is equal to 0
     - mbX is greater than or equal to (( ScaledRefLayerLeftOffset + 15 ) / 16)
     - mbX is less than (( ScaledRefLayerLeftOffset + ScaledRefLayerPicWidthInSamples$_L$ ) / 16)
     - mbY0 is greater than or equal to (( ScaledRefLayerTopOffset + scalMbH - 1 ) / scalMbH)
     - mbY1 is less than (( ScaledRefLayerTopOffset + ScaledRefLayerPicHeightInSamples$_L$ ) / scalMbH)
   - Otherwise, the return value of in_crop_window( mbAddr ) is equal to FALSE.

### G.7.3 Syntax in tabular form

#### G.7.3.1 NAL unit syntax

The syntax table is specified in subclause 7.3.1.

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#### G.7.3.1.1 NAL unit header SVC extension syntax

| nal_unit_header_svc_extension( ) { | C | Descriptor |
|---|---|---|
| **reserved_one_bit** | All | u(1) |
| **idr_flag** | All | u(1) |
| **priority_id** | All | u(6) |
| **no_inter_layer_pred_flag** | All | u(1) |
| **dependency_id** | All | u(3) |
| **quality_id** | All | u(4) |
| **temporal_id** | All | u(3) |
| **use_ref_base_pic_flag** | All | u(1) |
| **discardable_flag** | All | u(1) |
| **output_flag** | All | u(1) |
| **reserved_three_2bits** | All | u(2) |
| } | | |

### G.7.3.2 Raw byte sequence payloads and RBSP trailing bits syntax

#### G.7.3.2.1 Sequence parameter set RBSP syntax

The syntax table is specified in subclause 7.3.2.1.

##### G.7.3.2.1.1 Sequence parameter set data syntax

The syntax table is specified in subclause 7.3.2.1.1.

###### G.7.3.2.1.1.1 Scaling list syntax

The syntax table is specified in subclause 7.3.2.1.1.1.

##### G.7.3.2.1.2 Sequence parameter set extension RBSP syntax

The syntax table is specified in subclause 7.3.2.1.2.

##### G.7.3.2.1.3 Subset sequence parameter set RBSP syntax

| subset_seq_parameter_set_rbsp( ) { | C | Descriptor |
|---|---|---|
| seq_parameter_set_data( ) | 0 | |
| if( profile_idc == 83 \|\| profile_idc == 86 ) { | | |
| seq_parameter_set_svc_extension( ) | 0 | |
| **svc_vui_parameters_present_flag** | 0 | u(1) |
| if( svc_vui_parameters_present_flag == 1 ) | | |
| svc_vui_parameters_extension( ) | 0 | |
| } | | |
| **additional_extension2_flag** | 0 | u(1) |
| if( additional_extension2_flag == 1 ) | | |
| while( more_rbsp_data( ) ) | | |
| **additional_extension2_data_flag** | 0 | u(1) |
| rbsp_trailing_bits( ) | 0 | |
| } | | |

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#### G.7.3.2.1.4 Sequence parameter set SVC extension syntax

| seq_parameter_set_svc_extension( ) { | C | Descriptor |
|---|---|---|
| **inter_layer_deblocking_filter_control_present_flag** | 0 | u(1) |
| **extended_spatial_scalability** | 0 | u(2) |
| if( ChromaArrayType == 1 \|\| ChromaArrayType == 2 ) | | |
| **chroma_phase_x_plus1_flag** | 0 | u(1) |
| if( ChromaArrayType == 1 ) | | |
| **chroma_phase_y_plus1** | 0 | u(2) |
| if( extended_spatial_scalability == 1 ) { | | |
| if( ChromaArrayType > 0 ) { | | |
| **seq_ref_layer_chroma_phase_x_plus1_flag** | 0 | u(1) |
| **seq_ref_layer_chroma_phase_y_plus1** | 0 | u(2) |
| } | | |
| **seq_scaled_ref_layer_left_offset** | 0 | se(v) |
| **seq_scaled_ref_layer_top_offset** | 0 | se(v) |
| **seq_scaled_ref_layer_right_offset** | 0 | se(v) |
| **seq_scaled_ref_layer_bottom_offset** | 0 | se(v) |
| } | | |
| **seq_tcoeff_level_prediction_flag** | 0 | u(1) |
| if( seq_tcoeff_level_prediction_flag ) { | | |
| **adaptive_tcoeff_level_prediction_flag** | 0 | u(1) |
| } | | |
| **slice_header_restriction_flag** | 0 | u(1) |
| } | | |

### G.7.3.2.2 Picture parameter set RBSP syntax

The syntax table is specified in subclause 7.3.2.2.

### G.7.3.2.3 Supplemental enhancement information RBSP syntax

The syntax table is specified in subclause 7.3.2.3.

#### G.7.3.2.3.1 Supplemental enhancement information message syntax

The syntax table is specified in subclause 7.3.2.3.1.

### G.7.3.2.4 Access unit delimiter RBSP syntax

The syntax table is specified in subclause 7.3.2.4.

### G.7.3.2.5 End of sequence RBSP syntax

The syntax table is specified in subclause 7.3.2.5.

### G.7.3.2.6 End of stream RBSP syntax

The syntax table is specified in subclause 7.3.2.6.

### G.7.3.2.7 Filler data RBSP syntax

The syntax table is specified in subclause 7.3.2.7.

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#### G.7.3.2.8 Slice layer without partitioning RBSP syntax

The syntax table is specified in subclause 7.3.2.8.

#### G.7.3.2.9 Slice data partition RBSP syntax

Slice data partition syntax is not present in coded video sequences conforming to one or more of the profiles specified in this Annex.

#### G.7.3.2.10 RBSP slice trailing bits syntax

The syntax table is specified in subclause 7.3.2.10.

#### G.7.3.2.11 RBSP trailing bits syntax

The syntax table is specified in subclause 7.3.2.11.

#### G.7.3.2.12 Prefix NAL unit RBSP syntax

| prefix_nal_unit_rbsp( ) { | C | Descriptor |
|---|---|---|
| if( nal_ref_idc != 0 ) { | | |
| **store_ref_base_pic_flag** | 2 | u(1) |
| if( ( use_ref_base_pic_flag \|\| store_ref_base_pic_flag ) && !idr_flag ) | | |
| dec_ref_base_pic_marking( ) | 2 | |
| **prefix_nal_unit_additional_extension_flag** | 2 | u(1) |
| if( prefix_nal_unit_additional_extension_flag == 1 ) | | |
| while( more_rbsp_data( ) ) | | |
| **prefix_nal_unit_extension_flag** | 2 | u(1) |
| rbsp_trailing_bits( ) | 2 | |
| } | | |
| } | | |

#### G.7.3.2.13 Slice layer in scalable extension RBSP syntax

| slice_layer_in_scalable_extension_rbsp( ) { | C | Descriptor |
|---|---|---|
| slice_header_in_scalable_extension( ) | 2 | |
| if( !slice_skip_flag ) | | |
| slice_data_in_scalable_extension( ) | 2 \| 3 \| 4 | |
| rbsp_slice_trailing_bits( ) | 2 | |
| } | | |

### G.7.3.3 Slice header syntax

The syntax table is specified in subclause 7.3.3.

#### G.7.3.3.1 Reference picture list reordering syntax

The syntax table is specified in subclause 7.3.3.1.

#### G.7.3.3.2 Prediction weight table syntax

The syntax table is specified in subclause 7.3.3.2.

#### G.7.3.3.3 Decoded reference picture marking syntax

The syntax table is specified in subclause 7.3.3.3.

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### G.7.3.3.4 Slice header in scalable extension syntax

| slice_header_in_scalable_extension( ) { | C | Descriptor |
|---|---|---|
| **first_mb_in_slice** | 2 | ue(v) |
| **slice_type** | 2 | ue(v) |
| **pic_parameter_set_id** | 2 | ue(v) |
| if( separate_colour_plane_flag == 1 ) | | |
| **colour_plane_id** | 2 | u(2) |
| **frame_num** | 2 | u(v) |
| if( !frame_mbs_only_flag ) { | | |
| **field_pic_flag** | 2 | u(1) |
| if( field_pic_flag ) | | |
| **bottom_field_flag** | 2 | u(1) |
| } | | |
| if( idr_flag == 1 ) | | |
| **idr_pic_id** | 2 | ue(v) |
| if( pic_order_cnt_type == 0 ) { | | |
| **pic_order_cnt_lsb** | 2 | u(v) |
| if( pic_order_present_flag && !field_pic_flag ) | | |
| **delta_pic_order_cnt_bottom** | 2 | se(v) |
| } | | |
| if( pic_order_cnt_type == 1 && !delta_pic_order_always_zero_flag ) { | | |
| **delta_pic_order_cnt[** 0 **]** | 2 | se(v) |
| if( pic_order_present_flag && !field_pic_flag ) | | |
| **delta_pic_order_cnt[** 1 **]** | 2 | se(v) |
| } | | |
| if( redundant_pic_cnt_present_flag ) | | |
| **redundant_pic_cnt** | 2 | ue(v) |
| if( quality_id == 0 ) { | | |
| if( slice_type == EB ) | | |
| **direct_spatial_mv_pred_flag** | 2 | u(1) |
| if( slice_type == EP \|\| slice_type == EB ) { | | |
| **num_ref_idx_active_override_flag** | 2 | u(1) |
| if( num_ref_idx_active_override_flag ) { | | |
| **num_ref_idx_l0_active_minus1** | 2 | ue(v) |
| if( slice_type == EB ) | | |
| **num_ref_idx_l1_active_minus1** | 2 | ue(v) |
| } | | |
| } | | |
| ref_pic_list_reordering( ) | 2 | |
| if( ( weighted_pred_flag && slice_type == EP ) \|\| ( weighted_bipred_idc == 1 && slice_type == EB ) ) { | | |
| if( !no_inter_layer_pred_flag ) | | |
| **base_pred_weight_table_flag** | 2 | u(1) |
| if( no_inter_layer_pred_flag \|\| !base_pred_weight_table_flag ) | | |
| pred_weight_table( ) | 2 | |

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| | | |
|---|---|---|
| } | | |
| if( nal_ref_idc != 0 ) { | | |
| dec_ref_pic_marking( ) | 2 | |
| if( !slice_header_restriction_flag ) { | | |
| **store_ref_base_pic_flag** | 2 | u(1) |
| if ( ( use_ref_base_pic_flag \|\| store_ref_base_pic_flag ) && !idr_flag ) | | |
| dec_ref_base_pic_marking( ) | 2 | |
| } | | |
| } | | |
| } | | |
| if( entropy_coding_mode_flag && slice_type != EI ) | | |
| **cabac_init_idc** | 2 | ue(v) |
| **slice_qp_delta** | 2 | se(v) |
| if( deblocking_filter_control_present_flag ) { | | |
| **disable_deblocking_filter_idc** | 2 | ue(v) |
| if( disable_deblocking_filter_idc != 1 ) { | | |
| **slice_alpha_c0_offset_div2** | 2 | se(v) |
| **slice_beta_offset_div2** | 2 | se(v) |
| } | | |
| } | | |
| if( quality_id == 0 && num_slice_groups_minus1 > 0 && slice_group_map_type >= 3 && slice_group_map_type <= 5 ) | | |
| **slice_group_change_cycle** | 2 | u(v) |
| if( !no_inter_layer_pred_flag && quality_id == 0 ) { | | |
| **ref_layer_dq_id** | 2 | ue(v) |
| if( inter_layer_deblocking_filter_control_present_flag ) { | | |
| **disable_inter_layer_deblocking_filter_idc** | 2 | ue(v) |
| if( disable_inter_layer_deblocking_filter_idc != 1 ) { | | |
| **inter_layer_slice_alpha_c0_offset_div2** | 2 | se(v) |
| **inter_layer_slice_beta_offset_div2** | 2 | se(v) |
| } | | |
| } | | |
| **constrained_intra_resampling_flag** | 2 | u(1) |
| if( extended_spatial_scalability == 2 ) { | | |
| if( ChromaArrayType > 0 ) { | | |
| **ref_layer_chroma_phase_x_plus1_flag** | 2 | u(1) |
| **ref_layer_chroma_phase_y_plus1** | 2 | u(2) |
| } | | |
| **scaled_ref_layer_left_offset** | 2 | se(v) |
| **scaled_ref_layer_top_offset** | 2 | se(v) |
| **scaled_ref_layer_right_offset** | 2 | se(v) |
| **scaled_ref_layer_bottom_offset** | 2 | se(v) |
| } | | |
| } | | |
| if( !no_inter_layer_pred_flag ) { | | |

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| | | |
|---|---|---|
| **slice_skip_flag** | 2 | u(1) |
| if( slice_skip_flag ) | | |
| **num_mbs_in_slice_minus1** | 2 | ue(v) |
| else { | | |
| **adaptive_base_mode_flag** | 2 | u(1) |
| if( !adaptive_base_mode_flag ) | | |
| **default_base_mode_flag** | 2 | u(1) |
| if( !default_base_mode_flag ) { | | |
| **adaptive_motion_prediction_flag** | 2 | u(1) |
| if( !adaptive_motion_prediction_flag ) | | |
| **default_motion_prediction_flag** | 2 | u(1) |
| } | | |
| **adaptive_residual_prediction_flag** | 2 | u(1) |
| if( adaptive_residual_prediction_flag ) | | |
| **default_residual_prediction_flag** | 2 | u(1) |
| } | | |
| if( adaptive_tcoeff_level_prediction_flag == 1 ) | | |
| **tcoeff_level_prediction_flag** | 2 | u(1) |
| } | | |
| if( !slice_header_restriction_flag ) { | | |
| **scan_idx_start** | 2 | u(4) |
| **scan_idx_end** | 2 | u(4) |
| } | | |
| } | | |

#### G.7.3.3.5 Decoded reference base picture marking syntax

| dec_ref_base_pic_marking( ) { | C | Descriptor |
|---|---|---|
| **adaptive_ref_base_pic_marking_mode_flag** | 2 \| 5 | u(1) |
| if( adaptive_ref_base_pic_marking_mode_flag ) | | |
| do { | | |
| **memory_management_control_operation** | 2 \| 5 | ue(v) |
| if( memory_management_control_operation == 1 ) | | |
| **difference_of_pic_nums_minus1** | 2 \| 5 | ue(v) |
| if( memory_management_control_operation == 2 ) | | |
| **long_term_pic_num** | 2 \| 5 | ue(v) |
| } while( memory_management_control_operation != 0 ) | | |
| } | | |

### G.7.3.4 Slice data syntax

The syntax table is specified in subclause 7.3.4.

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#### G.7.3.4.1 Slice data in scalable extension syntax

| slice_data_in_scalable_extension( ) { | C | Descriptor |
|---|---|---|
| if( entropy_coding_mode_flag) | | |
| while( !byte_aligned( ) ) | | |
| **cabac_alignment_one_bit** | 2 | f(1) |
| CurrMbAddr = first_mb_in_slice * ( 1 + MbaffFrameFlag ) | | |
| moreDataFlag = 1 | | |
| prevMbSkipped = 0 | | |
| do { | | |
| if( slice_type != EI ) | | |
| if( !entropy_coding_mode_flag ) { | | |
| **mb_skip_run** | 2 | ue(v) |
| prevMbSkipped = ( mb_skip_run > 0 ) | | |
| for( i = 0; i < mb_skip_run; i++ ) | | |
| CurrMbAddr = NextMbAddress( CurrMbAddr ) | | |
| moreDataFlag = more_rbsp_data( ) | | |
| } else { | | |
| **mb_skip_flag** | 2 | ae(v) |
| moreDataFlag = !mb_skip_flag | | |
| } | | |
| if( moreDataFlag ) { | | |
| if( MbaffFrameFlag && ( ( CurrMbAddr % 2 ) == 0 \|\| ( ( CurrMbAddr % 2 ) == 1 && prevMbSkipped ) ) ) | | |
| **mb_field_decoding_flag** | 2 | u(1) \| ae(v) |
| macroblock_layer_in_scalable_extension( ) | 2 \| 3 \| 4 | |
| } | | |
| if( !entropy_coding_mode_flag ) | | |
| moreDataFlag = more_rbsp_data( ) | | |
| else { | | |
| if( slice_type != EI ) | | |
| prevMbSkipped = mb_skip_flag | | |
| if( MbaffFrameFlag && ( CurrMbAddr % 2 ) == 0 ) | | |
| moreDataFlag = 1 | | |
| else { | | |
| **end_of_slice_flag** | 2 | ae(v) |
| moreDataFlag = !end_of_slice_flag | | |
| } | | |
| } | | |
| CurrMbAddr = NextMbAddress( CurrMbAddr ) | | |
| } while( moreDataFlag ) | | |
| } | | |

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### G.7.3.5 Macroblock layer syntax

The syntax table is specified in subclause 7.3.5.

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#### G.7.3.5.1 Macroblock prediction syntax

The syntax table is specified in subclause 7.3.5.1.

#### G.7.3.5.2 Sub-macroblock prediction syntax

The syntax table is specified in subclause 7.3.5.2.

#### G.7.3.5.3 Residual data syntax

The syntax table is specified in subclause 7.3.5.3.

#### G.7.3.5.3.1 Residual luma syntax

The syntax table is specified in subclause 7.3.5.3.1.

#### G.7.3.5.3.2 Residual block CAVLC syntax

The syntax table is specified in subclause 7.3.5.3.2.

#### G.7.3.5.3.3 Residual block CABAC syntax

The syntax table is specified in subclause 7.3.5.3.3.

### G.7.3.6 Macroblock layer in scalable extension syntax

| macroblock_layer_in_scalable_extension( ) { | C | Descriptor |
|---|---|---|
| if( in_crop_window( CurrMbAddr ) && adaptive_base_mode_flag ) | | |
| **base_mode_flag** | 2 | u(1) \| ae(v) |
| if( !base_mode_flag) | | |
| **mb_type** | 2 | ue(v) \| ae(v) |
| if( !base_mode_flag && mb_type == I_PCM ) { | | |
| while( !byte_aligned( ) ) | | |
| **pcm_alignment_zero_bit** | 3 | f(1) |
| for( i = 0; i < 256; i++ ) | | |
| **pcm_sample_luma[** i **]** | 3 | u(v) |
| for( i = 0; i < 2 * MbWidthC * MbHeightC; i++ ) | | |
| **pcm_sample_chroma[** i **]** | 3 | u(v) |
| } else { | | |
| if( ! base_mode_flag ) { | | |
| noSubMbPartSizeLessThan8x8Flag = 1 | | |
| if( mb_type != I_NxN && MbPartPredMode( mb_type, 0 ) != Intra_16x16 && NumMbPart( mb_type ) == 4 ) { | | |
| sub_mb_pred_in_scalable_extension( mb_type ) | 2 | |
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| if( sub_mb_type[ mbPartIdx ] != B_Direct_8x8 ) { | | |
| if( NumSubMbPart( sub_mb_type [ mbPartIdx ] ) > 1 ) | | |
| noSubMbPartSizeLessThan8x8Flag = 0 | | |
| } else if( !direct_8x8_inference_flag ) | | |
| noSubMbPartSizeLessThan8x8Flag = 0 | | |
| } else { | | |
| if( transform_8x8_mode_flag && mb_type == I_NxN ) | | |
| **transform_size_8x8_flag** | 2 | u(1) \| ae(v) |
| mb_pred_in_scalable_extension( mb_type ) | 2 | |

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| | | |
|---|---|---|
| } | | |
| } | | |
| if( adaptive_residual_prediction_flag && slice_type != EI && ( base_mode_flag \|\| ( MbPartPredMode( mb_type, 0 ) != Intra_16x16 && MbPartPredMode( mb_type, 0 ) != Intra_8x8 && MbPartPredMode( mb_type, 0 ) != Intra_4x4 && mb_type != I_PCM && in_crop_window( CurrMbAddr ) ) ) ) | | |
| **residual_prediction_flag** | 2 | u(1) \| ae(v) |
| if( scan_idx_end >= scan_idx_start ) { | | |
| if( base_mode_flag \|\| MbPartPredMode( mb_type, 0 ) != Intra_16x16 ) { | | |
| **coded_block_pattern** | 2 | me(v) \| ae(v) |
| if( CodedBlockPatternLuma > 0 && transform_8x8_mode_flag && ( base_mode_flag \|\| ( mb_type != I_NxN && noSubMbPartSizeLessThan8x8Flag && ( mb_type != B_Direct_16x16 \|\| direct_8x8_inference_flag ) ) ) ) | | |
| **transform_size_8x8_flag** | 2 | u(1) \| ae(v) |
| } | | |
| if( CodedBlockPatternLuma > 0 \|\| CodedBlockPatternChroma > 0 \|\| ( !base_mode_flag && MbPartPredMode( mb_type, 0 ) == Intra_16x16 ) ) { | | |
| **mb_qp_delta** | 2 | se(v) \| ae(v) |
| residual( base_mode_flag, scan_idx_start, scan_idx_end ) | 3 \| 4 | |
| } | | |
| } | | |
| } | | |
| } | | |

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### G.7.3.6.1 Macroblock prediction in scalable extension syntax

| mb_pred_in_scalable_extension( mb_type ) { | C | Descriptor |
|---|---|---|
| if( MbPartPredMode( mb_type, 0 ) == Intra_4x4 \|\| MbPartPredMode( mb_type, 0 ) == Intra_8x8 \|\| MbPartPredMode( mb_type, 0 ) == Intra_16x16 ) { | | |
| if( MbPartPredMode( mb_type, 0 ) == Intra_4x4 ) | | |
| for( luma4x4BlkIdx = 0; luma4x4BlkIdx < 16; luma4x4BlkIdx++ ) { | | |
| **prev_intra4x4_pred_mode_flag[** luma4x4BlkIdx **]** | 2 | u(1) \| ae(v) |
| if( !prev_intra4x4_pred_mode_flag[ luma4x4BlkIdx ] ) | | |
| **rem_intra4x4_pred_mode[** luma4x4BlkIdx **]** | 2 | u(3) \| ae(v) |
| } | | |
| if( MbPartPredMode( mb_type, 0 ) == Intra_8x8 ) | | |
| for( luma8x8BlkIdx = 0; luma8x8BlkIdx < 4; luma8x8BlkIdx++ ) { | | |
| **prev_intra8x8_pred_mode_flag[** luma8x8BlkIdx **]** | 2 | u(1) \| ae(v) |
| if( !prev_intra8x8_pred_mode_flag[ luma8x8BlkIdx ] ) | | |
| **rem_intra8x8_pred_mode[** luma8x8BlkIdx **]** | 2 | u(3) \| ae(v) |
| } | | |
| if( ChromaArrayType != 0 ) | | |
| **intra_chroma_pred_mode** | 2 | ue(v) \| ae(v) |
| } else if( MbPartPredMode( mb_type, 0 ) != Direct ) { | | |
| if( in_crop_window( CurrMbAddr ) && adaptive_motion_prediction_flag ) { | | |
| for( mbPartIdx = 0; mbPartIdx < NumMbPart( mb_type ); mbPartIdx++) | | |
| if( MbPartPredMode( mb_type, mbPartIdx ) != Pred_L1 ) | | |
| **motion_prediction_flag_l0[** mbPartIdx **]** | 2 | u(1) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < NumMbPart( mb_type ); mbPartIdx++) | | |
| if( MbPartPredMode( mb_type, mbPartIdx ) != Pred_L0 ) | | |
| **motion_prediction_flag_l1[** mbPartIdx **]** | 2 | u(1) \| ae(v) |
| } | | |
| for( mbPartIdx = 0; mbPartIdx < NumMbPart( mb_type ); mbPartIdx++) | | |
| if( ( num_ref_idx_l0_active_minus1 > 0 \|\| mb_field_decoding_flag ) && MbPartPredMode( mb_type, mbPartIdx ) != Pred_L1 && !motion_prediction_flag_l0[ mbPartIdx ] ) | | |
| **ref_idx_l0[** mbPartIdx **]** | 2 | te(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < NumMbPart( mb_type ); mbPartIdx++) | | |
| if( ( num_ref_idx_l1_active_minus1 > 0 \|\| mb_field_decoding_flag ) && MbPartPredMode( mb_type, mbPartIdx ) != Pred_L0 && !motion_prediction_flag_l1[ mbPartIdx ] ) | | |
| **ref_idx_l1[** mbPartIdx **]** | 2 | te(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < NumMbPart( mb_type ); mbPartIdx++) | | |
| if( MbPartPredMode ( mb_type, mbPartIdx ) != Pred_L1 ) | | |
| for( compIdx = 0; compIdx < 2; compIdx++ ) | | |
| **mvd_l0[** mbPartIdx **][** 0 **][** compIdx **]** | 2 | se(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < NumMbPart( mb_type ); mbPartIdx++) | | |
| if( MbPartPredMode( mb_type, mbPartIdx ) != Pred_L0 ) | | |
| for( compIdx = 0; compIdx < 2; compIdx++ ) | | |
| **mvd_l1[** mbPartIdx **][** 0 **][** compIdx **]** | 2 | se(v) \| ae(v) |
| } | | |
| } | | |

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#### G.7.3.6.2 Sub-macroblock prediction in scalable extension syntax

| sub_mb_pred_in_scalable_extension( mb_type ) { | C | Descriptor |
|---|---|---|
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| **sub_mb_type[** mbPartIdx **]** | 2 | ue(v) \| ae(v) |
| if( in_crop_window( CurrMbAddr ) && adaptive_motion_prediction_flag ) { | | |
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| if( SubMbPredMode( sub_mb_type[ mbPartIdx ] ) != Direct && SubMbPredMode( sub_mb_type[ mbPartIdx ] ) != Pred_L1 ) | | |
| **motion_prediction_flag_l0[ mbPartIdx ]** | 2 | u(1) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| if( SubMbPredMode( sub_mb_type[ mbPartIdx ] ) != Direct && SubMbPredMode( sub_mb_type[ mbPartIdx ] ) != Pred_L0 ) | | |
| **motion_prediction_flag_l1[ mbPartIdx ]** | 2 | u(1) \| ae(v) |
| } | | |
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| if( ( num_ref_idx_l0_active_minus1 > 0 \|\| mb_field_decoding_flag ) && mb_type != P_8x8ref0 && sub_mb_type[ mbPartIdx ] != B_Direct_8x8 && SubMbPredMode( sub_mb_type[ mbPartIdx ] ) != Pred_L1 && !motion_prediction_flag_l0[ mbPartIdx ] ) | | |
| **ref_idx_l0[** mbPartIdx **]** | 2 | te(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| if( (num_ref_idx_l1_active_minus1 > 0 \|\| mb_field_decoding_flag ) && sub_mb_type[ mbPartIdx ] != B_Direct_8x8 && SubMbPredMode( sub_mb_type[ mbPartIdx ] ) != Pred_L0 && !motion_prediction_flag_l1[ mbPartIdx ] ) | | |
| **ref_idx_l1[** mbPartIdx **]** | 2 | te(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| if( sub_mb_type[ mbPartIdx ] != B_Direct_8x8 && SubMbPredMode( sub_mb_type[ mbPartIdx ] ) != Pred_L1 ) | | |
| for( subMbPartIdx = 0; subMbPartIdx < NumSubMbPart( sub_mb_type[ mbPartIdx ] ); subMbPartIdx++) | | |
| for( compIdx = 0; compIdx < 2; compIdx++ ) | | |
| **mvd_l0[** mbPartIdx **][** subMbPartIdx **][** compIdx **]** | 2 | se(v) \| ae(v) |
| for( mbPartIdx = 0; mbPartIdx < 4; mbPartIdx++ ) | | |
| if( sub_mb_type[ mbPartIdx ] != B_Direct_8x8 && SubMbPredMode( sub_mb_type[ mbPartIdx ] ) != Pred_L0 ) | | |
| for( subMbPartIdx = 0; subMbPartIdx < NumSubMbPart( sub_mb_type[ mbPartIdx ] ); subMbPartIdx++) | | |
| for( compIdx = 0; compIdx < 2; compIdx++ ) | | |
| **mvd_l1[** mbPartIdx **][** subMbPartIdx **][** compIdx **]** | 2 | se(v) \| ae(v) |
| } | | |

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### G.7.4 Semantics

Semantics associated with the syntax structures and syntax elements within these structures (in subclause G.7.3 and in subclause 7.3 by reference in G.7.3) are specified in this subclause and by reference to subclause 7.4. When the semantics of a syntax element are specified using a table or a set of tables, any values that are not specified in the table(s) shall not be present in the bitstream unless otherwise specified in this International Standard.

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One or more sub-bitstreams may be derived from a bitstream conforming to one or more of the profiles specified in this Annex. Sub-bitstreams that are derived according to the process specified in subclause G.8.8.1 conform to one or more of the profiles specified in Annex A or one or more of the profiles specified in this Annex.

One or more sub-bitstreams conform to the profiles specified in Annex A. The decoding for these sub-bitstreams is specified in clauses 2-9 and Annexes B-E.

The decoding for bitstreams conforming to one or more of the profiles specified in this Annex is completely specified in this Annex with reference made to clauses 2-9 and Annexes B-E.

A specification or a process in clauses 2-9 and Annexes B-E may be used as is or by specifying assignments or alternative meanings of certain parts.

### G.7.4.1 NAL unit semantics

The semantics for the syntax elements in subclause G.7.3.1 are specified in subclause 7.4.1. The following specifications additionally apply.

For NAL units with nal_unit_type equal to 14, nal_ref_idc shall be identical to nal_ref_idc of the associated NAL unit, which succeeds the NAL unit with nal_unit_type equal to 14 in decoding order.

The value of nal_ref_idc shall be identical for all VCL NAL units of a dependency representation.

The variable refNalRefIdc is derived as follows.

– When nal_unit_type is not equal to 20 or dependency_id is equal to the minimum value of dependency_id for all VCL NAL units of the access unit, refNalRefIdc is set equal to 0.

– Otherwise, refNalRefIdc is set equal to the maximum value of nal_ref_idc for all VCL NAL units of the access unit with a value of dependency_id less than the current value of dependency_id.

When refNalRefIdc is greater than 0, the value of nal_ref_idc shall not be equal to 0.

nal_ref_idc equal to 0 for a NAL unit containing a slice and having a value of dependency_id that is equal to the maximum value of dependency_id in the access unit indicates that all coded slice NAL units of the access unit are coded slice NAL units of a non-reference picture.

nal_ref_idc greater than 0 for a NAL unit containing a slice and having a value of dependency_id that is equal to the maximum value of dependency_id in the access unit indicates that all coded slice NAL units of the access unit are coded slice NAL units of a non-reference picture.

#### G.7.4.1.1 NAL unit header SVC extension semantics

The syntax elements idr_flag, priority_id, no_inter_layer_pred_flag, dependency_id, quality_id, temporal_id, use_ref_base_pic_flag, discardable_flag, and output_flag, when present in a prefix NAL unit, are considered to apply to the associated NAL unit.

**reserved_one_bit** shall be equal to 1. The value of reserved_one_bit may be specified by future extension of this International Standard. Decoders shall ignore the value of reserved_one_bit.

**idr_flag** equal to 1 specifies that the current access unit is an IDR access unit when the value of dependency_id for the NAL unit is equal to the maximum value of dependency_id for the access unit.

The value of idr_flag shall be the same for all NAL units of a dependency representation. For filler prefix NAL units, idr_flag shall be equal to 0. When idr_flag is equal to 1 for a VCL prefix NAL unit, the associated NAL unit shall have nal_unit_type equal to 5. When idr_flag is equal to 0 for a VCL prefix NAL unit, the associated NAL unit shall have nal_unit_type equal to 1.

When nal_ref_idc is equal to 0, the value of idr_flag shall be equal to 0.

For NAL units, in which idr_flag is present, the variable IdrPicFlag derived in subclause 7.4.1 is modified by setting it equal to idr_flag.

Let dIdMax be the maximum value of dependency_id in the NAL units of an access unit. An access unit is referred to as an IDR access unit when IdrPicFlag is equal to 1 for any NAL unit with dependency_id equal to dIdMax.

NOTE 1 – The classification of an access unit as IDR access unit and the partitioning of a sequence of access units in coded video sequences depends on the maximum present value of dependency_id in the associated NAL units. When NAL units are removed from a bitstream, e.g. in order to adjust the bitstream to the capabilities of a receiving device, the classification of access units as IDR access units and the partitioning of the sequence of access units into coded video sequences may change.

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**priority_id** specifies a priority identifier for the NAL unit.

NOTE 2 – The syntax element priority_id is not required by the decoding process specified in this International Standard. The syntax element priority_id may be used as determined by the application within the specified constraints.

**no_inter_layer_pred_flag** specifies, when present in a coded slice NAL unit, whether inter-layer prediction may be used for decoding the coded slice. When no_inter_layer_pred_flag is equal to 1, inter-layer prediction is not used for decoding the coded slice. When no_inter_layer_pred_flag is equal to 0, inter-layer prediction may or may not be used for decoding the coded slice as signalled in the macroblock layer.

For prefix NAL units, no_inter_layer_pred_flag shall be equal to 1. When nal_unit_type is equal to 20 and quality_id is greater than 0, no_inter_layer_pred_flag shall be equal to 0.

**dependency_id** specifies a dependency identifier for the NAL unit. dependency_id shall be equal to 0 in VCL prefix NAL units.

**quality_id** specifies a quality identifier for the NAL unit. quality_id shall be equal to 0 in VCL prefix NAL units.

The variable DQId is derived by

$$DQId = ( dependency_id << 4 ) + quality_id \quad \text{(G-66)}$$

**temporal_id** specifies a temporal identifier for the NAL unit.

The value of temporal_id shall be the same for all prefix and coded slice in scalable extension NAL units of an access unit. When an access unit contains any NAL unit with nal_unit_type equal to 5 or idr_flag equal to 1, temporal_id shall be equal to 0.

The bitstream that would be obtained by invoking the bitstream extraction process as specified in subclause G.8.8.1 with pIdTarget equal to any value in the range of 0 to 63, inclusive, tIdTarget equal to any value in the range of 0 to 7, inclusive, dIdTarget equal to any value in the range of 0 to 7, inclusive, and qIdTarget equal to any value in the range of 0 to 15, inclusive, shall be conforming to this International Standard.

NOTE 3 – A conforming bitstream contains one or more coded slice NAL units with priority_id equal to 0, dependency_id equal to 0, quality_id equal to 0, and temporal_id equal to 0.

**use_ref_base_pic_flag** equal to 1 specifies that reference base pictures are used as reference pictures for the inter prediction process. use_ref_base_pic_flag equal to 0 specifies that decoded pictures are used as reference pictures during the inter prediction process.

The values of use_ref_base_pic_flag shall be the same for all NAL units of a dependency representation. use_ref_base_pic_flag shall be equal to 0 in filler prefix NAL units.

**discardable_flag** equal to 1 specifies that the current NAL unit is not used for decoding NAL units of the current access unit and all subsequent access units that have a greater value of dependency_id than the current NAL unit. discardable_flag equal to 0 specifies that the current NAL unit may be used for decoding NAL units of the current access unit and all subsequent access units that have a greater value of dependency_id than the current NAL unit.

discardable_flag shall be equal to 1 in filler prefix NAL units.

**output_flag** affects the decoded picture output and removal processes as specified in Annex C. The value of output_flag shall be the same for all NAL units of a dependency representation. The value of output_flag shall be the same for both fields of a complementary field pair.

output_flag shall be equal to 0 in filler prefix NAL units.

**reserved_three_2bits** shall be equal to 3. The values of reserved_three_2bits may be specified by future extension of this International Standard. Decoders shall ignore the value of reserved_three_2bits.

#### G.7.4.1.2 Order of NAL units and association to coded pictures, access units, and video sequences

This subclause specifies constraints on the order of NAL units in the bitstream. Any order of NAL units in the bitstream obeying these constraints is referred to in the text as the decoding order of NAL units. Within a NAL unit, the syntax in subclauses 7.3, D.1, E.1, G.7.3, G.13.1, and G.14.1 specifies the decoding order of syntax elements. Decoders conforming to this International Standard shall be capable of receiving NAL units and their syntax elements in decoding order.

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#### G.7.4.1.2.1 Order of SVC sequence parameter set RBSPs and picture parameter set RBSPs and their activation

NOTE 1 – The sequence and picture parameter set mechanism decouples the transmission of infrequently changing information from the transmission of coded macroblock data. Sequence and picture parameter sets may, in some applications, be conveyed "out-of-band" using a reliable transport mechanism.

A picture parameter set RBSP includes parameters that can be referred to by the coded slice NAL units of one or more layer representations of one or more coded pictures.

Each picture parameter set RBSP is initially considered not active at the start of the operation of the decoding process. At most one picture parameter set RBSP is considered as the active picture parameter set RBSP at any given moment during the operation of the decoding process, and when any particular picture parameter set RBSP becomes the active picture parameter set RBSP, the previously-active picture parameter set RBSP (if any) is deactivated.

In addition to the active picture parameter set RBSP, zero or more picture parameter set RBSPs may be specifically active for layer representations (with a particular value of DQId less than DQIdMax) that are referred to through inter-layer prediction in decoding the target layer representation. Such a picture parameter set RBSP is referred to as active layer picture parameter set RBSP for the particular value of DQId (less than DQIdMax). The restrictions on active picture parameter set RBSPs also apply to active layer picture parameter set RBSPs with a particular value of DQId.

When a picture parameter set RBSP (with a particular value of pic_parameter_set_id) is not the active picture parameter set RBSP and it is referred to by a coded slice NAL unit with DQId equal to DQIdMax (using that value of pic_parameter_set_id), it is activated. This picture parameter set RBSP is called the active picture parameter set RBSP until it is deactivated when another picture parameter set RBSP becomes the active picture parameter set RBSP. A picture parameter set RBSP, with that particular value of pic_parameter_set_id, shall be available to the decoding process prior to its activation.

When a picture parameter set RBSP (with a particular value of pic_parameter_set_id) is not the active layer picture parameter set for a particular value of DQId less than DQIdMax and it is referred to by a coded slice NAL unit with the particular value of DQId (using that value of pic_parameter_set_id), it is activated for layer representations with the particular value of DQId. This picture parameter set RBSP is called the active layer picture parameter set RBSP for the particular value of DQId until it is deactivated when another picture parameter set RBSP becomes the active layer picture parameter set RBSP for the particular value of DQId or when decoding an access unit with DQIdMax less than or equal to the particular value of DQId. A picture parameter set RBSP, with that particular value of pic_parameter_set_id, shall be available to the decoding process prior to its activation.

Any picture parameter set NAL unit containing the value of pic_parameter_set_id for the active picture parameter set RBSP shall have the same content as that of the active picture parameter set RBSP unless it follows the last VCL NAL unit of a coded picture and precedes the first VCL NAL unit of another coded picture. Any picture parameter set NAL unit containing the value of pic_parameter_set_id for the active layer picture parameter set RBSP for a particular value of DQId less than DQIdMax shall have the same content as that of the active layer picture parameter set RBSP for the particular value of DQId unless it follows the last VCL NAL unit of a coded picture and precedes the first VCL NAL unit of another coded picture.

An SVC sequence parameter set RBSP includes parameters that can be referred to by one or more picture parameter set RBSPs or one or more SEI NAL units containing a buffering period SEI message.

Each SVC sequence parameter set RBSP is initially considered not active at the start of the operation of the decoding process. At most one SVC sequence parameter set RBSP is considered as the active SVC sequence parameter set RBSP at any given moment during the operation of the decoding process, and when any particular SVC sequence parameter set RBSP becomes the active SVC sequence parameter set RBSP, the previously-active SVC sequence parameter set RBSP (if any) is deactivated.

In addition to the active SVC sequence parameter set RBSP, zero or more SVC sequence parameter set RBSPs may be specifically active for layer representations (with a particular value of DQId less than DQIdMax) that are referred to through inter-layer prediction in decoding the target layer representation. Such an SVC sequence parameter set RBSP is referred to as active layer SVC sequence parameter set RBSP for the particular value of DQId (less than DQIdMax). The restrictions on active SVC sequence parameter set RBSPs also apply to active layer SVC sequence parameter set RBSPs with a particular value of DQId.

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When a sequence parameter set RBSP (nal_unit_type is equal to 7) with a particular value of seq_parameter_set_id is not already the active SVC sequence parameter set RBSP and it is referred to by activation of a picture parameter set RBSP (using that value of seq_parameter_set_id) and the picture parameter set RBSP is activated by a coded slice NAL unit with DQId equal to DQIdMax (the picture parameter set RBSP becomes the active picture parameter set RBSP) and nal_unit_type equal to 1 or 5, it is activated. This sequence parameter set RBSP, is called the active SVC sequence parameter set RBSP until it is deactivated when another SVC sequence parameter set RBSP becomes the active SVC sequence parameter set RBSP. A sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation.

When a sequence parameter set RBSP (nal_unit_type is equal to 7) with a particular value of seq_parameter_set_id is not already the active SVC sequence parameter set RBSP and it is referred to by an SEI NAL unit containing a buffering period SEI message (using that value of seq_parameter_set_id) that is not included in a scalable nesting SEI message and represents the last buffering period SEI message in decoding order in the access unit and DQIdMax is equal to 0, it is activated. This sequence parameter set RBSP is called the active SVC sequence parameter set RBSP until it is deactivated when another SVC sequence parameter set RBSP becomes the active SVC sequence parameter set RBSP. A sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation.

When a subset sequence parameter set RBSP (nal_unit_type is equal to 15) with a particular value of seq_parameter_set_id is not already the active SVC sequence parameter set RBSP and it is referred to by activation of a picture parameter set RBSP (using that value of seq_parameter_set_id) and the picture parameter set RBSP is activated by a coded slice in scalable extension NAL unit (nal_unit_type is equal to 20) with DQId equal to DQIdMax (the picture parameter set RBSP becomes the active picture parameter set RBSP), it is activated. This subset sequence parameter set RBSP is called the active SVC sequence parameter set RBSP until it is deactivated when another SVC sequence parameter set RBSP becomes the active SVC sequence parameter set RBSP. A subset sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation.

When a subset sequence parameter set RBSP (nal_unit_type is equal to 15) with a particular value of seq_parameter_set_id is not already the active SVC sequence parameter set RBSP and it is referred to by an SEI NAL unit containing a buffering period SEI message (using that value of seq_parameter_set_id) that is included in a scalable nesting SEI message and represents the last buffering period SEI message in decoding order in the access unit that is associated with a value of DQId in the range of ( (DQIdMax >> 4) << 4) to ( ( ( DQIdMax >> 4 ) << 4 ) + 15), inclusive, it is activated. This subset sequence parameter set RBSP, is called the active SVC sequence parameter set RBSP until it is deactivated when another SVC sequence parameter set RBSP becomes the active SVC sequence parameter set RBSP. A subset sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation.

NOTE 2 – The active SVC sequence parameter set RBSP is either a sequence parameter set RBSP or a subset sequence parameter set RBSP. Sequence parameter set RBSPs are activated by coded slice NAL units with nal_unit_type equal to 1 or 5 or buffering period SEI messages that are not included in a scalable nesting SEI message. Subset sequence parameter sets are activated by coded slice in scalable extension NAL units (nal_unit_type equal to 20) or buffering period SEI messages that are included in a scalable nesting SEI message. A sequence parameter set RBSP and a subset sequence parameter set RBSP may have the same value of seq_parameter_set_id.

For the following specification, the activating buffering period SEI message is specified as follows.

– If DQIdMax is less than 16 and the access unit contains one or more buffering period SEI messages and the last of these buffering period SEI messages in decoding order is not included in a scalable nesting SEI message, then this last buffering period SEI message is the activating buffering period SEI message.

– Otherwise, if the access unit contains one or more buffering period SEI messages that are included in a scalable nesting SEI message and are associated with a values of DQId in the range of ( (DQIdMax >> 4) << 4) to ( ( ( DQIdMax >> 4 ) << 4 ) + 15), inclusive, then the last of these buffering period SEI messages in decoding order is the activating buffering period SEI message.

– Otherwise, the access unit does not contain an activating buffering period SEI message.

When an SVC sequence parameter set RBSP is referred to by activation of a picture parameter set RBSP inside a particular access unit and this picture parameter set RBSP is activated by a coded slice NAL unit with DQId equal to DQIdMax (the picture parameter set RBSP becomes the active picture parameter set RBSP) and this particular access unit also contains an activating buffering period SEI message that refers to an SVC sequence parameter set RBSP that is different then the SVC sequence parameter set RBSP referred to by the activation of the picture parameter set RBSP, then the SVC sequence parameter set RBSP that is referred to by the activating buffering period SEI message becomes the active SVC sequence parameter set.

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NOTE 3 – Buffering period SEI messages have a higher priority for activating SVC sequence parameter sets then coded slice NAL units.

NOTE 4 – Compared to the specifications for profiles specified in Annex A, where an activated sequence parameter set RBSP must remain active for the entire coded video sequence, the specification for profiles specified in this Annex differs. When an SVC sequence parameter set RBSP is already active (as the active SVC sequence parameter set RBSP), another SVC sequence parameter set RBSP becomes the active SVC sequence parameter set RBSP in a non-IDR access unit when it is referred to by an activating buffering period SEI message or by the activation of a picture parameter set RBSP (as the active picture parameter set RBSP). In this case, the contents of the de-activated and activated SVC sequence parameter set RBSP are mutually restricted as described below. Hence, within a coded video sequence, multiple successively activated/de-activated SVC sequence parameter set RBSPs can be present.

When a sequence parameter set RBSP (nal_unit_type is equal to 7) with a particular value of seq_parameter_set_id is not already the active layer SVC sequence parameter set RBSP for a particular value of DQId and it is referred to by activation of a picture parameter set RBSP (using that value of seq_parameter_set_id) and the picture parameter set RBSP is activated by a coded slice NAL unit with DQId less than DQIdMax (the picture parameter set RBSP becomes the active layer picture parameter set RBSP for the particular value of DQId) and nal_unit_type equal to 1 or 5, it is activated for the layer representation with the particular value of DQId. This sequence parameter set RBSP is called the active layer SVC sequence parameter set RBSP for the particular value of DQId until it is deactivated when another SVC sequence parameter set RBSP becomes the active layer SVC sequence parameter set RBSP for the particular value of DQId or when decoding an access unit with DQIdMax less than or equal to the particular value of DQId. A sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation.

When a subset sequence parameter set RBSP (nal_unit_type is equal to 15) with a particular value of seq_parameter_set_id is not already the active layer SVC sequence parameter set RBSP for a particular value of DQId and it is referred to by activation of a picture parameter set RBSP (using that value of seq_parameter_set_id) and the picture parameter set RBSP is activated by a coded slice NAL unit with DQId less than DQIdMax (the picture parameter set RBSP becomes the active layer picture parameter set RBSP for the particular value of DQId) and nal_unit_type equal to 20, it is activated for the layer representation with the particular value of DQId. This subset sequence parameter set RBSP is called the active layer SVC sequence parameter set RBSP for the particular value of DQId until it is deactivated when another SVC sequence parameter set RBSP becomes the active layer SVC sequence parameter set RBSP for the particular value of DQId or when decoding an access unit with DQIdMax less than or equal to the particular value of DQId. A subset sequence parameter set RBSP, with that particular value of seq_parameter_set_id, shall be available to the decoding process prior to its activation.

A sequence parameter set RBSP or a subset sequence parameter set RBSP that includes a value of profile_idc not specified in Annex A or Annex G shall not be referred to by activation of a picture parameter set RBSP as the active picture parameter set RBSP or as active layer picture parameter set RBSP (using that value of seq_parameter_set_id) or referred to by an SEI NAL unit containing a buffering period SEI message (using that value of seq_parameter_set_id). A sequence parameter set RBSP or a subset sequence parameter set RBSP including a value of profile_idc not specified in Annex A or Annex G is ignored in the decoding for profiles specified in Annex A or Annex G.

An SVC sequence parameter set RBSP (SPSB) that becomes the active SVC sequence parameter set RBSP in a non-IDR access unit is restricted with regards to its contents compared to the SVC sequence parameter set RBSP that it deactivates (SPSA) as specified in the following.

– The values of the syntax elements in the seq_parameter_set_data( ) syntax structure of SPSA and SPSB may only differ for the syntax elements profile_idc, constraint_setX_flag (with X being equal to 0 to 3, inclusive), level_idc, seq_parameter_set_id, and the hrd_parameters( ) syntax structure and shall be the same otherwise.

– When the seq_parameter_set_svc_extension( ) syntax structure is present in both SPSA and SPSB, the values of all syntax elements in the seq_parameter_set_svc_extension( ) syntax structure shall be the same.

For each particular value of DQId, the SVC sequence parameter set RBSPs that are active layer SVC sequence parameter set RBPSs for the particular value of DQId in any access unit inside a coded video sequence are restricted with regards to their contents. The values of the syntax elements in these SVC sequence parameter set RBSPs (for the particular value of DQId) may only differ for the syntax elements profile_idc, constraint_setX_flag (with X being equal to 0 to 3, inclusive), level_idc, and the hrd_parameters( ) syntax structure and shall be the same otherwise.

The active layer SVC sequence parameter set RBSPs for different values of DQId may be the same SVC sequence parameter set RBSP. The active SVC sequence parameter set RBSP and an active layer SVC sequence parameter set RBSP for a particular value of DQId may be the same SVC sequence parameter set RBSP.

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When the active SVC sequence parameter set RBSP is a sequence parameter set RBSP, any sequence parameter set RBSP with the value of seq_parameter_set_id for the active SVC sequence parameter set RBSP shall have the same content as that of the active SVC sequence parameter set RBSP unless it follows the last access unit of a coded video sequence and precedes the first VCL NAL unit and the first SEI NAL unit containing a buffering period SEI message (when present) of another coded video sequence.

When the active SVC sequence parameter set RBSP is a subset sequence parameter set RBSP, any subset sequence parameter set RBSP with the value of seq_parameter_set_id for the active SVC sequence parameter set RBSP shall have the same content as that of the active SVC sequence parameter set RBSP unless it follows the last access unit of a coded video sequence and precedes the first VCL NAL unit and the first SEI NAL unit containing a buffering period SEI message (when present) of another coded video sequence.

For each particular value of DQId, the following applies.

– When the active layer SVC sequence parameter set RBSP is a sequence parameter set RBSP, any sequence parameter set RBSP with the value of seq_parameter_set_id for the active layer SVC sequence parameter set RBSP shall have the same content as that of the active layer SVC sequence parameter set RBSP unless it follows the last access unit of a coded video sequence and precedes the first VCL NAL unit of another coded video sequence.

– When the active layer SVC sequence parameter set RBSP is a subset sequence parameter set RBSP, any subset sequence parameter set RBSP with the value of seq_parameter_set_id for the active layer SVC sequence parameter set RBSP shall have the same content as that of the active layer SVC sequence parameter set RBSP unless it follows the last access unit of a coded video sequence and precedes the first VCL NAL unit of another coded video sequence.

NOTE 5 – If picture parameter set RBSP or sequence parameter set RBSP are conveyed within the bitstream, these constraints impose an order constraint on the NAL units that contain the picture parameter set RBSP or sequence parameter set RBSP, respectively. Otherwise (picture parameter set RBSP or sequence parameter set RBSP are conveyed by other means not specified in this International Standard), they must be available to the decoding process in a timely fashion such that these constraints are obeyed.

When present, a sequence parameter set extension RBSP includes parameters having a similar function to those of a sequence parameter set RBSP. For purposes of establishing constraints on the syntax elements of the sequence parameter set extension RBSP and for purposes of determining activation of a sequence parameter set extension RBSP, the sequence parameter set extension RBSP shall be considered part of the preceding sequence parameter set RBSP with the same value of seq_parameter_set_id. When a sequence parameter set RBSP is present that is not followed by a sequence parameter set extension RBSP with the same value of seq_parameter_set_id prior to the activation of the sequence parameter set RBSP, the sequence parameter set extension RBSP and its syntax elements shall be considered not present for the active sequence parameter set RBSP. The contents of sequence parameter set extension RBSPs only apply when the base layer, which conforms to one or more of the profiles specified in Annex A, of a coded video sequence conforming to one or more profiles specified in Annex G is decoded. Subset sequence parameter set RBSPs shall not be followed by a sequence parameter set extension RBSP.

NOTE 6 – Sequence parameter sets extension RBSPs are not considered to be part of a subset sequence parameter set RBSP and subset sequence parameter set RBSPs shall not be followed by a sequence parameter set extension RBSP.

For layer representations with DQId equal to DQIdMax, all constraints that are expressed on the relationship between the values of the syntax elements (and the values of variables derived from those syntax elements) in SVC sequence parameter sets and picture parameter sets and other syntax elements are expressions of constraints that apply only to the active SVC sequence parameter set and the active picture parameter set. For layer representations with a particular value of DQId less than DQIdMax, all constraints that are expressed on the relationship between the values of the syntax elements (and the values of variables derived from those syntax elements) in SVC sequence parameter sets and picture parameter sets and other syntax elements are expressions of constraints that apply only to the active layer SVC sequence parameter set and the active layer picture parameter set for the particular value of DQId. If any SVC sequence parameter set RBSP having profile_idc equal to one of the profile_idc values specified in Annex A or Annex G is present that is never activated in the bitstream (i.e., it never becomes the active SVC sequence parameter set or an active layer SVC sequence parameter set), its syntax elements shall have values that would conform to the specified constraints if it were activated by reference in an otherwise-conforming bitstream. If any picture parameter set RBSP is present that is never ever activated in the bitstream (i.e., it never becomes the active picture parameter set or an active layer picture parameter set), its syntax elements shall have values that would conform to the specified constraints if it were activated by reference in an otherwise-conforming bitstream.

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During operation of the decoding process (see clause G.8), for layer representations with DQId equal to DQIdMax, the values of parameters of the active picture parameter set and the active SVC sequence parameter set shall be considered in effect. For layer representations with a particular value of DQId less than DQIdMax, the values of the parameters of the active layer picture parameter set and the active layer SVC sequence parameter set for the particular value of DQId shall be considered in effect. For interpretation of SEI messages that apply to access unit or dependency representations with dependency_id equal to DependencyIdMax or layer representation with DQId equal to DQIdMax, the values of the parameters of the picture parameter set and SVC sequence parameter set that are the active picture parameter set and the active SVC sequence parameter set, respectively, for the operation of the decoding process for the VCL NAL units of the primary coded picture in the same access unit shall be considered in effect unless otherwise specified in the SEI message semantics. For interpretation of SEI messages that apply to dependency representations with a particular value of dependency_id less than DependencyIdMax, the values of the parameters of the picture parameter set and SVC sequence parameter set that are the active layer picture parameter set and the active layer SVC sequence parameter set, respectively, for the operation of the decoding process for the VCL NAL units of the layer representation with DQId equal to ( dependency_id << 4 ) in the same access unit shall be considered in effect unless otherwise specified in the SEI message semantics. For interpretation of SEI messages that apply to layer representations with a particular value of DQId less than DQIdMax, the values of the parameters of the picture parameter set and SVC sequence parameter set that are the active layer picture parameter set and the active layer SVC sequence parameter set, respectively, for the operation of the decoding process for the VCL NAL units of the layer representation with the particular value of DQId in the same access unit shall be considered in effect unless otherwise specified in the SEI message semantics.

#### G.7.4.1.2.2 Order of access units and association to coded video sequences

The specification of subclause 7.4.1.2.2 applies with the following modifications.

The first access unit of the bitstream shall only contain coded slice NAL units with nal_unit_type equal to 5 or idr_flag equal to 1.

The order of NAL units and coded pictures and their association to access units is described in subclause G.7.4.1.2.3.

#### G.7.4.1.2.3 Order of NAL units and coded pictures and association to access units

The specification of subclause 7.4.1.2.3 applies with the following modifications.

The association of VCL NAL units to primary or redundant coded pictures is specified in subclause G.7.4.1.2.5.

The constraints for the detection of the first VCL NAL unit of a primary coded picture are specified in subclause G.7.4.1.2.4.

The constraint expressed in subclause 7.4.1.2.3 on the order of a buffering period SEI message is replaced by the following constraints.

- When an SEI NAL unit containing a buffering period SEI message is present, the following applies.
  - If the buffering period SEI message is the only buffering period SEI message in the access unit and it is not included in a scalable nesting SEI message, the buffering period SEI message shall be the first SEI message payload of the first SEI NAL unit in the access unit.
  - Otherwise (the buffering period SEI message is not the only buffering period SEI message in the access unit or it is included in a scalable nesting SEI message), the following applies.
    - When a buffering period SEI message that is not included in a scalable nesting SEI message is present, this buffering period SEI message shall be the only SEI message payload of the first SEI NAL unit in the access unit.
    - A scalable nesting SEI message that includes a buffering period SEI message shall not include any other SEI messages and the scalable nesting SEI message that includes a buffering period SEI message shall be the only SEI message inside an SEI NAL unit.
    - All SEI NAL units that precede an SEI NAL unit that contains a scalable nesting SEI message with a buffering period SEI message as payload in an access unit shall only contain buffering period SEI messages or scalable nesting SEI messages with a buffering period SEI message as payload.
    - When present, a scalable nesting SEI message with all_layer_representations_in_au_flag equal to 1 and a buffering period SEI message as payload shall be the first scalable nesting SEI message in an access unit.

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  - Any scalable nesting SEI messages that precedes a particular scalable nesting SEI message with particular values of sei_dependency_id[ i ] and sei_quality_id[ i ] and a buffering period SEI message as payload shall have values ( sei_dependency_id[ i ] << 4 ) + sei_quality_id[ i ] for all present i that are less than any of the particular values ( sei_dependency_id[ i ] << 4 ) + sei_quality_id[ i ] for the particular scalable nesting SEI message with a buffering period SEI message as payload.

The following additional constraints shall be obeyed.

- Each NAL unit with nal_unit_type equal to 1, 5 or 12 shall be immediately preceded by a prefix NAL unit.
- Each prefix NAL unit shall be immediately followed by a NAL unit with nal_unit_type equal to 1, 5, or 12.

#### G.7.4.1.2.4 Detection of the first VCL NAL unit of a primary coded picture

This subclause specifies constraints on VCL NAL unit syntax that are sufficient to enable the detection of the first VCL NAL unit of each primary coded picture.

The first VCL NAL unit of the primary coded picture of the current access unit, in decoding order, shall be different from the last VCL NAL unit of the primary coded picture of the previous access unit, in decoding order, in one or more of the following ways.

- dependency_id of the first VCL NAL unit of the primary coded picture of the current access unit is smaller than dependency_id of the last VCL NAL unit of the primary coded picture of the previous access unit
- dependency_id of the first VCL NAL unit of the primary coded picture of the current access unit is equal to dependency_id of the last VCL NAL unit of the primary coded picture of the previous access unit and any of the following conditions is true
  - quality_id of the first VCL NAL unit of the primary coded picture of the current access unit is smaller than quality_id of the last VCL NAL unit of the primary coded picture of the previous access unit
  - quality_id of the first VCL NAL unit of the primary coded picture of the current access unit and the last VCL NAL unit of the primary coded picture of the previous access unit is equal to 0, and any of the conditions specified in subclause 7.4.1.2.4 is fulfilled

#### G.7.4.1.2.5 Order of VCL NAL units and association to coded pictures

Each VCL NAL unit is part of a coded picture.

Let dId be the value of dependency_id and let qId be the value of quality_id of any particular VCL NAL unit. The order of the VCL NAL units within a coded picture is constrained as follows.

- For all VCL NAL units following this particular VCL NAL unit, the value of dependency_id shall be greater than or equal to dId.
- For all VCL NAL units with a value of dependency_id equal to dId following this particular VCL NAL unit, the value of quality_id shall be greater than or equal to qId.

For each set of VCL NAL units within a layer representation, the following applies.

- If arbitrary slice order, as specified in Annex A or subclause G.10, is allowed, coded slice NAL units of a layer representation may have any order relative to each other.
- Otherwise (arbitrary slice order is not allowed), coded slice NAL units of a slice group shall not be interleaved with coded slice NAL units of another slice group and the order of coded slice NAL units within a slice group shall be in the order of increasing macroblock address for the first macroblock of each coded slice NAL unit of the same slice group.

NAL units having nal_unit_type equal to 12 may be present in the access unit but shall not precede the first VCL NAL unit of the primary coded picture within the access unit.

NAL units having nal_unit_type equal to 0 or in the range of 24 to 31, inclusive, which are unspecified, may be present in the access unit but shall not precede the first VCL NAL unit of the primary coded picture within the access unit.

NAL units having nal_unit_type in the range of 21 to 23, inclusive, which are reserved, shall not precede the first VCL NAL unit of the primary coded picture within the access unit (when specified in the future by ITU-T | ISO/IEC).

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### G.7.4.2 Raw byte sequence payloads and RBSP trailing bits semantics

#### G.7.4.2.1 Sequence parameter set RBSP semantics

The semantics specified in subclause 7.4.2.1 apply.

##### G.7.4.2.1.1 Sequence parameter set data semantics

The semantics specified in subclause 7.4.2.1.1 apply with substituting SVC sequence parameter set for sequence parameter set. All constraints specified in subclause 7.4.2.1.1 apply only to the layer representations for which the SVC sequence parameter set is the active SVC sequence parameter set or the active layer SVC sequence parameter set as specified in subclause G.7.4.1.2.1. Additionally, the following applies.

**constraint_set0_flag** specifies the following.

– If the sequence parameter set data syntax structure is included in a sequence parameter set RBSP, the semantics specified in subclause 7.4.2.1.1 apply.

– Otherwise (the sequence parameter set data syntax structure is included in a subset sequence parameter set RBSP), contraint_set0_flag specifies that the coded video sequence obeys all constraints specified in subclause G.10.1.1. constraint_set0_flag equal to 0 specifies that the coded video sequence may or may not obey all constraints specified in subclause G.10.1.1.

**constraint_set1_flag** specifies the following.

– If the sequence parameter set data syntax structure is included in a sequence parameter set RBSP, the semantics specified in subclause 7.4.2.1.1 apply.

– Otherwise (the sequence parameter set data syntax structure is included in a subset sequence parameter set RBSP), contraint_set1_flag specifies that the coded video sequence obeys all constraints specified in subclause G.10.1.2. constraint_set1_flag equal to 0 specifies that the coded video sequence may or may not obey all constraints specified in subclause G.10.1.2.

**constraint_set2_flag** specifies the following.

– If the sequence parameter set data syntax structure is included in a sequence parameter set RBSP, the semantics specified in subclause 7.4.2.1.1 apply.

– Otherwise (the sequence parameter set data syntax structure is included in a subset sequence parameter set RBSP), the value of 1 for constraint_set2_flag is reserved for future use by ITU-T | ISO/IEC. constraint_set2_flag shall be equal to 0 for coded video sequences with profile_idc equal to 83 and 86 in bitstreams conforming to this International Standard. Decoders conforming to this International Standard shall ignore the value of constraint_set2_flag when profile_idc is equal to 83 or 86.

**constraint_set3_flag** specifies the following.

– If the sequence parameter set data syntax structure is included in a sequence parameter set RBSP, the semantics specified in subclause 7.4.2.1.1 apply.

– Otherwise (the sequence parameter set data syntax structure is included in a subset sequence parameter set RBSP), the following applies.

  – If profile_idc is equal to 86, constraint_set3_flag equal to 1 specifies that the coded video sequence obeys all constraints specified in subclause G.10.1.3, and constraint_set3_flag equal to 0 specifies that the coded video sequence may or may not obey these corresponding constraints.

  – Otherwise (profile_idc is not equal to 86), the value of 1 for constraint_set3_flag is reserved for future use by ITU-T | ISO/IEC. constraint_set3_flag shall be equal to 0 for coded video sequences with profile_idc not equal to 86 in bitstreams conforming to this International Standard. Decoders conforming to this International Standard shall ignore the value of constraint_set3_flag when profile_idc is not equal to 86.

The value of separate_colour_plane_flag shall be equal to 0 and the value of qpprime_y_zero_transform_bypass_flag shall be equal to 0.

When the value of profile_idc does not indicate conformance to any of the profiles specified in Annex A and vui_parameters_present_flag is equal to 1, timing_info_present_flag shall be equal to 0, nal_hrd_parameters_present_flag shall be equal to 0, vcl_hrd_parameters_present_flag shall be equal to 0, and pic_struct_present_flag shall be equal to 0.

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When the value of profile_idc does indicate conformance to one or more of the profiles specified in Annex A and vui_parameters_present_flag is equal to 1, the values of timing_info_present_flag, num_units_in_tick, time_scale, fixed_frame_rate_flag, nal_hrd_parameters_present_flag, vcl_hrd_parameters_present_flag, low_delay_hrd_flag, pic_struct_present_flag and the values of syntax elements included in the hrd_parameters( ) syntax structures, when present, shall be such that the bitstream activating the sequence parameter set is conforming to one or more of the profiles specified in Annex A.

#### G.7.4.2.1.1.1 Scaling list semantics

The semantics specified in subclause 7.4.2.1.1.1 apply.

### G.7.4.2.1.2 Sequence parameter set extension RBSP semantics

The semantics specified in subclause 7.4.2.1.2 apply. Additionally, the following applies.

Sequence parameter set extension RBSPs can only follow sequence parameter set RBSPs in decoding order. Subset sequence parameter set RBSPs shall not be followed by a sequence parameter set extension RBSP. The contents of sequence parameter set extension RBSPs only apply when the base layer, which conforms to one or more of the profiles specified in Annex A, of a coded video sequence conforming to one or more profiles specified in Annex G is decoded.

### G.7.4.2.1.3 Subset sequence parameter set RBSP semantics

**svc_vui_parameters_present_flag** equal to 0 indicates that the syntax structure svc_vui_parameters_extensions( ) is not present. svc_vui_parameters_present_flag equal to 1 indicates that the syntax structure svc_vui_parameters_extensions( ) is present.

**additional_extension2_flag** shall be equal to 0. The value of 1 for additional_extension2_flag is reserved for future use by ITU-T | ISO/IEC.

**additional_extension2_data_flag** may have any value. It shall not affect the conformance to profiles specified in Annex A or Annex G.

### G.7.4.2.1.4 Sequence parameter set SVC extension semantics

**inter_layer_deblocking_filter_control_present_flag** equal to 1 specifies that a set of syntax elements controlling the characteristics of the deblocking filter for inter-layer prediction is present in the slice header. inter_layer_deblocking_filter_control_present_flag equal to 0 specifies that the set of syntax elements controlling the characteristics of the deblocking filter for inter-layer prediction is not present in the slice headers and their inferred values are in effect.

**extended_spatial_scalability** specifies the presence of syntax elements related to geometrical parameters for the resampling processes. The value of extended_spatial_scalability shall be in the range of 0 to 2, inclusive. When extended_spatial_scalability is equal to 0, no geometrical parameters are present in the subset sequence parameter set and the slice headers referring to this subset sequence parameter set. When extended_spatial_scalability is equal to 1, geometrical parameters are present in the subset sequence parameter set, but not in the slice headers referring to this subset sequence parameter set. When extended_spatial_scalability is equal to 2, geometrical parameters are not present in the subset sequence parameter set, but they are present in the slice headers referring to this subset sequence parameter set.

**chroma_phase_x_plus1_flag** specifies the horizontal phase shift of the chroma components in units of half luma samples of a frame or layer frame. When chroma_phase_x_plus1_flag is not present, it shall be inferred to be equal to 1.

When chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are present, the following applies.

– If chroma_phase_x_plus1_flag is equal to 0, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should be equal to 0, 2, or 4.

– Otherwise (chroma_phase_x_plus1_flag is equal to 1), chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should be equal to 1, 3, or 5.

**chroma_phase_y_plus1** specifies the vertical phase shift of the chroma components in units of half luma samples of a frame or layer frame. When chroma_phase_y_plus1 is not present, it shall be inferred to be equal to 1. The value of chroma_phase_y_plus1 shall be in the range of 0 to 2, inclusive.

When chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are present, the following applies.

– If chroma_phase_y_plus1 is equal to 0, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should be equal to 2 or 3.

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– Otherwise, if chroma_phase_y_plus1 is equal to 1, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should be equal to 0 or 1.

– Otherwise (chroma_phase_y_plus1 is equal to 2), chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field should be equal to 4 or 5.

**seq_ref_layer_chroma_phase_x_plus1_flag** specifies the horizontal phase shift of the chroma components in units of half luma samples of a layer frame for the layer pictures that may be used for inter-layer prediction. When seq_ref_layer_chroma_phase_x_plus1_flag is not present, it shall be inferred to be equal to chroma_phase_x_plus1_flag.

**seq_ref_layer_chroma_phase_y_plus1** specifies the vertical phase shift of the chroma components in units of half luma samples of a layer frame for the layer pictures that may be used for inter-layer prediction. When seq_ref_layer_chroma_phase_y_plus1 is not present, it shall be inferred to be equal to chroma_phase_y_plus1. The value of seq_ref_layer_chroma_phase_y_plus1 shall be in the range of 0 to 2, inclusive.

**seq_scaled_ref_layer_left_offset** specifies the horizontal offset between the upper-left luma sample of a resampled layer picture used for inter-layer prediction and the upper-left luma sample of the current picture or current layer picture in units of two luma samples. When seq_scaled_ref_layer_left_offset is not present, it shall be inferred to be equal to 0.

**seq_scaled_ref_layer_top_offset** specifies the vertical offset between the upper-left luma sample of an resampled layer picture used for inter-layer prediction and the upper-left luma sample of the current picture or current layer picture. The vertical offset is specified in units of two luma samples when frame_mbs_only_flag is equal to 1, and it is specified in units of four luma samples when frame_mbs_only_flag is equal to 0. When seq_scaled_ref_layer_top_offset is not present, it shall be inferred to be equal to 0.

**seq_scaled_ref_layer_right_offset** specifies the horizontal offset between the bottom-right luma sample of an resampled layer picture used for inter-layer prediction and the bottom-right luma sample of the current picture or current layer picture in units of two luma samples. When seq_scaled_ref_layer_right_offset is not present, it shall be inferred to be equal to 0.

**seq_scaled_ref_layer_bottom_offset** specifies the vertical offset between the bottom-right luma sample of an resampled layer picture used for inter-layer prediction and the bottom-right luma sample of the current picture or current layer picture. The vertical offset is specified in units of two luma samples when frame_mbs_only_flag is equal to 1, and it is specified in units of four luma samples when frame_mbs_only_flag is equal to 0. When seq_scaled_ref_layer_bottom_offset is not present, it shall be inferred to be equal to 0.

**seq_tcoeff_level_prediction_flag** specifies the presence of the syntax element adaptive_tcoeff_level_prediction_flag in the subset sequence parameter set.

**adaptive_tcoeff_level_prediction_flag** specifies the presence of tcoeff_level_prediction_flag in the slice headers that refer to the subset sequence parameter set. When adaptive_tcoeff_level_prediction_flag is not present, it shall be inferred to be equal to 0.

**slice_header_restriction_flag** specifies the presence of the syntax elements in the slice headers that refer to the subset sequence parameter set.

#### G.7.4.2.2 Picture parameter set RBSP semantics

The semantics specified in subclause 7.4.2.2 apply with substituting SVC sequence parameter set for sequence parameter set. All constraints specified in subclause 7.4.2.2 apply only to the layer representations for which the picture parameter set is the active picture parameter set or the active layer picture parameter set as specified in subclause G.7.4.1.2.1.

#### G.7.4.2.3 Supplemental enhancement information RBSP semantics

The semantics specified in subclause 7.4.2.3 apply.

##### G.7.4.2.3.1 Supplemental enhancement information message semantics

The semantics specified in subclause 7.4.2.3.1 apply.

#### G.7.4.2.4 Access unit delimiter RBSP semantics

The semantics specified in subclause 7.4.2.4 apply.

#### G.7.4.2.5 End of sequence RBSP semantics

The semantics specified in subclause 7.4.2.5 apply.

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#### G.7.4.2.6 End of stream RBSP semantics

The semantics specified in subclause 7.4.2.6 apply.

#### G.7.4.2.7 Filler data RBSP semantics

The semantics specified in subclause 7.4.2.7 apply.

#### G.7.4.2.8 Slice layer without partitioning RBSP semantics

The semantics specified in subclause 7.4.2.8 apply.

#### G.7.4.2.9 Slice data partition RBSP semantics

Slice data partition syntax is not present in bitstreams conforming to one or more of the profiles specified in Annex G.

#### G.7.4.2.10 RBSP slice trailing bits semantics

The semantics specified in subclause 7.4.2.10 apply.

#### G.7.4.2.11 RBSP trailing bits semantics

The semantics specified in subclause 7.4.2.11 apply.

#### G.7.4.2.12 Prefix NAL unit RBSP semantics

**store_ref_base_pic_flag** equal to 1 specifies that, when the value of dependency_id as specified in the NAL unit header is equal to the maximum value of dependency_id for the VCL NAL units of the current access unit, an additional representation of the coded picture that may or may not be identical to the decoded picture is marked as "used for reference". This additional representation is also referred to as reference base picture and may be used for inter prediction of following pictures in decoding order, but it is not output. When store_ref_base_pic_flag is not present, it shall be inferred to be equal to 0.

The syntax element store_ref_base_pic_flag shall have an identical value for all VCL NAL units of a dependency representation. When nal_ref_idc is equal to 0, the value of store_ref_base_pic_flag shall be equal to 0.

store_ref_base_pic_flag is considered to apply to the associated NAL unit.

**prefix_nal_unit_additional_extension_flag** shall be equal to 0. The value of 1 for prefix_nal_unit_additional_extension_flag is reserved for future use by ITU-T | ISO/IEC.

**prefix_nal_unit_extension_flag** may have any value.

NOTE – The syntax elements prefix_nal_unit_additional_extension_flag and prefix_nal_unit_extension_flag are not required by the decoding process specified in this International Standard.

#### G.7.4.2.13 Slice layer in scalable extension RBSP semantics

The slice layer in scalable extension RBSP consists of a slice header in scalable extension and slice data in scalable extension.

### G.7.4.3 Slice header semantics

The semantics specified in subclause 7.4.3 apply with the following modifications.

All constraints specified in subclause 7.4.3 apply only to the layer representations with DQId equal to 0.

**frame_num** has the same semantics as specified in subclause G.7.4.3.4.

The slice_header( ) syntax structure shall be considered to contain the following syntax elements with the following inferred values.

– ref_layer_dq_id is inferred to be equal to –1.

– scan_idx_start is inferred to be equal to 0.

– scan_idx_end is inferred to be equal to 15.

The value of direct_spatial_mv_pred_flag shall be equal to 1.

The variable SpatialResolutionChangeFlag is set equal to 0.

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#### G.7.4.3.1 Reference picture list reordering semantics

The semantics specified in subclause 7.4.3.1 apply.

#### G.7.4.3.2 Prediction weight table semantics

The semantics specified in subclause 7.4.3.2 apply.

#### G.7.4.3.3 Decoded reference picture marking semantics

The semantics specified in subclause 7.4.3.3 apply with substituting SVC sequence parameter set for sequence parameter set. The constraints specified in subclause 7.4.3.3 apply only to the dependency representation with dependency_id equal to the current value of dependency_id and the modifications a) and b) specified in subclause G.8.2 apply with currDependencyId being equal to the current value of dependency_id.

#### G.7.4.3.4 Slice header in scalable extension semantics

The value of the following SVC sequence parameter set syntax elements shall be the same across all coded slice NAL units of an access unit: bit_depth_luma_minus8, bit_depth_chroma_minus8, and chroma_format_idc.

When present, the value of following slice header syntax elements shall be the same across all coded slice NAL units of an access unit: field_pic_flag and bottom_field_flag.

When present, the value of the following slice header syntax elements shall be the same across all slices of a dependency representation including slice headers of NAL units with nal_unit_type equal to 1, 2, or 5: frame_num, idr_pic_id, pic_order_cnt_lsb, delta_pic_order_cnt_bottom, delta_pic_order_cnt[ 0 ], and delta_pic_order_cnt[ 1 ].

When present, the value of the following slice header syntax elements shall be the same across all slices of a layer representation: pic_parameter_set_id, ref_layer_dq_id, disable_inter_layer_deblocking_filter_idc, inter_layer_slice_alpha_c0_offset_div2, inter_layer_slice_beta_offset_div2, constrained_intra_resampling_flag, ref_layer_chroma_phase_x_plus1_flag, ref_layer_chroma_phase_y_plus1, scaled_ref_layer_left_offset, scaled_ref_layer_top_offset, scaled_ref_layer_right_offset, scaled_ref_layer_bottom_offset, slice_group_change_cycle, store_ref_base_pic_flag, tcoeff_level_prediction_flag, and all syntax elements of the syntax structures dec_ref_pic_marking( ) and dec_ref_base_pic_marking( ).

Let setOfRefLayerSlices be the set of slices with dependency_id equal to the current value of dependency_id and quality_id equal to 0 that are covered or partly covered by the macroblocks of the current slice.

When quality_id is greater than 0, the value of (slice_type % 5) for all slices in the set setOfRefLayerSlices shall be the same as the value of (slice_type % 5) for the current slice.

When quality_id is greater than 0 and setOfRefLayerSlices contains more than one slice, the following constraints shall be obeyed.

a) When slice_type specifies an EP or EB slice, the value of the syntax element num_ref_idx_l0_active_minus1 (either the value transmitted in the slice header when num_ref_idx_active_override_flag is equal to 1 or the value of the referenced picture parameter set when num_ref_idx_active_override_flag is equal to 0) shall be the same across all slices of the set setOfRefLayerSlices.

b) When slice_type specifies an EB slice, the value of the syntax element num_ref_idx_l1_active_minus1 (either the value transmitted in the slice header when num_ref_idx_active_override_flag is equal to 1 or the value of the referenced picture parameter set when num_ref_idx_active_override_flag is equal to 0) shall be the same across all slices of the set setOfRefLayerSlices.

c) All elements of the syntax structure ref_pic_list_reordering( ) shall be the same across all slices of the set setOfRefLayerSlices.

d) When slice_type specifies an EP slice, the syntax element weighted_pred_flag shall be the same across all slices of the set setOfRefLayerSlices and the following applies.

   i. When weighted_pred_flag is equal to 1 and no_inter_layer_pred_flag is equal to 0 for any of the slices of the set setRefLayerSlices, base_pred_weight_table_flag shall be the same across all slices of the set setOfRefLayerSlices.

   ii. When weighted_pred_flag is equal to 1 for any of the slices of the set setRefLayerSlices and pred_weight_table( ) is present in any of the slices of the set setOfRefLayerSlices, pred_weight_table( ) shall be present in all slices of the set setOfRefLayerSlices and all syntax elements inside the syntax structure pred_weight_table( ) shall be the same across all slices of the set setOfRefLayerSlices.

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e) When slice_type specifies an EB slice, the syntax element weighted_bipred_idc shall be the same across all slices of the set setOfRefLayerSlices and the following applies.

i. When weighted_bipred_idc is equal to 1 and no_inter_layer_pred_flag is equal to 0 for any of the slices of the set setRefLayerSlices, base_pred_weight_table_flag shall the same across all slices of the set setOfRefLayerSlices.

ii. When weighted_bipred_idc is equal to 1 for any of the slices of the set setRefLayerSlices and pred_weight_table( ) is present in any of the slices of the set setOfRefLayerSlices, pred_weight_table( ) shall be present in all slices of the set setOfRefLayerSlices and all syntax elements inside the syntax structure pred_weight_table( ) shall be the same across all slices of the set setOfRefLayerSlices.

When quality_id is greater than 0, the following syntax elements (that are not present) shall be inferred to be equal to the corresponding syntax elements of the slice headers of the slice with dependency_id equal to the current value of dependency_id and quality_id equal to 0 that covers the macroblock with the macroblock address first_mb_in_slice when present in this slice: direct_spatial_mv_pred_flag, num_ref_idx_l0_active_minus1, num_ref_idx_l1_active_minus1, all syntax elements of the syntax structure ref_pic_list_reordering( ), base_pred_weight_table_flag, all syntax elements of the syntax structure pred_weight_table( ), all syntax elements of the syntax structure dec_ref_pic_marking( ), all syntax elements of the syntax structure dec_ref_base_pic_marking( ), slice_group_change_cycle, and store_ref_base_pic_flag.

**first_mb_in_slice** has the same semantics as specified in subclause 7.4.3.

**slice_type** specifies the coding type of the slice according to Table G-1.

**Table G-1 – Name association to slice_type for NAL units with nal_unit_type equal to 20.**

| slice_type | Name of slice_type |
|---|---|
| 0, 5 | EP (P slice in scalable extension) |
| 1, 6 | EB (B slice in scalable extension) |
| 2, 7 | EI (I slice in scalable extension) |

slice_type values in the range of 5 to 7, inclusive, specify, in addition to the coding type of the current slice, that all other slices of the current layer representation shall have a value of slice_type equal to the current value of slice_type or equal to the current value of slice_type minus 5.

When idr_flag is equal to 1 or num_ref_frames is equal to 0, slice_type shall be equal to 2 or 7.

**pic_parameter_set_id** has the same semantics as specified in subclause 7.4.3. The syntax element profile_idc of the SVC sequence parameter set that is referred to by the picture_parameter_set (by using seq_parameter_set_id) with pic_parameter_set_id shall be equal to 83 or 86.

**frame_num** is used as an identifier for dependency representations and shall be represented by log2_max_frame_num_minus4 + 4 bits in the bitstream.

frame_num is constrained as specified in subclause 7.4.3 where this constraint applies to dependency representations with dependency_id equal to the current value of dependency_id and the modifications a) and b) specified in subclause G.8.2 apply with currDependencyId being equal to the current value of dependency_id.

**field_pic_flag** and **bottom_field_flag** have the same semantics as specified in subclause7.4.3.

**idr_pic_id** identifies an IDR picture when dependency_id is equal to the maximum present value of dependency_id in the VCL NAL units of the current access unit. The value of idr_pic_id shall be in the range of 0 to 65535, inclusive.

When dependency_id is equal to the maximum value of dependency_id in all VCL NAL units of the current access unit and two consecutive access units in decoding order are both IDR access units, the value of idr_pic_id in the slices of the dependency representation with dependency_id equal to the current value of dependency_id in the first such IDR access unit shall differ from the idr_pic_id in the slices of the dependency representation with dependency_id equal to the current value of dependency_id in the second such IDR access unit.

NOTE 1 – The classification of an access unit as IDR access unit depends on the maximum present value of dependency_id. When NAL units are removed from a bitstream, e.g. in order to adjust the bitstream to the capabilities of a receiving device, the classification of access units as IDR access units may change. Since all bitstreams for different conformance points supported in a scalable bitstream (especially for different maximum values of dependency_id) shall conform to this specification, the constraints on idr_pic_id shall be obeyed for all conformance points that are contained in a scalable bitstream.

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**pic_order_cnt_lsb**, **delta_pic_order_cnt_bottom**, **delta_pic_order_cnt**[ 0 ], and **delta_pic_order_cnt**[ 1 ] have the same semantics as specified in subclause 7.4.3.

**redundant_pic_cnt** has the same semantics as specified in subclause 7.4.3.

**direct_spatial_mv_pred_flag** has the same semantics as specified in subclause 7.4.3. Additionally, the value of direct_spatial_mv_pred_flag shall be equal to 1.

**num_ref_idx_active_override_flag**, **num_ref_idx_l0_active_minus1**, and **num_ref_idx_l1_active_minus1** have the same semantics as specified in subclause 7.4.3.

**base_pred_weight_table_flag** equal to 1 specifies that the variables for weighted prediction are inferred. When base_pred_weight_table_flag is not present, it shall be inferred as follows.

– If no_inter_layer_pred_flag is equal to 1 or quality_id is greater than 0, base_pred_weight_table_flag is inferred to be equal to 0.

– Otherwise (no_inter_layer_pred_flag is equal to 0 and quality_id is equal to 0), base_pred_weight_table_flag is inferred to be equal to 1.

Let setOfRefLayerSlices be the set of slices that is represented by the VCL NAL units with dependency_id equal to (ref_layer_dq_id >> 4) and quality_id equal to 0 inside the current access unit.

When base_pred_weight_table_flag equal to 1 the following constraints shall be obeyed.

a) For all slices in setOfRefLayerSlices, the value of (slice_type % 5) shall be equal to (slice_type % 5) of the current slice.

b) When base_pred_weight_table_flag equal to 1 and the syntax structure pred_weight_table( ) is present in any slice in setOfRefLayerSlices, it shall be present for all slices in setOfRefLayerSlices, and all syntax elements inside the syntax structure pred_weight_table( ) shall be identical for all slices in setOfRefLayerSlices.

c) When base_pred_weight_table_flag is present in any slice in setOfRefLayerSlices, it shall have an identical value in all slices in setOfRefLayerSlices.

d) When the current slice is an EP slice, the following applies.

   i. The value of num_ref_idx_l0_active_minus1 of all slices in setOfRefLayerSlices shall be identical to the value of num_ref_idx_l0_active_minus1 of the current slice.

   ii. For each slice in setOfRefLayerSlices all syntax elements inside the syntax structure ref_pic_list_reordering( ) shall be identical, and the syntax structure ref_pic_list_reordering( ) for the slices in setOfRefLayerSlices shall contain syntax elements so that for useRefBasePicFlag equal to 0 and 1, an invocation of subclause G.8.2.3 with currDependencyId set equal to (ref_layer_dq_id >> 4), useRefLayerRepFlag, and any slice of setOfRefLayerSlices as the inputs derives a reference picture list refPicList0RefLayer that is identical to the reference picture list refPicList0, which is derived by invoking subclause G.8.2.3 with currDependencyId set equal to dependency_id, useRefLayerRepFlag, and the current slice as the inputs.

   iii. The syntax element weighted_pred_flag shall be equal to 1 for all slices in setOfRefLayerSlices.

e) When the current slice is an EB slice, the following applies.

   i. The value of num_ref_idx_l0_active_minus1 and num_ref_idx_l1_active_minus1 of all slices in setOfRefLayerSlices shall be identical to the value of num_ref_idx_l0_active_minus1 and num_ref_idx_l1_active_minus1, respectively, of the current slice.

   ii. For each slice in setOfRefLayerSlices all syntax elements inside the syntax structure ref_pic_list_reordering( ) shall be identical, and the syntax structure ref_pic_list_reordering( ) for the slices in setOfRefLayerSlices shall contain syntax elements so that for useRefBasePicFlag equal to 0 and 1, an invoking of subclause G.8.2.3 with currDependencyId set equal to (ref_layer_dq_id >> 4), useRefLayerRepFlag, and any slice of setOfRefLayerSlices as the inputs derives reference picture lists refPicList0RefLayer and refPicList1RefLayer that are identical to the reference picture lists refPicList0 and refPicList1, respectively, which are derived by invoking subclause G.8.2.3 with currDependencyId set equal to dependency_id, useRefLayerRepFlag, and the current slice as the inputs.

   iii. The syntax element weighted_bipred_idc shall be equal to 1 for all slices in setOfRefLayerSlices.

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When quality_id is greater than 0, all elements of pred_weight_table are inferred as specified in the beginning of this subclause.

**store_ref_base_pic_flag** has the same semantics as specified in subclause G.7.4.2.12.

**cabac_init_idc** and **slice_qp_delta** have the same semantics as specified in subclause 7.4.3.

**disable_deblocking_filter_idc** specifies whether the operation of the deblocking filter shall be disabled across some block edges of the slice and specifies for which edges the filtering is disabled. When disable_deblocking_filter_idc is not present in the slice header, the value of disable_deblocking_filter_idc shall be inferred to be equal to 0.

The value of disable_deblocking_filter_idc shall be in the range of 0 to 6, inclusive. disable_deblocking_filter_idc equal to 0 specifies that all luma and chroma block edges of the current picture are filtered. disable_deblocking_filter_idc equal to 1 specifies that deblocking is disabled for all block edges of the current picture. disable_deblocking_filter_idc equal to 2 specifies that all luma and chroma block edges are filtered with exception of the block edges that coincide with slice boundaries. disable_deblocking_filter_idc equal to 3 specifies a two stage deblocking filter process. After filtering all block luma and chroma block edges that do not coincide with slice boundaries (as if disable_deblocking_filter_idc were equal to 2), the luma and chroma block edges that coincide with slice boundaries are filtered. disable_deblocking_filter_idc equal to 4 specifies that all luma block edges of the current picture are filtered, but the deblocking of the chroma block edges is disabled. disable_deblocking_filter_idc equal to 5 specifies that all luma block edges are filtered with exception of the block edges that coincide with slice boundaries (as if disable_deblocking_filter_idc were equal to 2), and that deblocking for chroma block edges is disabled. disable_deblocking_filter_idc equal to 6 specifies that the deblocking for chroma block edges is disabled and that the two stage deblocking filter process is used for luma block edges: After filtering all block luma block edges that do not coincide with slice boundaries (as if disable_deblocking_filter_idc were equal to 2), the luma block edges that coincide with slice boundaries are filtered.

**slice_alpha_c0_offset_div2**, and **slice_beta_offset_div2** have the same semantics as specified in subclause 7.4.3.

**slice_group_change_cycle** has the same semantics as specified in subclause 7.4.3.

**ref_layer_dq_id** specifies the layer representation inside the current access unit that is used for inter-layer prediction of the current layer representation. When ref_layer_dq_id is not present, it shall be inferred as follows.

– If quality_id is greater than 0, ref_layer_dq_id is inferred to be equal to (DQId – 1).

– Otherwise (quality_id is equal to 0), ref_layer_dq_id is inferred to be equal to –1.

When quality_id is equal to 0, the NAL units with DQId equal to ref_layer_dq_id shall have discardable_flag equal to 0.

When present, the value of ref_layer_dq_id shall be the same for all coded slice NAL units of a layer representation.

When ref_layer_dq_id is not equal to –1, the following variables are derived as follows.

– RefLayerPicSizeInMbs is set equal to the value of the variable PicSizeInMbs for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerPicWidthInMbs is set equal to the value of the variable PicWidthInMbs for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerPicHeightInMbs is set equal to the value of the variable PicHeightInMbs for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerChromaFormatIdc is set equal to the value of the syntax element chroma_format_idc for the layer representation with DQId equal to the value of ref_layer_dq_id.

– RefLayerChromaArrayType is set equal to the value of ChromaArrayType for the layer representation with DQId equal to the value of ref_layer_dq_id.

– $RefLayerPicWidthInSamples_L$ is set equal to the value of the variable $PicWidthInSamples_L$ for the layer representation with DQId equal to the value of ref_layer_dq_id.

– $RefLayerPicHeightInSamples_L$ is set equal to the value of the variable $PicHeightInSamples_L$ for the layer representation with DQId equal to the value of ref_layer_dq_id.

– $RefLayerPicWidthInSamples_C$ is set equal to the value of the variable $PicWidthInSamples_C$ for the layer representation with DQId equal to the value of ref_layer_dq_id.

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- RefLayerPicHeightInSamples$_C$ is set equal to the value of the variable PicHeightInSamples$_C$ for the layer representation with DQId equal to the value of ref_layer_dq_id.
- RefLayerMbWidthC is set equal to the value of the variable MbWidthC for the layer representation with DQId equal to the value of ref_layer_dq_id.
- RefLayerMbHeightC is set equal to the value of the variable MbHeightC for the layer representation with DQId equal to the value of ref_layer_dq_id.
- RefLayerFrameMbsOnlyFlag is set equal to the value of the syntax element frame_mbs_only_flag for the layer representation with DQId equal to the value of ref_layer_dq_id.
- RefLayerFieldPicFlag is set equal to the value of the syntax element field_pic_flag for the layer representation with DQId equal to the value of ref_layer_dq_id.
- RefLayerBottomFieldFlag is set equal to the value of the syntax element bottom_field_flag for the layer representation with DQId equal to the value of ref_layer_dq_id.
- RefLayerMbaffFrameFlag is set equal to the value of the variable MbaffFrameFlag for the layer representation with DQId equal to the value of ref_layer_dq_id.

**disable_inter_layer_deblocking_filter_idc** specifies whether the operation of the deblocking filter for inter-layer intra prediction is disabled across some block edges of the slice and specifies for which edges the filtering is disabled. When disable_inter_layer_deblocking_filter_idc is not present in the slice header, the value of disable_inter_layer_deblocking_filter_idc shall be inferred to be equal to 0. The value of disable_inter_layer_deblocking_filter_idc shall be in the range of 0 to 6, inclusive. The values 0 to 6 of disable_inter_layer_deblocking_filter_idc specify the same deblocking filter operations as the corresponding values of disable_deblocking_filter_idc, but for the deblocking of the intra macroblocks of the dependency representation specified by ref_layer_dq_id before resampling.

When quality_id is equal to 0 and SpatialResolutionChangeFlag as specified in the following paragraphs is equal to 0, disable_inter_layer_deblocking_filter_idc shall be equal to 1.

**inter_layer_slice_alpha_c0_offset_div2** specifies the offset used in accessing the α and $t_{C0}$ deblocking filter tables for filtering operations controlled by the macroblocks within the slice for inter-layer prediction. From this value, the offset that is applied when addressing these tables shall be computed as:

$$\text{InterlayerFilterOffsetA} = \text{inter_layer_slice_alpha_c0_offset_div2} << 1 \qquad \text{(G-67)}$$

The value of inter_layer_slice_alpha_c0_offset_div2 shall be in the range of –6 to +6, inclusive. When inter_layer_slice_alpha_c0_offset_div2 is not present in the slice header, the value of inter_layer_slice_alpha_c0_offset_div2 shall be inferred to be equal to 0.

**inter_layer_slice_beta_offset_div2** specifies the offset used in accessing the β deblocking filter table for filtering operations controlled by the macroblocks within the slice for inter-layer prediction. From this value, the offset that is applied when addressing the β table of the deblocking filter is computed as:

$$\text{InterlayerFilterOffsetB} = \text{inter_layer_slice_beta_offset_div2} << 1 \qquad \text{(G-68)}$$

The value of inter_layer_slice_beta_offset_div2 shall be in the range of –6 to +6, inclusive. When inter_layer_slice_beta_offset_div2 is not present in the slice header the value of inter_layer_slice_beta_offset_div2 shall be inferred to be equal to 0.

**constrained_intra_resampling_flag** specifies whether slice boundaries of the dependency representation that is specified for inter-layer prediction by ref_layer_dq_id are treated similar to layer picture boundaries for the intra resampling process. When constrained_intra_resampling_flag is equal to 1, disable_inter_layer_deblocking_filter_idc shall be equal to 1, 2, or 4.

When constrained_intra_resampling_flag is equal to 1, a macroblock cannot be coded using the Intra_Base macroblock prediction mode when it covers more than one slice in the reference layer as specified in subclause G.8.6.2.

When constrained_intra_resampling_flag is not present, it shall be inferred to be equal to 0.

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**ref_layer_chroma_phase_x_plus1_flag** specifies the horizontal phase shift of the chroma components in units of half luma samples of a layer frame for the layer pictures that may be used for inter-layer prediction. When ref_layer_chroma_phase_x_plus1_flag is not present, it shall be inferred to be equal to seq_ref_layer_chroma_phase_x_plus1_flag.

When no_inter_layer_pred_flag is equal to 0, the following applies.

– When ref_layer_dq_id is greater than 0, ref_layer_chroma_phase_x_plus1_flag should be equal to chroma_phase_x_plus1_flag of the subset sequence parameter set RBSP that is referred to by the reference layer representation (with DQId equal to ref_layer_dq_id).

– When chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are present in the SVC sequence parameter set that is referred to by the reference layer representation (with DQId equal to ref_layer_dq_id), the following applies.

  – If ref_layer_chroma_phase_x_plus1_flag is equal to 0, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field of the SVC sequence parameter set that is referred to by the reference layer representation should be equal to 0, 2, or 4.

  – Otherwise (ref_layer_chroma_phase_x_plus1_flag is equal to 1), chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field of the SVC sequence parameter set that is referred to by the reference layer representation should be equal to 1, 3, or 5.

**ref_layer_chroma_phase_y_plus1** specifies the vertical phase shift of the chroma components in units of half luma samples of a layer frame for the layer pictures that may be used for inter-layer prediction. When ref_layer_chroma_phase_y_plus1 is not present, it shall be inferred to be equal to seq_ref_layer_chroma_phase_y_plus1. The value of ref_layer_chroma_phase_y_plus1 shall be in the range of 0 to 2, inclusive.

When no_inter_layer_pred_flag is equal to 0, the following applies.

– When ref_layer_dq_id is greater than 0, ref_layer_chroma_phase_y_plus1 should be equal to chroma_phase_y_plus1 of the subset sequence parameter set RBSP that is referred to by the reference layer representation (with DQId equal to ref_layer_dq_id).

– When chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are present in the SVC sequence parameter set that is referred to by the reference layer representation (with DQId equal to ref_layer_dq_id), the following applies.

  – If ref_layer_chroma_phase_y_plus1 is equal to 0, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field of the SVC sequence parameter set that is referred to by the reference layer representation should be equal to 2 or 3.

  – Otherwise, if ref_layer_chroma_phase_y_plus1 is equal to 1, chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field of the SVC sequence parameter set that is referred to by the reference layer representation should be equal to 0 or 1.

  – Otherwise (chroma_phase_y_plus1 is equal to 2), chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field of the SVC sequence parameter set that is referred to by the reference layer representation should be equal to 4 or 5.

**scaled_ref_layer_left_offset** specifies the horizontal offset between the upper-left luma sample of a resampled layer picture used for inter-layer prediction and the upper-left luma sample of the current picture or current layer picture in units of two luma samples.

When scaled_ref_layer_left_offset is not present, it shall be inferred as follows.

– If quality_id is greater than 0, scaled_ref_layer_left_offset is inferred to be equal to 0.

– Otherwise (quality_id is equal to 0), scaled_ref_layer_left_offset is inferred to be equal to seq_scaled_ref_layer_left_offset.

**scaled_ref_layer_top_offset** specifies the vertical offset between the upper-left luma sample of an resampled layer picture used for inter-layer prediction and the upper-left luma sample of the current picture or current layer picture. The vertical offset is specified in units of two luma samples when frame_mbs_only_flag is equal to 1, and it is specified in units of four luma samples when frame_mbs_only_flag is equal to 0.

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When scaled_ref_layer_top_offset is not present, it shall be inferred as follows.

– If quality_id is greater than 0, scaled_ref_layer_top_offset is inferred to be equal to 0.

– Otherwise (quality_id is equal to 0), scaled_ref_layer_top_offset is inferred to be equal to seq_scaled_ref_layer_top_offset.

**scaled_ref_layer_right_offset** specifies the horizontal offset between the bottom-right luma sample of an resampled layer picture used for inter-layer prediction and the bottom-right luma sample of the current picture or current layer picture in units of two luma samples.

When scaled_ref_layer_right_offset is not present, it shall be inferred as follows.

– If quality_id is greater than 0, scaled_ref_layer_right_offset is inferred to be equal to 0.

– Otherwise (quality_id is equal to 0), scaled_ref_layer_right_offset is inferred to be equal to seq_scaled_ref_layer_right_offset.

**scaled_ref_layer_bottom_offset** specifies the vertical offset between the bottom-right luma sample of an resampled layer picture used for inter-layer prediction and the bottom-right luma sample of the current picture or current layer picture. The vertical offset is specified in units of two luma samples when frame_mbs_only_flag is equal to 1, and it is specified in units of four luma samples when frame_mbs_only_flag is equal to 0.

When scaled_ref_layer_bottom_offset is not present, it shall be inferred as follows.

– If quality_id is greater than 0, scaled_ref_layer_bottom_offset is inferred to be equal to 0.

– Otherwise (quality_id is equal to 0), scaled_ref_layer_bottom_offset is inferred to be equal to seq_scaled_ref_layer_bottom_offset.

The variables ScaledRefLayerLeftOffset, ScaledRefLayerRightOffset, ScaledRefLayerTopOffset, ScaledRefLayerBottomOffset, $ScaledRefLayerPicWidthInSamples_L$, and $ScaledRefLayerPicHeightInSamples_L$ are derived by

$$ScaledRefLayerLeftOffset = 2 * scaled_ref_layer_left_offset \quad (G\text{-}69)$$
$$ScaledRefLayerRightOffset = 2 * scaled_ref_layer_right_offset \quad (G\text{-}70)$$
$$ScaledRefLayerTopOffset = 2 * scaled_ref_layer_top_offset * ( 2 - frame_mbs_only_flag ) \quad (G\text{-}71)$$
$$ScaledRefLayerBottomOffset = 2 * scaled_ref_layer_bottom_offset * ( 2 - frame_mbs_only_flag ) \quad (G\text{-}72)$$
$$ScaledRefLayerPicWidthInSamples_L = PicWidthInMbs * 16 - ScaledRefLayerLeftOffset - ScaledRefLayerRightOffset \quad (G\text{-}73)$$
$$ScaledRefLayerPicHeightInSamples_L = PicHeightInMbs * 16 - ( ScaledRefLayerTopOffset + ScaledRefLayerBottomOffset ) / ( 1 + field_pic_flag ) \quad (G\text{-}74)$$

When no_inter_layer_pred_flag is equal to 0, the following applies.

– The bitstream shall not contain data that result in $ScaledRefLayerPicWidthInSamples_L$ less than $RefLayerPicWidthInSamples_L$.

– When RefLayerFrameMbsOnlyFlag is equal to 0 or frame_mbs_only_flag is equal to 1, the bitstream shall not contain data that result in ($ScaledRefLayerPicHeightInSamples_L$ * ( 1 + field_pic_flag )) less than ($RefLayerPicHeightInSamples_L$ * ( 1 + RefLayerFieldPicFlag )).

– When RefLayerFrameMbsOnlyFlag is equal to 1 and frame_mbs_only_flag is equal to 0, the bitstream shall not contain data that result in ($ScaledRefLayerPicHeightInSamples_L$ * ( 1 + field_pic_flag )) less than (2 * $RefLayerPicHeightInSamples_L$).

When ChromaArrayType is not equal to 0, the variables $ScaledRefLayerPicWidthInSamples_C$, and $ScaledRefLayerPicHeightInSamples_C$ are derived by

$$ScaledRefLayerPicWidthInSamples_C = ScaledRefLayerPicWidthInSamples_L / SubWidthC \quad (G\text{-}75)$$
$$ScaledRefLayerPicHeightInSamples_C = ScaledRefLayerPicHeightInSamples_L / SubHeightC \quad (G\text{-}76)$$

The variable CroppingChangeFlag is derived as follows.

– If quality_id is equal to 0 and extended_spatial_scalability is equal to 2, CroppingChangeFlag is set equal to 1.

– Otherwise (quality_id is greater than 0 or extended_spatial_scalability is less than 2), CroppingChangeFlag is set equal to 0.

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The variable SpatialResolutionChangeFlag is derived as follows.

– If no_inter_layer_pred_flag is equal to 1, quality_id is greater than 0, or all of the following conditions are true, SpatialResolutionChangeFlag is set equal to 0.
  – CroppingChangeFlag is equal to 0
  – $ScaledRefLayerPicWidthInSamples_L$ is equal to $RefLayerPicWidthInSamples_L$
  – $ScaledRefLayerPicHeightInSamples_L$ is equal to $RefLayerPicHeightInSamples_L$
  – (ScaledRefLayerLeftOffset % 16) is equal to 0
  – (ScaledRefLayerTopOffset % ( 16 * ( 1 + frame_mbs_only_flag ) ) ) is equal to 0
  – field_pic_flag is equal to RefLayerFieldPicFlag
  – MbaffFrameFlag is equal to RefLayerMbaffFrameFlag
  – chroma_format_idc is equal to RefLayerChromaFormatIdc
  – chroma_phase_x_plus1_flag is equal to ref_layer_chroma_phase_x_plus1_flag
  – chroma_phase_y_plus1 is equal to ref_layer_chroma_phase_y_plus1
– Otherwise, SpatialResolutionChangeFlag is set equal to 1.

The variable RestrictedSpatialResolutionChangeFlag is derived as follows.

– If no_inter_layer_pred_flag is equal to 1, quality_id is greater than 0, or all of the following conditions are true, RestrictedSpatialResolutionChangeFlag is set equal to 1.
  – $ScaledRefLayerPicWidthInSamples_L$ is equal to $RefLayerPicWidthInSamples_L$ or (2 * $RefLayerPicWidthInSamples_L$)
  – $ScaledRefLayerPicHeightInSamples_L$ is equal to $RefLayerPicHeightInSamples_L$ or (2 * $RefLayerPicHeightInSamples_L$)
  – (ScaledRefLayerLeftOffset % 16) is equal to 0
  – (ScaledRefLayerTopOffset % ( 16 * ( 1 + frame_mbs_only_flag ) ) ) is equal to 0
  – MbaffFrameFlag is equal to RefLayerMbaffFrameFlag
  – field_pic_flag is equal to RefLayerFieldPicFlag
– Otherwise, RestrictedSpatialResolutionChangeFlag is set equal to 0.

**slice_skip_flag** equal to 0 specifies the presence of slice data in the slice. slice_skip_flag equal to 1 specifies that the syntax elements for the macroblock layer of the slice are derived by the following process.

1. CurrMbAddr is derived by

$$CurrMbAddr = first_mb_in_slice * ( 1 + MbaffFrameFlag ) \quad (G\text{-}77)$$

2. The variable mbIdx proceeds over the values 0..num_mbs_in_slice_minus1, and for each value of mbIdx, the following ordered steps are specified.
   a. The bitstream shall not contain data that result in in_crop_window( CurrMbAddr ) equal to 0.
   b. For the macroblock with address CurrMbAddr, the syntax elements mb_skip_flag (when applicable), mb_skip_run (when applicable), mb_field_decoding_flag, base_mode_flag, residual_prediction_flag and coded_block_pattern shall be inferred as follows.
      – mb_skip_flag (when applicable) and mb_skip_run (when applicable) are inferred to be equal to 0
      – mb_field_decoding_flag is inferred to be equal to 0
        NOTE 2 – The frame/field mode used for decoding is inferred in subclause G.8.1.5.1.
      – base_mode_flag is inferred to be equal to 1
      – residual_prediction_flag is inferred to be equal to 1

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- coded_block_pattern is inferred to be equal to 0
- $QP_Y$ is inferred to be equal to $SliceQP_Y$
- $QP'_Y$ is inferred to be equal to $(QP_Y + QpBdOffset_Y)$

c. CurrMbAddr is set to NextMbAddress( CurrMbAddr )

**num_mbs_in_slice_minus1** plus 1specifies the number of macroblocks for a slice with slice_skip_flag equal to 1.

**adaptive_base_mode_flag** specifies the presence of syntax elements in the slice header and in the macroblock layer in scalable extension. When adaptive_base_mode_flag is not present, it shall be inferred to be equal to 0.

**default_base_mode_flag** specifies how base_mode_flag is inferred when it is not present in macroblock layer in scalable extension. When default_base_mode_flag is not present, it shall be inferred to be equal to 0.

**adaptive_motion_prediction_flag** specifies the presence of syntax elements in the macroblock layer in scalable extension. When adaptive_motion_prediction_flag is not present, it shall be inferred to be equal to 0.

**default_motion_prediction_flag** specifies how motion_prediction_flag_l0[ ] and motion_prediction_flag_l1[ ] are inferred when they are not present in macroblock layer in scalable extension. When default_motion_prediction_flag is not present, it shall be inferred to be equal to 0.

**adaptive_residual_prediction_flag** specifies the presence of syntax elements in the macroblock layer in scalable extension. When adaptive_residual_prediction_flag is not present, it shall be inferred to be equal to 0.

**default_residual_prediction_flag** specifies how residual_prediction_flag is inferred when it is not present in the macroblock layer in scalable extension. When default_residual_prediction_flag is not present, it shall be inferred to be equal to 0.

**tcoeff_level_prediction_flag** equal to 1 specifies that an alternative inter-layer prediction process is applied as specified in subclause G.8. When tcoeff_level_prediction_flag is not present it shall be inferred as follows.

- If no_inter_layer_pred_flag is equal to 1, tcoeff_level_prediction_flag is inferred to be equal to 0.
- Otherwise (no_inter_layer_pred_flag is equal to 0), tcoeff_level_prediction_flag is inferred to be equal to the value of seq_tcoeff_level_prediction_flag.

When SpatialResolutionChangeFlag is equal to 1, tcoeff_level_prediction_flag shall be equal to 0.

When tcoeff_level_prediction_flag is equal to 1, the following constraints shall be obeyed.

a) The layer representation with DQId equal to ref_layer_dq_id shall have no_inter_layer_pred_flag equal to 1 or tcoeff_level_prediction_flag equal to 1.

b) All elements of ScalingList4x4 shall be the same for the slices of the current layer representation and all slices of the layer representation with DQId equal to the value of ref_layer_dq_id.

c) All elements of ScalingList8x8 shall be the same for the slices of the current layer representation and all slices of the layer representation with DQId equal to the value of ref_layer_dq_id.

d) The value of the syntax element use_ref_base_pic_flag shall be equal to 0 for the slices of the current layer representation and all slices of the layer representation with DQId equal to the value of ref_layer_dq_id.

**scan_idx_start** specifies the first scanning position for the transform coefficient levels in the current slice. When scan_idx_start is not present, it shall be inferred to be equal to 0.

**scan_idx_end** specifies the last scanning position for the transform coefficient levels in the current slice. When scan_idx_end is not present, it shall be inferred to be equal to 15.

#### G.7.4.3.5 Decoded reference base picture marking semantics

The syntax elements adaptive_ref_base_pic_marking_mode_flag, memory_management_control_operation, difference_of_pic_nums_minus1 and long_term_pic_num specify marking of reference base pictures as "unused for reference".

**adaptive_ref_base_pic_marking_mode_flag** has the same semantics as the syntax element adaptive_ref_pic_marking_mode_flag in the dec_ref_pic_marking() syntax structure. When adaptive_ref_base_pic_marking_mode_flag is not present, it shall be inferred to be equal to 0.

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**memory_management_control_operation** specifies a control operation to be applied to affect the reference picture marking. The memory_management_control_operation syntax element is followed by data necessary for the operation specified by the value of memory_management_control_operation. The values and control operations associated with memory_management_control_operation are specified in Table G-2. The memory_management_control_operation syntax elements are processed by the decoding process in the order in which they appear, and the semantics constraints expressed for each memory_management_control_operation apply at the specific position in that order at which that individual memory_management_control_operation is processed.

memory_management_control_operation shall not be equal to 1 unless the specified reference picture is marked as "used for short-term reference" and as "reference base picture" when the memory_management_control_operation is processed by the decoding process.

memory_management_control_operation shall not be equal to 2 unless the specified long-term picture number refers to a reference picture that is marked as "used for long-term reference" and as "reference base picture" when the memory_management_control_operation is processed by the decoding process.

**Table G-2 – Memory management control operation (memory_management_control_operation) values**

| memory_management_control_operation | Memory Management Control Operation |
|---|---|
| 0 | End memory_management_control_operation syntax element loop |
| 1 | Mark a short-term reference base picture as "unused for reference" |
| 2 | Mark a long-term reference base picture as "unused for reference" |

**difference_of_pic_nums_minus1** is used (with memory_management_control_operation equal to 1) to mark a short-term reference picture as "unused for reference". When the associated memory_management_control_operation is processed by the decoding process, the resulting picture number derived from difference_of_pic_nums_minus1 shall be a picture number assigned to one of the reference pictures marked as "used for reference" and as "reference base picture".

The resulting picture number is constrained as follows.

– If field_pic_flag is equal to 0, the resulting picture number shall be one of the set of picture numbers assigned to reference frames or complementary reference field pairs, or there is no reference frame or complementary reference field pair that has been assigned the resulting picture number.

– Otherwise (field_pic_flag is equal to 1), the resulting picture number shall be one of the set of picture numbers assigned to reference fields, or there is no reference pair that has been assigned the resulting picture number.

**long_term_pic_num** is used (with memory_management_control_operation equal to 2) to mark a long-term reference picture as "unused for reference". When the associated memory_management_control_operation is processed by the decoding process, long_term_pic_num shall be equal to a long-term picture number assigned to one of the reference pictures marked as "used for long-term reference" and as "reference base picture".

The resulting long-term picture number is constrained as follows.

– If field_pic_flag is equal to 0, the resulting long-term picture number shall be one of the set of long-term picture numbers assigned to reference frames or complementary reference field pairs, or there is no reference frame or complementary reference field pair that has been assigned the resulting long-term picture number..

– Otherwise (field_pic_flag is equal to 1), the resulting long-term picture number shall be one of the set of long-term picture numbers assigned to reference fields, or there is no reference pair that has been assigned the resulting long-term picture number.

When present in a prefix NAL unit, the syntax elements of the dec_ref_base_pic_marking( ) syntax structure are considered to apply to the associated NAL unit.

### G.7.4.4 Slice data semantics

The semantics specified in subclause 7.4.4 apply.

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#### G.7.4.4.1 Slice data in scalable extension semantics

The semantic specified in subclauses 7.4.4 apply with the following modifications.

**mb_skip_run** specifies the number of consecutive skipped macroblocks for which, when decoding an EP slice, mb_type shall be inferred to be P_Skip and the macroblock type is collectively referred to as a P macroblock type, or for which, when decoding an EB slice, mb_type shall be inferred to be B_Skip and the macroblock type is collectively referred to as a B macroblock type. The value of mb_skip_run shall be in the range of 0 to PicSizeInMbs – CurrMbAddr, inclusive.

**mb_skip_flag** equal to 1 specifies that for the current macroblock, when decoding an EP slice, mb_type shall be inferred to be P_Skip and the macroblock type is collectively referred to as P macroblock type, or for which, when decoding an EB slice, mb_type shall be inferred to be B_Skip and the macroblock type is collectively referred to as B macroblock type. mb_skip_flag equal to 0 specifies that the current macroblock is not skipped.

### G.7.4.5 Macroblock layer semantics

The semantics specified in subclause 7.4.5 apply. Additionally, the following applies.

The macroblock_layer( ) syntax structure shall be considered to contain the following syntax elements with the following inferred values.

– base_mode_flag is inferred to be equal to 0.

– residual_prediction_flag is inferred to be equal to 0.

#### G.7.4.5.1 Macroblock prediction semantics

The semantics specified in subclause 7.4.5.1 apply. Additionally, the following applies.

The mb_pred( ) syntax structure shall be considered to contain the following syntax elements with the following inferred values.

– motion_prediction_flag_l0[ mbPartIdx ] is inferred to be equal to 0 for each value of mbPartIdx in the range from 0 to NumMbPart( mb_type ) − 1, inclusive.

– motion_prediction_flag_l1[ mbPartIdx ] is inferred to be equal to 0 for each value of mbPartIdx in the range from 0 to NumMbPart( mb_type ) − 1, inclusive.

#### G.7.4.5.2 Sub-macroblock prediction semantics

The semantics specified in subclause 7.4.5.2 apply. Additionally, the following applies.

The sub_mb_pred( ) syntax structure shall be considered to contain the following syntax elements with the following inferred values.

– motion_prediction_flag_l0[ mbPartIdx ] is inferred to be equal to 0 for each value of mbPartIdx in the range from 0 to 3, inclusive.

– motion_prediction_flag_l1[ mbPartIdx ] is inferred to be equal to 0 for each value of mbPartIdx in the range from 0 to 3, inclusive.

#### G.7.4.5.3 Residual data semantics

The semantics specified in subclause 7.4.5.3 apply.

##### G.7.4.5.3.1 Residual luma semantics

The semantics specified in subclause 7.4.5.3.1 apply.

##### G.7.4.5.3.2 Residual block CAVLC semantics

The semantics specified in subclause 7.4.5.3.2 apply.

##### G.7.4.5.3.3 Residual block CABAC semantics

The semantics specified in subclause 7.4.5.3.3 apply.

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### G.7.4.6 Macroblock layer in scalable extension semantics

The semantic specified in subclauses 7.4.5 apply. Additionally, the following modifications and extensions are specified.

**base_mode_flag** equal to 1 specifies that the macroblock prediction mode as well as the corresponding motion data (when applicable) are inferred as specified in subclause G.8. base_mode_flag equal to 0 specifies that mb_type is not inferred.

When base_mode_flag is not present, base_mode_flag shall be inferred as follows.

– If in_crop_window( CurrMbAddr ) is equal to 0, the value of base_mode_flag is inferred to be equal to 0.

– Otherwise (in_crop_window( CurrMbAddr ) is equal to 1), the value of base_mode_flag is inferred to be equal to default_base_mode_flag.

When store_ref_base_pic_flag is equal to 1 and quality_id is greater than 0, base_mode_flag shall be equal to 1.

**mb_type** specifies the macroblock type. The semantics of mb_type depend on the slice type.

Tables and semantics are specified for the various macroblock types for EI, EP, and EB slices. Each table presents the value of mb_type, the name of mb_type, the number of macroblock partitions used (given by NumMbPart( mb_type ) function), the prediction mode of the macroblock (when it is not partitioned) or the first partition (given by the MbPartPredMode( mb_type, 0 ) function) and the prediction mode of the second partition (given by the MbPartPredMode( mb_type, 1 ) function). When a value is not applicable it is designated by "na". In the text, the value of mb_type may be referred to as the macroblock type and a value X of MbPartPredMode( ) may be referred to in the text by "X macroblock (partition) prediction mode" or as "X prediction macroblocks".

Table G-3 shows the allowed collective macroblock types for each slice_type.

**Table G-3 – Allowed collective macroblock types for slice_type.**

| slice_type | allowed collective macroblock types |
|---|---|
| EI (slice) | I (see Table 7-11 and Table G-4) (macroblock types) |
| EP (slice) | P (see Table 7-13) and I (see Table 7-11 and Table G-4) (macroblock types) |
| EB (slice) | B (see Table 7-14) and I (see Table 7-11 and Table G-4) (macroblock types) |

Macroblock types that may be collectively referred to as I macroblock types are specified in Table G-4 and Table 7-11. mb_type value 0 is specified in Table G-4, whereas the other mb_type are specified in Table 7-11. Table G-4 additionally specifies the inferred macroblock type I_BL.

The macroblock types for EI slices are all I macroblock types.

**Table G-4 – Macroblock types for EI slices.**

| mb_type | Name of mb_type | transform_size_8x8_flag | MbPartPredMode ( mb_type, 0 ) | Intra16x16PredMode | CodedBlockPatternChroma | CodedBlockPatternLuma |
|---|---|---|---|---|---|---|
| 0 | I_NxN | 0 | Intra_4x4 | na | Equation 7-34 | Equation 7-34 |
| 0 | I_NxN | 1 | Intra_8x8 | na | Equation 7-34 | Equation 7-34 |
| inferred | I_BL | na | Intra_Base | na | Equation 7-34 | Equation 7-34 |

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Macroblock types that may be collectively referred to as P macroblock types are specified in Table 7-13.

The macroblock types for EP slices are specified in Table 7-13, Table 7-11 and Table G-4. mb_type values 0 to 4 are specified in Table 7-13, mb_type value 5 is specified in Table G-4 indexed by subtracting 5 from the value of mb_type and mb_type values 6 to 30 are specified in Table 7-11, indexed by subtracting 5 from the value of mb_type. Table G-4 additionally specifies the inferred macroblock type I_BL.

Macroblock types that may be collectively referred to as B macroblock types are specified in Table 7-14.

The macroblock types for EB slices are specified in Table 7-14, Table 7-11 and Table G-4. mb_type values 0 to 22 are specified in Table 7-14, mb_type values 23 is specified in Table G-4 indexed by subtracting 23 from the value of mb_type and mb_type 24 to 48 are specified in Table 7-14, indexed by subtracting 23 from the value of mb_type. Table G-4 additionally specifies the inferred macroblock type I_BL.

**coded_block_pattern** specifies which of the four 8x8 luma blocks and associated chroma blocks of a macroblock may contain non-zero transform coefficient values. For macroblocks with prediction mode not equal to Intra_16x16, coded_block_pattern is present in the bitstream and the variables CodedBlockPatternLuma and CodedBlockPatternChroma are derived as specified by Equation (7-34).

The meaning of CodedBlockPatternLuma and CodedBlockPatternChroma is specified in subclause 7.4.5.

**residual_prediction_flag** equal to 1 specifies that the residual signal of the current macroblock is predicted as specified in subclause G.8 using the layer representation specified by ref_layer_dq_id. residual_prediction_flag equal to 0 specifies that the residual signal of the current macroblock is not predicted.

When the syntax element residual_prediction_flag is not present, residual_prediction_flag shall be inferred as follows.

– If all of the following conditions are true, residual_prediction_flag is inferred to be equal to default_residual_prediction_flag.
  – slice_type is not equal to EI
  – in_crop_window( CurrMbAddr ) is equal to 1
  – base_mode_flag is equal to 1 or mb_type does not specify an I macroblock type
– Otherwise, residual_prediction_flag is inferred to be equal to 0.

All elements of the arrays LumaLevel, LumaLevel8x8, Intra16x16DCLevel, Intra16x16ACLevel, CbLevel, CbLevel8x8, CbIntra16x16DCLevel, CbIntra16x16ACLevel, CrLevel, CrLevel8x8, CrIntra16x16DCLevel, CrIntra16x16ACLevel, ChromaDCLevel, and ChromaACLevel are set equal to 0 before parsing the residual( ) syntax structure.

#### G.7.4.6.1 Macroblock prediction in scalable extension semantics

The semantics specified in subclauses 7.3.5.1 apply. Additionally, the following semantics are specified.

**motion_prediction_flag_l0[** mbPartIdx **]** equal to 1 specifies that an alternative motion vectors prediction process as specified in subclause G.8 is used for deriving the list 0 motion vector of the macroblock partition mbPartIdx and that the list 0 reference index of the macroblock partition mbPartIdx is inferred as specified in subclause G.8.

When motion_prediction_flag_l0[ mbPartIdx ] is not present, motion_prediction_flag_l0[ mbPartIdx ] shall be inferred as follows.

– If in_crop_window( CurrMbAddr ) is equal to 0, motion_prediction_flag_l0[ mbPartIdx ] is inferred to be equal to 0.
– Otherwise (in_crop_window( CurrMbAddr ) is equal to 1), motion_prediction_flag_l0[ mbPartIdx ] is inferred to be equal to default_motion_prediction_flag.

**motion_prediction_flag_l1[** mbPartIdx **]** has the same semantics as motion_prediction_flag_l0[ mbPartIdx ], with l0 and list 0 replaced by l1 and list 1, respectively.

#### G.7.4.6.2 Sub-macroblock prediction in scalable extension semantics

The semantic specified in subclauses 7.4.5.2 apply. Additionally, the following semantics are specified.

**motion_prediction_flag_l0[** mbPartIdx **]** and **motion_prediction_flag_l1[** mbPartIdx **]** have the same semantics as specified in subclause G.7.3.6.1.

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## G.8 SVC decoding process

This subclause describes the decoding process for an access unit, given syntax elements and upper-case variables from subclause G.7 (with reference made to clause 7 in subclause G.7) that are derived from the bitstream.

NOTE 1 – All syntax elements and upper-case variables from subclause G.7 are available for the entire current access unit. When syntax elements or upper-case variables appear with identical names in subclause G.7 they are referred herein through unique identifiers.

Output of this process are decoded samples of the current primary coded picture.

The decoding process is specified such that all decoders shall produce numerically identical results. Any decoding process that produces identical results to the process described here conforms to the decoding process requirements of this International Standard.

All sub-bitstreams that can be derived using the sub-bitstream extraction process as specified in subclause G.8.8.1 with any combination of values for priority_id, temporal_id, dependency_id, or quality_id as the input shall result in a set of coded video sequences, with each coded video sequence conforming to one or more of the profiles specified in Annex A and Annex G.

This subclause specifies the decoding process for an access unit of a coded video sequence conforming to one or more of the profiles specified in subclause G.10.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the decoding process specified in this subclause and all child processes invoked from the process specified in this subclause are the syntax elements and derived upper-case variables for the current access unit.

At the start of the decoding process for an access unit, the following applies.

1. Variables and functions relating to picture order count are derived by invoking the SVC decoding process for picture order count as specified in subclause G.8.2.1.
2. The SVC decoding process for gaps in frame_num as specified in subclause G.8.2.5 is invoked.
3. For each value of dependency_id present in the NAL units that are input to this process as specified above, the following applies.
   - The decoding process for macroblock to slice group map as specified in subclause 8.2.2 is invoked with the syntax elements of the NAL units with dependency_id as input.
   - The function NextMbAddress( ) as specified in subclause 8.2.2 is used for parsing the slice data syntax structures of all NAL units with the corresponding value of dependency_id.

The derivation process for the set of layer representations required for decoding as specified in subclause G.8.1.1 is invoked and the output is a list dqIdList of integer values specifying layer representation identifiers. The variables DQIdMin and DQIdMax are set equal to the minimum and maximum values, respectively, of the entries of the list dqIdList, and the variable DependencyIdMax is set equal to (DQIdMax >> 4). DependencyIdMax shall be the same for all access units of the coded video sequence.

The collective terms currentVars and refLayerVars are initially marked as not available.

The variable currDQId proceeds over the values DQIdMin..DQIdMax, and when a value of currDQId is present in the list dqIdList, the following ordered steps apply.

1. The variable spatResChangeFlag is set equal to the variable SpatialResolutionChangeFlag of the layer representation with DQId equal to currDQId.
2. Depending on spatResChangeFlag, the following applies.
   - If spatResChangeFlag is equal to 0, the base decoding process for layer representations without resolution change as specified in subclause G.8.1.3.1 is invoked with currDQId and currentVars as the inputs and the output is a modified version of currentVars.
   - Otherwise (spatResChangeFlag is equal to 1), the base decoding process for layer representations with resolution change as specified in subclause G.8.1.3.2 is invoked with currDQId and currentVars as the inputs and the outputs are variables assigned to the collective term refLayerVars and a modified version of currentVars.

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3. When currDQId is equal to (DependencyIdMax << 4) and store_ref_base_pic_flag for the dependency representation with dependency_id equal to DependencyIdMax is equal to 1, the target layer representation decoding process as specified in subclause G.8.1.3.3 is invoked with currDQId, refLayerVars, and currentVars as the inputs and the outputs are assigned to the sample array $B_L$ and, when ChromaArrayType is not equal to 0, the sample arrays $B_{Cb}$ and $B_{Cr}$.

   NOTE 2 – The sample arrays $B_L$, $B_{Cb}$, and $B_{Cr}$ represent the reference base picture for an access unit with store_ref_base_pic_flag equal to 1 for the dependency representation with dependency_id equal to DependencyIdMax.

The target layer representation decoding process as specified in subclause G.8.1.3.3 is invoked with currDQId, refLayerVars, and currentVars as the inputs and the outputs are assigned to the sample array $S_L$ and, when ChromaArrayType is not equal to 0, the sample arrays $S_{Cb}$ and $S_{Cr}$.

NOTE 3 – The sample arrays $S_L$, $S_{Cb}$, and $S_{Cr}$ represent the decoded picture for the access unit.

The SVC decoded reference picture marking process as specified in subclause G.8.2.4 is invoked.

### G.8.1 SVC initialization and decoding processes

Subclause G.8.1.1 specifies the derivation process for the set of layer representations required for decoding.

Subclause G.8.1.2 specifies the array assignment, initialisation, and restructuring processes.

Subclause G.8.1.3 specifies the layer representation decoding processes.

Subclause G.8.1.4 specifies the slice decoding processes.

Subclause G.8.1.5 specifies the macroblock initialisation and decoding processes.

#### G.8.1.1 Derivation process for the set of layer representations required for decoding

Inputs to this process are the coded slice NAL units of an access unit.

Output of this process is a list dqIdList of integer values specifying layer representation identifiers.

With currDQId being set equal to the maximum value of DQId for all coded slice NAL units of the access unit and with refLayerDQId( dqId ) specifying the maximum value of ref_layer_dq_id for all coded slice NAL units of the layer representation of the access unit with DQId equal to dqId, the list dqIdList is derived as specified by the following pseudo-code.

```
numEntries = 0
dqIdList[ numEntries++ ] = currDQId
while( refLayerDQId( currDQId ) >= 0 ) {
    dqIdList[ numEntries++ ] = refLayerDQId( currDQId )                (G-78)
    currDQId = dqIdList[ numEntries – 1 ]
}
```

#### G.8.1.2 Array assignment, initialisation, and restructuring processes

Subclause G.8.1.2.1 specifies the array assignment and initialisation process.

Subclause G.8.1.2.2 specifies the array restructuring process.

##### G.8.1.2.1 Array assignment and initialization process

Output of this process is a set of arrays that are assigned to the collective term currentVars.

The following arrays are collectively referred to as currentVars.

– A one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as sliceIdc[ mbAddr ]. All elements of the array sliceIdc are initially marked as unspecified.

– A one-dimensional array fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of a layer representation are field macroblocks and which macroblocks are frame macroblock. An element of this array for a macroblock with address mbAddr is referred to as fieldMbFlag[ mbAddr ]. All elements of the array fieldMbFlag are initially marked as unspecified.

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– A one-dimensional array cTrafo with PicSizeInMbs elements specifying the luma and, when ChromArrayType is equal to 3, chroma transform types for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as cTrafo[ mbAddr ]. Unless marked as unspecified, each element of cTrafo is equal to T_4x4, T_8x8, T_16x16, or T_PCM. All elements of the array cTrafo are initially marked as unspecified.

– A one-dimensional array mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as mbType[ mbAddr ]. Unless marked as unspecified, each element of mbType is equal to I_4x4, I_8x8, I_16x16, I_PCM, I_BL, or one of the Inter macroblock types specified in Table 7-13 and Table 7-14. All elements of the array mbType are initially marked as unspecified.

– A (PicSizeInMbs)x4 array subMbType specifying sub-macroblock types for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr and a macroblock partition index mbPartIdx is referred to as subMbType[ mbAddr ][ mbPartIdx ]. A one-dimensional array specifying sub-macroblock types for the macroblock partitions of a macroblock with address mbAddr is referred to as subMbType[ mbAddr ]. Unless marked as unspecified, each element of subMbType is equal to one of the sub-macroblock types specified in Table 7-17 and Table 7-18. All elements of the array subMbType are initially marked as unspecified.

– A one-dimensional array mvCnt with PicSizeInMbs elements specifying the number of motion vectors for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as mvCnt[ mbAddr ]. All elements of the array mvCnt are initially set equal to 0.

– A one-dimensional array $tQP_Y$ with PicSizeInMbs elements specifying luma quantization parameters for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as $tQP_Y$[ mbAddr ]. All elements of the array $tQP_Y$ are initially set equal to 0.

– When ChromaArrayType is not equal to 0, two one-dimensional arrays $tQP_{Cb}$ and $tQP_{Cr}$ with PicSizeInMbs elements specifying Cb and Cr quantization parameters, respectively, for the macroblocks of a layer representation. An element of these arrays for a macroblock with address mbAddr is referred to as $tQP_{CX}$[ mbAddr ] with CX being replaced by Cb or Cr. All elements of the arrays $tQP_{Cb}$ and $tQP_{Cr}$ are initially set equal to 0.

– A (PicSizeInMbs)x16 array ipred4x4 specifying Intra_4x4 prediction modes for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr and a 4x4 block with index c4x4BlkIdx is referred to as ipred4x4[ mbAddr ][ c4x4BlkIdx ]. A one-dimensional array specifying Intra_4x4 prediction modes for the 4x4 blocks of a macroblock with address mbAddr is referred to as ipred4x4[ mbAddr ]. All elements of the array ipred4x4 are initially marked as unspecified.

– A (PicSizeInMbs)x4 array ipred8x8 specifying Intra_8x8 prediction modes for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr and a 8x8 block with index c8x8BlkIdx is referred to as ipred8x8[ mbAddr ][ c8x8BlkIdx ]. A one-dimensional array specifying Intra_8x8 prediction modes for the 8x8 blocks of a macroblock with address mbAddr is referred to as ipred8x8[ mbAddr ]. All elements of the array ipred8x8 are initially marked as unspecified.

– A one-dimensional array ipred16x16 with PicSizeInMbs elements specifying Intra_16x16 prediction modes for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as ipred16x16[ mbAddr ]. All elements of the array ipred16x16 are initially marked as unspecified.

– When ChromaArrayType is equal to 1 or 2, a one-dimensional array ipredChroma with PicSizeInMbs elements specifying intra chroma prediction modes for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr is referred to as ipredChroma[ mbAddr ]. All elements of the array ipredChroma are initially marked as unspecified.

– Two (PicSizeInMbs)x4 arrays predFlagL0 and predFlagL1 specifying prediction utilization flags for the macroblocks of a layer representation. An element of these arrays for a macroblock with address mbAddr and a macroblock partition index mbPartIdx is referred to as predFlagLX[ mbAddr ][ mbPartIdx ] with X being replaced by 0 or 1. A one-dimensional array specifying prediction utilization flags for the macroblock partitions of a macroblock with address mbAddr is referred to as predFlagLX[ mbAddr ] with X being replaced by 0 or 1. All elements of the arrays predFlagL0 and predFlagL1 are initially set equal to 0.

– Two (PicSizeInMbs)x4 arrays refIdxL0 and refIdxL1 specifying reference indices for the macroblocks of a layer representation. An element of these arrays for a macroblock with address mbAddr and a macroblock partition index mbPartIdx is referred to as refIdxLX[ mbAddr ][ mbPartIdx ] with X being replaced by 0 or 1. A one-dimensional

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array specifying reference indices for the macroblock partitions of a macroblock with address mbAddr is referred to as refIdxLX[ mbAddr ] with X being replaced by 0 or 1. All elements of the arrays refIdxL0 and refIdxL1 are initially set equal to –1.

– Two (PicSizeInMbs)x4x4x2 arrays mvL0 and mvL1 specifying motion vector components for the macroblocks of a layer representation. An element of these arrays for a macroblock with address mbAddr, a macroblock partition index mbPartIdx, a sub-macroblock partition index subMbPartIdx, and a motion vector component index c is referred to as mvLX[ mbAddr ][ mbPartIdx ][ subMbPartIdx ][ c ] with X being replaced by 0 or 1. A one-dimensional array with 2 elements representing the motion vector for a sub-macroblock partition subMbPartIdx of a macroblock partition mbPartIdx inside a macroblock mbAddr is referred to as mvLX[ mbAddr ][ mbPartIdx ][ subMbPartIdx ] with X being replaced by 0 or 1. A 4x2 array representing the motion vectors for a macroblock partition mbPartIdx inside a macroblock mbAddr is referred to as mvLX[ mbAddr ][ mbPartIdx ] with X being replaced by 0 or 1. A 4x4x2 array representing the motion vectors for a macroblock mbAddr is referred to as mvLX[ mbAddr ] with X being replaced by 0 or 1. A motion vector component with component index c for a macroblock partition mbPartIdx of a macroblock mbAddr that is not split into sub-macroblock partitions can also be referred to as mvLX[ mbAddr ][ mbPartIdx ][ c ] with X being replaced by 0 or 1, which is identical to mvLX[ mbAddr ][ mbPartIdx ][ 0 ][ c ]. A motion vector for a macroblock partition mbPartIdx of a macroblock mbAddr that is not split into sub-macroblock partitions can also be referred to as mvLX[ mbAddr ][ mbPartIdx ] with X being replaced by 0 or 1, which is identical to mvLX[ mbAddr ][ mbPartIdx ][ 0 ]. All elements of the arrays mvL0 and mvL1 are initially set equal to 0.

– A (PicSizeInMbs)x(256 + 2 * MbWidthC * MbHeightC) array tCoeffLevel specifying transform coefficient level values for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr and a transform coefficient index tCoeffIdx is referred to as tCoeffLevel[ mbAddr ][ tCoeffIdx ]. A one-dimensional array specifying the transform coefficient level values for a macroblock with address mbAddr is referred to as tCoeffLevel[ mbAddr ]. All elements of the array tCoeffLevel are initially set equal to 0.

– A (PicSizeInMbs)x(256 + 2 * MbWidthC * MbHeightC) array sTCoeff specifying scaled transform coefficient values for the macroblocks of a layer representation. An element of this array for a macroblock with address mbAddr and a transform coefficient index tCoeffIdx is referred to as sTCoeff[ mbAddr ][ tCoeffIdx ]. A one-dimensional array specifying the scaled transform coefficient values for a macroblock with address mbAddr is referred to as sTCoeff[ mbAddr ]. All elements of the array sTCoeff are initially set equal to 0.

– A (PicWidthInSamples$_L$)x(PicHeightInSamples$_L$) array $rS_L$ specifying residual luma sample values for a layer picture. An element of this array for a luma location ( x, y ) relative to the upper-left luma sample of the macroblock with address 0 is referred to as $rS_L$[ x, y ]. All elements of the array $rS_L$ are initially set equal to 0.

– When ChromaArrayType is not equal to 0, two (PicWidthInSamples$_C$)x(PicHeightInSamples$_C$) arrays $rS_{Cb}$ and $rS_{Cr}$ specifying residual chroma sample values for a layer picture. An element of these arrays for a chroma location ( x, y ) relative to the upper-left chroma sample of the macroblock with address 0 is referred to as $rS_{CX}$[ x, y ] with CX being replaced by Cb or Cr. All elements of the arrays $rS_{Cb}$ and $rS_{Cr}$ are initially set equal to 0.

– A (PicWidthInSamples$_L$)x(PicHeightInSamples$_L$) array $cS_L$ specifying constructed luma sample values for a layer picture. An element of this array for a luma location ( x, y ) relative to the upper-left luma sample of the macroblock with address 0 is referred to as $cS_L$[ x, y ]. All elements of the array $cS_L$ are initially set equal to 0.

– When ChromaArrayType is not equal to 0, two (PicWidthInSamples$_C$)x(PicHeightInSamples$_C$) arrays $cS_{Cb}$ and $cS_{Cr}$ specifying constructed chroma sample values for a layer picture. An element of these arrays for a chroma location ( x, y ) relative to the upper-left chroma sample of the macroblock with address 0 is referred to as $cS_{CX}$[ x, y ] with CX being replaced by Cb or Cr. All elements of the arrays $cS_{Cb}$ and $cS_{Cr}$ are initially set equal to 0.

#### G.8.1.2.2 Array restructuring process

This process is only invoked when no_inter_layer_pred_flag is equal to 0, SpatialResolutionChangeFlag is equal to 0, and any of the variables ScaledRefLayerLeftOffset, ScaledRefLayerRightOffset, ScaledRefLayerTopOffset, or ScaledRefLayerBottomOffset is not equal to 0.

Input to this process is a set of arrays collectively referred to as currentVars.

Output of this process is the set of arrays collectively referred to as currentVars with modifications related to the array sizes as well as the ordering of array elements.

The variables that are assigned to the collective term currentVars are assigned to the collective term refLayerVars.

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The array assignment and initialization process as specified in subclause G.8.1.2.1 is invoked and the output is the set of arrays collectively referred to as currentVars.

The variables xOffset, yOffset, xOffsetC, and yOffsetC are derived by

$$xOffset = ScaledRefLayerLeftOffset \quad (G\text{-}79)$$
$$yOffset = ScaledRefLayerTopOffset \ / ( 1 + field_pic_flag ) \quad (G\text{-}80)$$
$$xOffsetC = ( xOffset >> 4 ) * MbWidthC \quad (G\text{-}81)$$
$$yOffsetC = ( yOffset >> 4 ) * MbHeightC \quad (G\text{-}82)$$

For the macroblock address mbAddr proceeding over the values 0..(PicSizeInMbs – 1), the following ordered steps are specified.

1. With eS set equal to (1 + MbaffFrameFlag), the variables refMbX and refMbY are derived by

$$refMbX = ( ( mbAddr / eS ) \% PicWidthInMbs ) – ( xOffset / 16 ) \quad (G\text{-}83)$$
$$refMbY = ( ( mbAddr / eS ) \ / \ PicWidthInMbs ) * eS + ( mbAddr \% eS ) – ( yOffset / 16 ) \quad (G\text{-}84)$$

2. The reference layer macroblock address refMbAddr is derived as follows.
   - If any of the following conditions is true, refMbAddr is marked as not available.
     - refMbX is less than 0 or refMbX is greater than or equal to RefLayerPicWidthInMbs
     - refMbY is less than 0 or refMbY is greater than or equal to RefLayerPicHeightInMbs
   - Otherwise, with bS set equal to (1 + RefLayerMbaffFrameFlag), refMbAddr is derived by

$$refMbAddr = ( refMbY / bS ) * bS * RefLayerPicWidthInMbs + ( refMbY \% bS ) + refMbX \quad (G\text{-}85)$$

3. When refMbAddr is available, for X being replaced by sliceIdc, fieldMbFlag, cTrafo, mbType, subMbType, mvCnt, $tQP_Y$, $tQP_{Cb}$ (when ChromaArrayType is not equal to 0), $tQP_{Cb}$ (when ChromaArrayType is not equal to 0), ipred4x4, ipred8x8, ipred16x16, ipredChroma (when ChromaArrayType is equal to 1 or 2), predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, tCoeffLevel, and sTCoeff and with currArray representing the array X of the collective term currentVars and refLayerArray representing the array X of the collective term refLayerVars, the array element currArray[ mbAddr ], which can be a scalar or an array, is set equal to the array element refLayerArray[ refMbAddr ].

For X being replaced by $rS_Y$ and $cS_Y$ and with currArray representing the array X of the collective term currentVars and refLayerArray representing the array X of the collective term refLayerVars, the array currArray is modified by

$$currArray[ x, y ] = refLayerArray[ x – xOffset, y – yOffset ] \quad (G\text{-}86)$$
$$\text{with } x = Max( 0, xOffset )..Min( PicWidthInSamples_L, RefLayerPicWidthInSamples_L – xOffset )$$
$$\text{and } y = Max( 0, yOffset )..Min( PicHeightInSamples_L, RefLayerPicHeightInSamples_L – yOffset )$$

When ChromaArrayType is not equal to 0, for X being replaced by $rS_{Cb}$, $rS_{Cr}$, $cS_{Cb}$, and $cS_{Cr}$ and with currArray representing the array X of the collective term currentVars and refLayerArray representing the array X of the collective term refLayerVars, the array currArray is modified by

$$currArray[ x, y ] = refLayerArray[ x – xOffsetC, y – yOffsetC ] \quad (G\text{-}87)$$
$$\text{with } x = Max( 0, xOffsetC )..Min( PicWidthInSamples_C, RefLayerPicWidthInSamples_C – xOffsetC )$$
$$\text{and } y = Max( 0, yOffsetC )..Min( PicHeightInSamples_C, RefLayerPicHeightInSamples_C – yOffsetC )$$

### G.8.1.3 Layer representation decoding processes

Subclause G.8.1.3.1 specifies the base decoding process for layer representations without resolution change.

Subclause G.8.1.3.2 specifies the base decoding process for layer representations with resolution change.

Subclause G.8.1.3.3 specifies the target layer representation decoding process

#### G.8.1.3.1 Base decoding process for layer representations without resolution change

Inputs to this process are

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– a variable currDQId specifying the current layer representation,

– a set of arrays collectively referred to as currentVars.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current layer representation with DQId equal to currDQId.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current layer representation with DQId equal to currDQId.

The base decoding process for layer representations without resolution change proceeds in the following ordered steps.

1. The variable noInterLayerPredFlag is set equal to the minimum value of no_inter_layer_pred_flag of the slices of the layer representation with DQId equal to currDQId.
2. Depending on noInterLayerPredFlag, the following applies.
   – If noInterLayerPredFlag is equal to 1, the array assignment and initialization process as specified in subclause G.8.1.2.1 is invoked and the output is a modified set of arrays collectively referred to as currentVars.
   – Otherwise (noInterLayerPredFlag is equal to 0), the following ordered steps are specified.
     a. When tcoeff_level_prediction_flag is equal to 0, the macroblock address mbAddr proceeds over the values 0..(RefLayerPicSizeInMbs – 1), and for each macroblock address mbAddr, the macroblock decoding process prior to decoding a layer representation without resolution change and tcoeff_level_prediction_flag equal to 0 as specified in subclause G.8.1.5.4 is invoked with ref_layer_dq_id, mbAddr, and currentVars as the inputs and the output is a modified version of currentVars.
     b. When any of the variables ScaledRefLayerLeftOffset, ScaledRefLayerRightOffset, ScaledRefLayerTopOffset, or ScaledRefLayerBottomOffset is not equal to 0, the array restructuring process as specified in subclause G.8.1.2.2 is invoked with currentVars as the input and the output is a modified version of currentVars.
3. Let setOfSlices be the set of all slices of the current layer representation with DQId equal to currDQId. For each slice of the set setOfSlices, the base decoding process for slices without resolution change as specified in subclause G.8.1.4.1 is invoked with currSlice representing the currently processed slice, currDQId, and currentVars as the inputs and the output is a modified version of currentVars.
4. When currDQId is less than or equal to (DependencyIdMax << 4), with sliceIdc being the array sliceIdc of the collective term currentVars, the bitstream shall not contain data that results in any value of (sliceIdc[ mbAddr ] & 127) with mbAddr = 0..(PicSizeInMbs – 1) not equal to currDQId.

   NOTE – This constraint and a similar constraint in subclause G.8.1.3.2 specify that all layer representations with quality_id equal to 0 and all layer representations that are employed for inter-layer prediction shall be completely covered by the slices of the access unit. An additional constraint for layer representations with dependency_id equal to DependencyIdMax and quality_id greater than 0 is specified in subclause G.8.1.5.1.

#### G.8.1.3.2 Base decoding process for layer representations with resolution change

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a set of arrays collectively referred to as currentVars.

Outputs of this process are

– a set of arrays collectively referred to as refLayerVars,

– the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current layer representation with DQId equal to currDQId.

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Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current layer representation with DQId equal to currDQId.

The base decoding process for layer representations with resolution change proceeds in the following ordered steps.

1. The macroblock address mbAddr proceeds over the values 0..(RefLayerPicSizeInMbs – 1), and for each macroblock address mbAddr, the macroblock decoding process prior to resolution change as specified in subclause G.8.1.5.5 is invoked with ref_layer_dq_id, mbAddr, and currentVars as the inputs and the output is a modified version of currentVars.
2. The deblocking filter process for Intra_Base prediction as specified in subclause G.8.7.1 is invoked with dependencyIdRefLayer set equal to (ref_layer_dq_id >> 4) and currentVars as the inputs and the output is a modified version of currentVars.
3. The variables that are assigned to the collective term currentVars are assigned to the collective term refLayerVars.
4. The array assignment and initialization process as specified in subclause G.8.1.2.1 is invoked and the output is assigned to the collective term currentVars.
5. Let setOfSlices be the set of all slices of the current layer representation with DQId equal to currDQId. For each slice of the set setOfSlices, the base decoding process for slices with resolution change as specified in subclause G.8.1.4.2 is invoked with currSlice representing the currently processed slice, currDQId, refLayerVars, and currentVars as the inputs and the output is a modified version of currentVars.
6. With sliceIdc being the array sliceIdc of the collective term currentVars, the bitstream shall not contain data that results in any value of (sliceIdc[ mbAddr ] & 127) with mbAddr = 0..(PicSizeInMbs – 1) not equal to currDQId.

   NOTE – This constraint and a similar constraint in subclause G.8.1.3.1 specify that all layer representations with quality_id equal to 0 and all layer representation that are employed for inter-layer prediction shall be completely covered by the slices of the access unit. An additional constraint for layer representations with dependency_id equal to DependencyIdMax and quality_id greater than 0 is specified in subclause G.8.1.5.1.

#### G.8.1.3.3 Target layer representation decoding process

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a set of arrays collectively referred to as refLayerVars,

– a set of arrays collectively referred to as currentVars.

Outputs of this process are

– a (PicWidthInSamples$_L$)x(PicHeightInSamples$_L$) array $s_L$ containing constructed luma sample values,

– when ChromaArrayType is not equal to 0, two (PicWidthInSamples$_C$)x(PicHeightInSamples$_C$) arrays $s_{Cb}$ and $s_{Cr}$ containing constructed chroma sample values.

In this process the constructed samples of the array $s_L$ and, when ChromaArrayType is not equal to 0, the arrays $s_{Cb}$ and $s_{Cr}$ are derived using the variables that are assigned to currentVars.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current layer representation with DQId equal to currDQId.

The target layer representation decoding process proceeds in the following ordered steps.

1. The variables that are assigned to the collective term currentVars are assigned to the collective term tempVars, and in the following of this subclause, the arrays that are collectively referred to as tempVars are referred to by their names as specified in subclause G.8.1.2.1.

   NOTE 1 – Any following modification of the variables assigned to the collective term tempVars does not influence the variables assigned to the collective term currentVars.
2. The reference picture lists refPicList0 and refPicList1 are initially marked as not available.

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3. The macroblock address mbAddr proceeds over the values 0..(PicSizeInMbs – 1), and for each macroblock address mbAddr, the following ordered steps are specified.

   a. Let currSlice specify the slice with DQId equal to ( ( ( sliceIdc[ mbAddr ] & 127 ) >> 4 ) << 4 ) and first_mb_in_slice equal to ( sliceIdc[ mbAddr ] >> 7 ).

   b. Let firstMbInSlice and sliceType be the syntax elements first_mb_in_slice and slice_type of the slice currSlice.

   c. When mbAddr is equal to firstMbInSlice, the reference picture lists refPicList0 and refPicList1 are marked as not available.

   d. When mbAddr is equal to firstMbInSlice and (sliceType % 5) is less than 2, the SVC decoding process for reference picture lists construction as specified in subclause G.8.2.3 is invoked with dependency_id, use_ref_base_pic_flag, and the current slice as the inputs and the outputs are the modified reference picture list refPicList0 and, when (sliceType % 5) is equal to 1, the modified reference picture list refPicList1.

      NOTE 2 – The reference picture lists refPicList0 and refPicList1 are only constructed for the slices of the layer representation with dependency_id equal to DependencyIdMax and quality_id equal to 0. For slices with dependency_id equal to DependencyIdMax and quality_id greater than 0, the reference picture lists are inferred.

   e. The target macroblock decoding process as specified in subclause G.8.1.5.6 is invoked with currDQId, mbAddr, refLayerVars, tempVars, refPicList0 (when available), and refPicList1 (when available) as the inputs and the output is a modified version of tempVars.

      NOTE 3 – Although the target layer representation decoding process is invoked twice for pictures with store_ref_base_pic_flag equal to 1, only a single motion compensation operation is needed for each macroblock.

4. The deblocking filter process for target representations as specified in subclause G.8.7.2 is invoked with tempVars as the input and the output is a modified version of tempVars.

5. All sample values of the array $S_L$ are copied to the array $s_L$, which is output of this subclause.

6. When ChromaArrayType is not equal to 0, all sample values of the arrays $S_{Cb}$ and $S_{Cr}$ are copied to the arrays $s_{Cb}$ and $s_{Cr}$, respectively, which are output of this subclause.

### G.8.1.4 Slice decoding processes

Subclause G.8.1.4.1 specifies the base decoding process for slices without resolution change.

Subclause G.8.1.4.2 specifies the base decoding process for slices with resolution change.

#### G.8.1.4.1 Base decoding process for slices without resolution change

Inputs to this process are

– the current slice currSlice,

– a variable currDQId specifying the current layer representation,

– a set of arrays collectively referred to as currentVars.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current slice currSlice.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the slice header of the current slice currSlice, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice currSlice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

When currDQId is equal to 0 and (slice_type % 5) is equal to 1, the SVC decoding process for reference picture lists construction as specified in subclause G.8.2.3 is invoked with currDependencyId equal to 0, useRefBasePicFlag equal to use_ref_base_pic_flag, and the current slice as input and the output is the reference picture list refPicList1.

The macroblocks of the current slice currSlice are processed in increasing order of their macroblock addresses. For each macroblock with macroblock address mbAddr, the base decoding process for macroblocks in slices without resolution change as specified in subclause G.8.1.5.2 is invoked with currDQId, mbAddr, currentVars, and, when currDQId is equal to 0 and (slice_type % 5) is equal to 1, the reference picture list refPicList1 as the inputs and the output is a modified version of currentVars.

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#### G.8.1.4.2 Base decoding process for slices with resolution change

Inputs to this process are

– the current slice currSlice,

– a variable currDQId specifying the current layer representation,

– a set of arrays collectively referred to as refLayerVars,

– a set of arrays collectively referred to as currentVars.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current slice currSlice.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the slice header of the current slice currSlice, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice currSlice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

When CroppingChangeFlag is equal to 1 and (slice_type % 5) is less than 2, the SVC decoding process for reference picture lists construction as specified in subclause G.8.2.3 is invoked with dependency_id, use_ref_base_pic_flag, and the current slice as the inputs and the outputs are the reference picture list refPicList0 and, when (sliceType % 5) is equal to 1, the reference picture list refPicList1.

The macroblocks of the current slice currSlice are processed in increasing order of their macroblock addresses. For each macroblock with macroblock address mbAddr, the base decoding process for macroblocks in slices with resolution change as specified in subclause G.8.1.5.3 is invoked with currDQId, mbAddr, refLayerVars, currentVars, refPicList0 (when CroppingChangeFlag is equal to 1 and (slice_type % 5) is less than 2), and refPicList1 (when CroppingChangeFlag is equal to 1 and (slice_type % 5) is equal to 1) as the inputs and the output is a modified version of currentVars.

### G.8.1.5 Macroblock initialisation and decoding processes

Subclause G.8.1.5.1 specifies the macroblock initialisation process.

Subclause G.8.1.5.2 specifies the base decoding process for macroblocks in slices without resolution change.

Subclause G.8.1.5.3 specifies the base decoding process for macroblocks in slices with resolution change.

Subclause G.8.1.5.4 specifies the macroblock decoding process prior to decoding a layer representation without resolution change and tcoeff_level_prediction_flag equal to 0.

Subclause G.8.1.5.5 specifies the macroblock decoding process prior to resolution change.

Subclause G.8.1.5.6 specifies the target macroblock decoding process.

#### G.8.1.5.1 Macroblock initialisation process

Inputs to this process are

– a set of arrays collectively referred to as refLayerVars,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is less than 2, the reference picture list refPicList0,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Outputs of this process are

– a variable sliceIdc specifying the slice identification for the current macroblock,

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a variable cTrafo specifying the transform type for the current macroblock,

– a variable mbType specifying the macroblock type of the current macroblock,

– a list subMbType with 4 elements specifying the sub-macroblock types of the current macroblock,

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– a variable mvCnt specifying an initialisation value for the motion vector count of the current macroblock,

– a variable $tQP_Y$ specifying the luma quantisation parameter for the current macroblock,

– when ChromaArrayType is not equal to 0, two variables $tQP_{Cb}$ and $tQP_{Cr}$ specifying the chroma quantisation parameters for the current macroblock.

– two 2x2 arrays refIdxILPredL0 and refIdxILPredL1 specifying inter-layer predictors for the reference indices of the current macroblock,

– two 4x4x2 arrays mvILPredL0 and mvILPredL1 specifying inter-layer predictors for the motion vector components of the current macroblock.

Inside this subclause, the arrays sliceIdc, fieldMbFlag, cTrafo, mbType, subMbType, $tQP_Y$, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, and sTCoeff that are collectively referred to as refLayerVars are referred to as refLayerSliceIdc, refLayerFieldMbFlag, refLayerCTrafo, refLayerMbType, refLayerSubMbType, $refLayerQP_Y$, refLayerPredFlagL0, refLayerPredFlagL1, refLayerRefIdxL0, refLayerRefIdxL1, refLayerMvL0, refLayerMvL1, and refLayerSTCoeff, respectively.

The variable sliceIdc is set equal to ( (first_mb_in_slice << 7 ) + DQId ).

The variable fieldMbFlag is derived as follows.

– If field_pic_flag is equal to 1, fieldMbFlag is set equal to 1.

– Otherwise, if SpatialResolutionChangeFlag is equal to 0 and slice_skip_flag is equal to 1, fieldMbFlag is set equal to refLayerFieldMbFlag[ CurrMbAddr ].

– Otherwise, fieldMbFlag is set equal to mb_field_decoding_flag.

The derivation process for macroblock type, sub-macroblock type, and inter-layer predictors for reference indices and motion vectors as specified in subclause G.8.1.5.1.1 is invoked with fieldMbFlag, refLayerFieldMbFlag, refLayerMbType, refLayerSubMbType, refLayerPredFlagL0, refLayerPredFlagL1, refLayerRefIdxL0, refLayerRefIdxL1, refLayerMvL0, refLayerMvL1, refPicList0 (when available), and refPicList1 (when available) as the inputs and the outputs are the variable mbType, the list subMbType, the 2x2 arrays refIdxILPredL0 and refIdxILPredL1, and the 4x4x2 arrays mvILPredL0 and mvILPredL1.

The derivation process for quantisation parameters and transform type as specified in subclause G.8.1.5.1.2 is invoked with mbType, subMbType, refLayerMbType, refLayerCTrafo, $refLayerQP_Y$, and refLayerSTCoeff as the inputs and the outputs are cTrafo, $tQP_Y$, and, when ChromaArrayType is not equal to 0, $tQP_{Cb}$ and $tQP_{Cr}$.

The variable mvCnt is set equal to 0.

When quality_id is greater than 0, the bitstream shall not contain data that result in (sliceIdcRefLayer[ CurrMbAddr ] & 127) not equal to (DQId – 1).

When no_inter_layer_pred_flag is equal to 0, SpatialResolutionChangeFlag is equal to 0, and fieldMbFlag is not equal to refLayerFieldMbRef[ CurrMbAddr ], the following constraints shall be obeyed.

a) The bitstream shall not contain data that result in base_mode_flag equal to 1, or any motion_prediction_flag_lX[ mbPartIdx ] with X being replaced by 0 and 1 and mbPartIdx = 0..3 equal to 1.

b) When residual_prediction_flag is equal to 1, the bitstream shall not contain data that result in any element refLayerSTCoeff[ CurrMbAddr ][ i ] not equal to 0 for i = 0..(255 + 2 * MbWidthC * MbHeightC).

#### G.8.1.5.1.1 Derivation process for macroblock type, sub-macroblock type, and inter-layer predictors for reference indices and motion vectors

Inputs to this process are

– a variable fieldMbFlag specifying whether the current macroblock is a field or a frame macroblock,

– a one-dimensional array refLayerFieldMbFlag with RefLayerPicSizeInMbs elements specifying which macroblocks of the reference layer representation are field macroblocks and which macroblocks are frame macroblock,

– a one-dimensional array refLayerMbType with RefLayerPicSizeInMbs elements specifying the macroblock types for the macroblocks of the reference layer representation,

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– a (RefLayerPicSizeInMbs)x4 array refLayerSubMbType specifying the sub-macroblock types for the macroblocks of the reference layer representation,

– two (RefLayerPicSizeInMbs)x4 arrays refLayerPredFlagL0 and refLayerPredFlagL1 specifying prediction utilization flags for the macroblocks of the reference layer representation,

– two (RefLayerPicSizeInMbs)x4 arrays refLayerRefIdxL0 and refLayerRefIdxL1 specifying reference indices for the macroblocks of the reference layer representation,

– two (RefLayerPicSizeInMbs)x4x4x2 arrays refLayerMvL0 and refLayerMvL1 specifying motion vector components for the macroblocks of the reference layer representation,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is less than 2, the reference picture list refPicList0,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Outputs of this process are

– a variable mbType specifying the macroblock type of the current macroblock,

– a list subMbType with 4 elements specifying the sub-macroblock types of the current macroblock,

– two 2x2 arrays refIdxILPredL0 and refIdxILPredL1 specifying inter-layer predictors for the reference indices of the current macroblock,

– two 4x4x2 arrays mvILPredL0 and mvILPredL1 specifying inter-layer predictors for the motion vector components of the current macroblock.

The variable mbTypeILPred, the list subMbTypeILPred, the 2x2 arrays refIdxILPredL0 and refIdxILPredL1, and the 4x4x2 arrays mvILPredL0 and mvILPredL1 are derived as follows.

– If base_mode_flag is equal to 1 or any syntax element motion_prediction_flag_lX[ mbPartIdx ] with X being replaced by 0 and 1 and mbPartIdx = 0..3 is equal to 1, the derivation process for inter-layer predictors for macroblock type, sub-macroblock type, reference indices, and motion vectors as specified in subclause G.8.6.1 is invoked with fieldMbFlag, refLayerFieldMbFlag, refLayerMbType, refLayerSubMbType, refLayerPredFlagL0, refLayerPredFlagL1, refLayerRefIdxL0, refLayerRefIdxL1, refLayerMvL0, refLayerMvL1, refPicList0 (when available), and refPicList1 (when available) as the inputs and the outputs are the variable mbTypeILPred, the list subMbTypeILPred, the 2x2 arrays refIdxILPredL0 and refIdxILPredL1, and the 4x4x2 arrays mvILPredL0 and mvILPredL1.

– Otherwise (base_mode_flag is equal to 0 and all syntax elements motion_prediction_flag_lX[ mbPartIdx ] with X being replaced by 0 and 1 and mbPartIdx = 0..3 are equal to 0), mbTypeILPred is marked as not available, all elements subMbTypeILPred[ mbPartIdx ] with mbPartIdx = 0..3 of the list subMbTypeILPred are marked as not available, all elements of the 2x2 arrays refIdxILPredL0 and refIdxILPredL1 are set equal to –1, and all elements of the 4x4x2 arrays mvILPredL0 and mvILPredL1 are set equal to 0.

Depending on base_mode_flag, mb_type, and transform_size_8x8_flag, the variable mbType is derived as follows.

– If base_mode_flag is equal to 1, mbType is set equal to mbTypeILPred.

– Otherwise, if MbPartPredMode( mb_type, 0 ) is equal to Intra_4x4, mbType is set equal to I_4x4.

– Otherwise, if MbPartPredMode( mb_type, 0 ) is equal to Intra_8x8, mbType is set equal to I_8x8.

– Otherwise, if MbPartPredMode( mb_type, 0 ) is equal to Intra_16x16, mbType is set equal to I_16x16.

– Otherwise, if mb_type is equal to I_PCM, mbType is set equal to I_PCM.

– Otherwise (base_mode_flag is equal to 0 and mb_type specifies a P or B macroblock type), mbType is set equal to mb_type.

Depending on mbType and base_mode_flag, the list subMbType is derived as follows.

– If mbType is not equal to P_8x8 or B_8x8, all elements subMbType[ mbPartIdx ] with mbPartIdx = 0..3 are marked as unspecified.

– Otherwise, if base_mode_flag is equal to 1, each element subMbType[ mbPartIdx ] with mbPartIdx = 0..3 is set equal to subMbTypeILPred[ mbPartIdx ].

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– Otherwise (mbType is equal to P_8x8 or B_8x8 and base_mode_flag is equal to 0), each element subMbType[ mbPartIdx ] with mbPartIdx = 0..3 is set equal to sub_mb_type[ mbPartIdx ].

When slice_type is equal to EP and base_mode_flag is equal to 1, the bitstream shall not contain data that result in any element refIdxILPredL0[ mbPartIdx ] with mbPartIdx = 0..3 that is less than 0.

When residual_prediction_flag equal to 1 is present in the bitstream, the bitstream shall not contain data that result in mbType being equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL.

#### G.8.1.5.1.2 Derivation process for quantisation parameters and transform type

Inputs to this process are

– a variable mbType specifying the macroblock type for the current macroblock,

– a list subMbType with 4 elements specifying the sub-macroblock types for the current macroblock,

– a one-dimensional array refLayerMbType specifying macroblock types for the macroblocks of the reference layer representation,

– a one-dimensional array refLayerCTrafo specifying transform types for the macroblocks of the reference layer representation,

– a one-dimensional array refLayer$QP_Y$ specifying luma quantisation parameters for the macroblocks of the reference layer representation,

– an (RefLayerPicSizeInMbs)x(256 + 2 * MbWidthC * MbHeightC) array refLayerSTCoeff specifying scaled transform coefficient values for the macroblocks of the reference layer representation.

Outputs of this process are

– a variable cTrafo specifying the transform type for the current macroblock,

– a variable $tQP_Y$ specifying the luma quantisation parameter for the current macroblock,

– when ChromaArrayType is not equal to 0, two variables $tQP_{Cb}$ and $tQP_{Cr}$ specifying the chroma quantisation parameters for the current macroblock.

The variable $tQP_Y$ is derived as follows.

– If SpatialResolutionChangeFlag is equal to 0, CodedBlockPatternLuma is equal to 0, CodedBlockPatternChroma is equal to 0, and any of the following conditions is true, $tQP_Y$ is set equal to refLayer$QP_Y$[ CurrMbAddr ].

  – mbType is equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL and base_mode_flag is equal to 1

  – mbType is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL and residual_prediction_flag is equal to 1

– Otherwise, $tQP_Y$ is set equal to $QP_Y$.

When ChromaArrayType is not equal to 0, for CX being replaced by Cb and Cr, the variable $tQP_{CX}$ is set equal to the value of $QP_{CX}$ that corresponds to a value of $tQP_Y$ for $QP_Y$ as specified in subclause 8.5.8.

The variable predCoeffFlag is derived as follows.

– If SpatialResolutionChangeFlag is equal to 0 and any of the following conditions is true, predCoeffFlag is set equal to 1.

  – base_mode_flag is equal to 1, tcoeff_level_prediction_flag is equal to 0, and refLayerMbType[ CurrMbAddr ] is equal to I_BL

  – base_mode_flag is equal to 1, tcoeff_level_prediction_flag is equal to 1, and mbType is equal to I_PCM, I_16x16, I_8x8, or I_4x4.

  – residual_prediction_flag is equal to 1 and mbType is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL

– Otherwise, predCoeffFlag is set equal to 0.

The variable cTrafo is derived as follows.

– If mbType is equal to I_PCM, cTrafo is set equal to T_PCM.

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– Otherwise, if mbType is equal to I_16x16, cTrafo is set equal to T_16x16.

– Otherwise, if mbType is equal to I_8x8 or transform_size_8x8_flag is equal to 1, cTrafo is set equal to T_8x8.

– Otherwise, if predCoeffFlag is equal to 1, cTrafo is set equal to cTrafoRefLayer.

– Otherwise (predCoeffFlag is equal to 0, transform_size_8x8_flag is equal to 0, and mbType is not equal to I_PCM, I_16x16, or I_8x8), cTrafo is set equal to T_4x4.

When base_mode_flag is equal to 1, the following constraints shall be obeyed.

a) When mbType is equal to P_8x8 or B8x8 and NumSubMbPart( subMbType[ mbPartIdx ] ) is not equal to 1 for any mbPartIdx = 0..3, the bitstream shall not contain transform_size_8x8_flag equal to 1.

b) When mbType is equal to I_PCM, the bitstream shall not contain data that result in CodedBlockPatternLuma not equal to 0 or CodedBlockPatternChroma not equal to 0.

c) When mbType is equal to I_16x16 or I_4x4, the bitstream shall not contain transform_8x8_size_flag equal to 1.

d) When mbType is equal to I_8x8 and transform_size_8x8_flag is equal to 0, the bitstream shall not contain data that result in CodedBlockPatternLuma not equal to 0.

When predCoeffFlag is equal to 1, the following constraints shall be obeyed.

a) When refLayerCTrafo[ CurrMbAddr ] is equal to T_8x8 and transform_size_8x8_flag is equal 0, the bitstream shall not contain data that result in CodedBlockPatternLuma not equal to 0.

b) When refLayerCTrafo[ CurrMbAddr ] is equal to T_4x4 and transform_size_8x8_flag equal to 1, the bitstream shall not contain data that result in any element refLayerSTCoeff[ CurrMbAddr ][ i ] not equal to 0 for i = 0..(ChromaArrayType != 3 ? 255 : 767).

#### G.8.1.5.2 Base decoding process for macroblocks in slices without resolution change

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a variable mbAddr specifying the current macroblock inside the current layer representation,

– a set of arrays collectively referred to as currentVars,

– when currDQId is equal to 0 and (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current macroblock, which is specified by its address mbAddr and the layer representation identifier currDQId.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current macroblock, which is the macroblock with address mbAddr inside the layer representation with DQId equal to currDQId, the slice header of the current slice, which is the slice that contains the current macroblock, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

The base decoding process for macroblocks in slices without resolution change is specified by the following ordered steps.

1. The variable CurrMbAddr is set equal to mbAddr.

2. When tcoeff_level_prediction_flag is equal to 1, the variable $refQP_Y$ is set equal to $tQP_Y$[ mbAddr ] and, when ChromaArrayType is not equal to 0, the variables $refQP_{Cb}$ and $refQP_{Cr}$ are set equal to $tQP_{Cb}$[ mbAddr ] and $tQP_{Cr}$[ mbAddr ], respectively.

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3. When no_inter_layer_pred_flag is equal to 0, the variable refLayerIntraBLFlag is derived as follows.
   - If mbType[ mbAddr ] is equal to I_BL, refLayerIntraBLFlag is set equal to 1.
   - Otherwise (mbType[ mbAddr ] is not equal to I_BL), refLayerIntraBLFlag is set equal to 0.
4. The macroblock initialization process as specified in subclause G.8.1.5.1 is invoked with refLayerVars set equal to currentVars as the input and the outputs are assigned to sliceIdc[ mbAddr ], fieldMbFlag[ mbAddr ], cTrafo[ mbAddr ], mbType[ mbAddr ], subMbType[ mbAddr ], mvCnt[ mbAddr ], $tQP_Y$[ mbAddr ], $tQP_{Cb}$[ mbAddr ] (when ChromaArrayType is not equal to 0), $tQP_{Cr}$[ mbAddr ] (when ChromaArrayType is not equal to 0), the 2x2 arrays refIdxILPredL0 and refIdxILPredL1, and the 4x4x2 arrays mvILPredL0 and mvILPredL1.
5. The SVC derivation process for motion vector components and reference indices as specified in subclause G.8.4.1 is invoked with sliceIdc, fieldMbFlag, mbType, subMbType, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, mvCnt, refIdxILPredL0, refIdxILPredL1, mvILPredL0, mvILPredL1, and refPicList1 (when available) as the inputs and the outputs are modified versions of the arrays predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, and mvCnt.
6. Depending on mbType[ mbAddr ], the following applies.
   - If mbType[ mbAddr ] is equal to I_PCM, I_16x16, I_8x8, or I_4x4, the following ordered steps are specified.
     a. When base_mode_flag is equal to 0, the SVC derivation process for intra prediction modes as specified in subclause G.8.3.1 is invoked with sliceIdc, fieldMbFlag, mbType, ipred4x4, ipred8x8, ipred16x16, and, when ChromaArrayType is equal to 1 or 2, ipredChroma as the inputs and the outputs are modified versions of ipred4x4, ipred8x8, ipred16x16, and, when ChromaArrayType is equal to 1 or 2, ipredChroma.
     b. When base_mode_flag is equal to 1, the transform coefficient level scaling process prior to transform coefficient refinement as specified in subclause G.8.5.2 is invoked with cTrafo[ mbAddr ], tCoeffLevel[ mbAddr ], $tQP_Y$[ mbAddr ], $refQP_Y$, and, when ChromaArrayType is not equal to 0, $tQP_{Cb}$[ mbAddr ], $tQP_{Cr}$[ mbAddr ], $refQP_{Cb}$, and $refQP_{Cr}$ as the inputs and the output is a modified version of tCoeffLevel[ mbAddr ].
     c. The transform coefficient scaling and refinement process as specified in subclause G.8.5.1 is invoked with refinementFlag set equal to base_mode_flag, fieldMbFlag[ mbAddr ], cTrafo[ mbAddr ], sTCoeff[ mbAddr ], and tCoeffLevel[ mbAddr ] as the inputs and the outputs are modified versions of sTCoeff[ mbAddr ] and tCoeffLevel[ mbAddr ].
     d. The sample array re-initialisation process as specified in subclause G.8.5.5 is invoked with fieldMbFlag[ mbAddr ], $rS_L$, and, when ChromaArrayType is not equal to 0, $rS_{Cb}$ and $rS_{Cr}$ as the inputs and the outputs are a modified version of $rS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $rS_{Cb}$ and $rS_{Cr}$.
     e. The sample array re-initialisation process as specified in subclause G.8.5.5 is invoked with fieldMbFlag[ mbAddr ], $cS_L$, and, when ChromaArrayType is not equal to 0, $cS_{Cb}$ and $cS_{Cr}$ as the inputs and the outputs are a modified version of $cS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $cS_{Cb}$ and $cS_{Cr}$.
   - Otherwise, if mbType[ mbAddr ] is equal to I_BL, the transform coefficient scaling and refinement process as specified in subclause G.8.5.1 is invoked with refinementFlag set equal to refLayerIntraBLFlag, fieldMbFlag[ mbAddr ], cTrafo[ mbAddr ], sTCoeff[ mbAddr ], and tCoeffLevel[ mbAddr ] as the inputs and the outputs are modified versions of sTCoeff[ mbAddr ] and tCoeffLevel[ mbAddr ].
   - Otherwise (mbType[ mbAddr ] is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL), the following ordered steps are specified.
     a. When residual_prediction_flag is equal to 1, the transform coefficient level scaling process prior to transform coefficient refinement as specified in subclause G.8.5.2 is invoked with cTrafo[ mbAddr ], tCoeffLevel[ mbAddr ], $tQP_Y$[ mbAddr ], $refQP_Y$, and, when ChromaArrayType is not equal to 0, $tQP_{Cb}$[ mbAddr ], $tQP_{Cr}$[ mbAddr ], $refQP_{Cb}$, and $refQP_{Cr}$ as the inputs and the output is a modified version of tCoeffLevel[ mbAddr ].

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b. The transform coefficient scaling and refinement process as specified in subclause G.8.5.1 is invoked with refinementFlag set equal to residual_prediction_flag, fieldMbFlag[ mbAddr ], cTrafo[ mbAddr ], sTCoeff[ mbAddr ], and tCoeffLevel[ mbAddr ] as the inputs and the outputs are modified versions of sTCoeff[ mbAddr ] and tCoeffLevel[ mbAddr ].

c. When residual_prediction_flag is equal to 0, the sample array re-initialisation process as specified in subclause G.8.5.5 is invoked with fieldMbFlag[ mbAddr ], $rS_L$, and, when ChromaArrayType is not equal to 0, $rS_{Cb}$ and $rS_{Cr}$ as the inputs and the outputs are a modified versions of $rS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $rS_{Cb}$ and $rS_{Cr}$.

d. When residual_prediction_flag is equal to 0, the sample array re-initialisation process as specified in subclause G.8.5.5 is invoked with fieldMbFlag[ mbAddr ], $cS_L$, and, when ChromaArrayType is not equal to 0, $cS_{Cb}$ and $cS_{Cr}$ as the inputs and the outputs are a modified versions of $cS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $cS_{Cb}$ and $cS_{Cr}$.

#### G.8.1.5.3 Base decoding process for macroblocks in slices with resolution change

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a variable mbAddr specifying the current macroblock inside the current layer representation,

– a set of arrays collectively referred to as refLayerVars,

– a set of arrays collectively referred to as currentVars,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is less than 2, the reference picture list refPicList0,

– when CroppingChangeFlag is equal to 1 and (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current macroblock, which is specified by its address mbAddr and the layer representation identifier currDQId, as well as variables assigned to refLayerVars.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current macroblock, which is the macroblock with address mbAddr inside the layer representation with DQId equal to currDQId, the slice header of the current slice, which is the slice that contains the current macroblock, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

Inside this subclause, the arrays sliceIdc, fieldMbFlag, cTrafo, mbType, $cS_L$, $cS_{Cb}$, $cS_{Cr}$, $rS_L$, $rS_{Cb}$, and $rS_{Cr}$ of the collective term refLayerVars are referred to as refLayerSliceIdc, refLayerFieldMbFlag, refLayerCTrafo, refLayerMbType, $refS_L$, $refS_{Cb}$, $refS_{Cr}$, $refR_L$, $refR_{Cb}$, and $refR_{Cr}$, respectively.

The base decoding process for macroblocks in slices with resolution change is specified by the following ordered steps.

1. The variable CurrMbAddr is set equal to mbAddr.
2. The macroblock initialization process as specified in subclause G.8.1.5.1 is invoked with refLayerVars, refPicList0 (when available), and refPicList1 (when available) as the inputs and the outputs are assigned to sliceIdc[ mbAddr ], fieldMbFlag[ mbAddr ], cTrafo[ mbAddr ], mbType[ mbAddr ], subMbType[ mbAddr ], mvCnt[ mbAddr ], $tQP_Y$[ mbAddr ], $tQP_{Cb}$[ mbAddr ] (when ChromaArrayType is not equal to 0), $tQP_{Cr}$[ mbAddr ] (when ChromaArrayType is not equal to 0), the 2x2 arrays refIdxILPredL0 and refIdxILPredL1, and the 4x4x2 arrays mvILPredL0 and mvILPredL1.
3. The SVC derivation process for motion vector components and reference indices as specified in subclause G.8.4.1 is invoked with sliceIdc, fieldMbFlag, mbType, subMbType, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, mvCnt, refIdxILPredL0, refIdxILPredL1, mvILPredL0, and mvILPredL1 as the inputs and the outputs are modified versions of the arrays predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, mvL1, and mvCnt.

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4. The variable intraResamplingFlag is derived as follows.
   - If any of the following conditions is true, intraResamplingFlag is set equal to 1.
     - RestrictedSpatialResolutionChangeFlag is equal to 1 and mbType[ mbAddr ] is equal to I_BL
     - RestrictedSpatialResolutionChangeFlag is equal to 0, MbaffFrameFlag is equal to 0, RefLayerMbaffFrameFlag is equal to 0, and mbType[ mbAddr ] is not equal to I_PCM, I_16x16, I_8x8, or I_4x4
   - Otherwise, intraResamplingFlag is set equal to 0.
5. When intraResamplingFlag is equal to 1, the resampling process for intra samples as specified in subclause G.8.6.2 is invoked with fieldMbFlag[ mbAddr ], refLayerSliceIdc, refLayerFieldMbFlag, refLayerMbType, $refS_L$, $cS_L$, and, when ChromaArrayType is not equal to 0, $refS_{Cb}$, $refS_{Cr}$, $cS_{Cb}$, and $cS_{Cr}$ as the inputs and the outputs are a modified version of the array $cS_L$ and, when ChromaArrayType is not equal to 0, modified versions of the array $cS_{Cb}$, and $cS_{Cr}$.
6. Depending on mbType[ mbAddr ], the following applies.
   - If mbType[ mbAddr ] is equal to I_PCM, I_16x16, I_8x8, or I_4x4, the SVC derivation process for intra prediction modes as specified in subclause G.8.3.1 is invoked with sliceIdc, fieldMbFlag, mbType, ipred4x4, ipred8x8, ipred16x16, and, when ChromaArrayType is equal to 1 or 2, ipredChroma as the inputs and the outputs are modified versions of ipred4x4, ipred8x8, ipred16x16, and, when ChromaArrayType is equal to 1 or 2, ipredChroma.
   - Otherwise, if mbType[ mbAddr ] is not equal to I_BL and residual_prediction_flag is equal to 1, the resampling process for residual samples as specified in subclause G.8.6.3 is invoked with fieldMbFlag[ mbAddr ], refLayerFieldMbFlag, refLayerCTrafo, $refR_L$, $rS_L$, and, when ChromaArrayType is not equal to 0, $refR_{Cb}$, $refR_{Cr}$, $rS_{Cb}$, and $rS_{Cr}$ as the inputs and the outputs are a modified version of the array $rS_L$ and, when ChromaArrayType is not equal to 0, modified versions of the array $rS_{Cb}$, and $rS_{Cr}$.
   - Otherwise, the arrays of the collective term currentVars are not modified.
7. The transform coefficient scaling and refinement process as specified in subclause G.8.5.1 is invoked with refinementFlag set equal to 0, fieldMbFlag[ mbAddr ], cTrafo[ mbAddr ], sTCoeff[ mbAddr ], and tCoeffLevel[ mbAddr ] as the inputs and the outputs are modified versions of sTCoeff[ mbAddr ] and tCoeffLevel[ mbAddr ].

#### G.8.1.5.4 Macroblock decoding process prior to decoding a layer representation without resolution change and tcoeff_level_prediction_flag equal to 0

Inputs to this process are

- a variable currDQId specifying the current layer representation,
- a variable mbAddr specifying the current macroblock inside the current layer representation,
- a set of arrays collectively referred to as currentVars.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current macroblock, which is specified by its address mbAddr and the layer representation identifier currDQId.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current macroblock, which is the macroblock with address mbAddr inside the layer representation with DQId equal to currDQId, the slice header of the current slice, which is the slice that contains the current macroblock, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

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The target macroblock decoding process is specified by the following ordered steps.

1. The variable CurrMbAddr is set equal to mbAddr.
2. When mbType[ mbAddr ] is equal to I_PCM, I_16x16, I_8x8, or I_4x4, the SVC intra sample prediction and construction process as specified in subclause G.8.3.2 is invoked with sliceIdc, fieldMbFlag, mbType, ipred4x4[ mbAddr ], ipred8x8[ mbAddr ], ipred16x16[ mbAddr ], ipredChroma[ mbAddr ], cTrafo[ mbAddr ], sTCoeff[ mbAddr ], $cS_L$, and, when ChromaArrayType is not equal to 0, $cS_{Cb}$ and $cS_{Cr}$ as the inputs and the outputs are a modified version of the array $cS_L$ and, when ChromaArrayType is not equal to 0, modified versions of the arrays $cS_{Cb}$ and $cS_{Cr}$.

#### G.8.1.5.5 Macroblock decoding process prior to resolution change

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a variable mbAddr specifying the current macroblock inside the current layer representation,

– a set of arrays collectively referred to as currentVars.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current macroblock, which is specified by its address mbAddr and the layer representation identifier currDQId.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current macroblock, which is the macroblock with address mbAddr inside the layer representation with DQId equal to currDQId, the slice header of the current slice, which is the slice that contains the current macroblock, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

The target macroblock decoding process is specified by the following ordered steps.

1. The variable CurrMbAddr is set equal to mbAddr.
2. Depending on mbType[ mbAddr ], the following applies.
   – If mbType[ mbAddr ] is equal to I_PCM, I_16x16, I_8x8, or I_4x4, the SVC intra sample prediction and construction process as specified in subclause G.8.3.2 in invoked with sliceIdc, fieldMbFlag, mbType, ipred4x4[ mbAddr ], ipred8x8[ mbAddr ], ipred16x16[ mbAddr ], ipredChroma[ mbAddr ], cTrafo[ mbAddr ], sTCoeff[ mbAddr ], $cS_L$, and, when ChromaArrayType is not equal to 0, $cS_{Cb}$ and $cS_{Cr}$ as the inputs and the outputs are a modified version of the array $cS_L$ and, when ChromaArrayType is not equal to 0, modified versions of the arrays $cS_{Cb}$ and $cS_{Cr}$.
   – Otherwise, if mbType[ mbAddr ] is equal to I_BL, the following ordered steps are specified.
     a. The residual construction and accumulation process as specified in subclause G.8.5.3 is invoked with accumulationFlag set equal to 0, fieldMbFlag[ mbAddr ], cTrafo[ mbAddr ], sTCoeff[ mbAddr ], $rS_L$, and, when ChromaArrayType is not equal to 0, $rS_{Cb}$ and $rS_{Cr}$ as the inputs and the outputs are a modified version of $rS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $rS_{Cb}$ and $rS_{Cr}$.
     b. The sample array accumulation process as specified in subclause G.8.5.4 is invoked with fieldMbFlag[ mbAddr ], $rS_L$, $cS_L$, and, when ChromaArrayType is not equal to 0, $rS_{Cb}$, $rS_{Cr}$ $cS_{Cb}$, and $cS_{Cr}$ as the inputs and the outputs are a modified version of $cS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $cS_{Cb}$ and $cS_{Cr}$.

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– Otherwise (mbType[ mbAddr ] is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL), the following ordered steps are specified.

  a. The residual construction and accumulation process as specified in subclause G.8.5.3 is invoked with accumulationFlag set equal to 1, fieldMbFlag[ mbAddr ], cTrafo[ mbAddr ], sTCoeff[ mbAddr ], $rS_L$, and, when ChromaArrayType is not equal to 0, $rS_{Cb}$ and $rS_{Cr}$ as the inputs and the outputs are a modified version of $rS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $rS_{Cb}$ and $rS_{Cr}$.

  b. The sample array re-initialisation process as specified in subclause G.8.5.5 is invoked with fieldMbFlag[ mbAddr ], $cS_L$, and, when ChromaArrayType is not equal to 0, $cS_{Cb}$ and $cS_{Cr}$ as the inputs and the outputs are a modified versions of $cS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $cS_{Cb}$ and $cS_{Cr}$.

#### G.8.1.5.6 Target macroblock decoding process

Inputs to this process are

– a variable currDQId specifying the current layer representation,

– a variable mbAddr specifying the current macroblock inside the current layer representation,

– a set of arrays collectively referred to as refLayerVars,

– a set of arrays collectively referred to as currentVars,

– when (slice_type % 5) is less than 2, the reference picture list refPicList0,

– when (slice_type % 5) is equal to 1, the reference picture list refPicList1.

Output of this process is the modified set of arrays collectively referred to as currentVars.

This process modifies the variables assigned to currentVars using syntax elements and derived upper-case variables for the current macroblock, which is specified by its address mbAddr and the layer representation identifier currDQId.

Unless stated otherwise, the syntax elements and derived upper-case variables that are referred to by the process specified in this subclause and all child processes invoked from this process are the syntax elements and derived upper-case variables for the current macroblock, which is the macroblock with address mbAddr inside the layer representation with DQId equal to currDQId, the slice header of the current slice, which is the slice that contains the current macroblock, the current picture parameter, which is identified by the syntax element pic_parameter_set_id inside the slice header of the current slice, and the current sequence parameter, which is identified by the syntax element seq_parameter_set_id inside the current picture parameter set.

Inside this subclause, the arrays that are collectively referred to as currentVars are referred to by their names as specified in subclause G.8.1.2.1.

Inside this subclause, the arrays fieldMbFlag and mbType of the collective term refLayerVars are referred to as refLayerFieldMbFlag and refLayerMbType, respectively.

The target macroblock decoding process is specified by the following ordered steps.

1. The variable CurrMbAddr is set equal to mbAddr.
2. When tcoeff_level_prediction is equal to 1, (sliceIdc[ mbAddr ] &127 ) is not equal to currDQId, and ChromaArrayType is not equal to 0, the following ordered steps are specified.

   NOTE – By the following ordered steps, only the transform coefficient levels for chroma are scaled (and the scaled transform coefficients are derived accordingly) when the chroma quantisation parameter offsets of the current layer representation with DQId equal to currDQId and the layer representation with DQId equal to (sliceIdc[ mbAddr ] &127 ) are different.

   a. The variable $cQP_Y$ is set equal to $tQP_Y$[ mbAddr ], and for CX being replaced by Cb and Cr, the variable $cQP_{CX}$ is set equal to the value of $QP_{CX}$ that corresponds to a value of $cQP_Y$ for $QP_Y$ as specified in subclause 8.5.8.

   b. The transform coefficient level scaling process prior to transform coefficient refinement as specified in subclause G.8.5.2 is invoked with cTrafo[ mbAddr ], tCoeffLevel[ mbAddr ], $tQP_Y$ set equal to $cQP_Y$, $refQP_Y$ set equal to $tQP_Y$[ mbAddr ], and, when ChromaArrayType is not equal to 0, $tQP_{Cb}$ set equal to $cQP_{Cb}$, $tQP_{Cr}$ set equal to $cQP_{Cr}$, $refQP_{Cb}$ set equal to $tQP_{Cb}$[ mbAddr ], $refQP_{Cr}$ set equal to $tQP_{Cr}$[ mbAddr ] as the inputs and the output is a modified version of tCoeffLevel[ mbAddr ].

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c. The transform coefficient scaling and refinement process as specified in subclause G.8.5.1 is invoked with refinementFlag equal to 1, fieldMbFlag[ mbAddr ], cTrafo[ mbAddr ], sTCoeff[ mbAddr ], and tCoeffLevel[ mbAddr ] as the inputs and the outputs are modified versions of sTCoeff[ mbAddr ] and tCoeffLevel[ mbAddr ]. For this invocation of the process in subclause G.8.5.1, all elements of the arrays LumaLevel, LumaLevel8x8, Intra16x16DCLevel, Intra16x16ACLevel, CbLevel, CbLevel8x8, CbIntra16x16DCLevel, CbIntra16x16ACLevel, CrLevel, CrLevel8x8, CrIntra16x16DCLevel, CrIntra16x16ACLevel, ChromaDCLevel, and ChromaACLevel are inferred to be equal to 0, and the quantisation parameter $QP'_Y$ is set equal to ($tQP_Y$[ mbAddr ] + $QpBdOffset_Y$).

3. Depending on mbType[ mbAddr ], the following applies.

– If mbType[ mbAddr ] is equal to I_PCM, I_16x16, I_8x8, or I_4x4, the SVC intra sample prediction and construction process as specified in subclause G.8.3.2 in invoked with sliceIdc, fieldMbFlag, mbType, ipred4x4[ mbAddr ], ipred8x8[ mbAddr ], ipred16x16[ mbAddr ], ipredChroma[ mbAddr ], cTrafo[ mbAddr ], sTCoeff[ mbAddr ], $cS_L$, and, when ChromaArrayType is not equal to 0, $cS_{Cb}$ and $cS_{Cr}$ as the inputs and the outputs are a modified version of the array $cS_L$ and, when ChromaArrayType is not equal to 0, modified versions of the arrays $cS_{Cb}$ and $cS_{Cr}$.

– Otherwise, if mbType[ mbAddr ] is equal to I_BL, the following ordered steps are specified.

a. The residual construction and accumulation process as specified in subclause G.8.5.3 is invoked with accumulationFlag set equal to 0, fieldMbFlag[ mbAddr ], cTrafo[ mbAddr ], sTCoeff[ mbAddr ], $rS_L$, and, when ChromaArrayType is not equal to 0, $rS_{Cb}$ and $rS_{Cr}$ as the inputs and the outputs are a modified version of $rS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $rS_{Cb}$ and $rS_{Cr}$.

b. The sample array accumulation process as specified in subclause G.8.5.4 is invoked with fieldMbFlag[ mbAddr ], $rS_L$, $cS_L$, and, when ChromaArrayType is not equal to 0, $rS_{Cb}$, $rS_{Cr}$ $cS_{Cb}$, and $cS_{Cr}$ as the inputs and the outputs are a modified version of $cS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $cS_{Cb}$ and $cS_{Cr}$.

– Otherwise (mbType[ mbAddr ] is not equal to I_PCM, I_16x16, I_8x8, I_4x4, or I_BL), the following ordered steps are specified.

a. The residual construction and accumulation process as specified in subclause G.8.5.3 is invoked with accumulationFlag set equal to 1, fieldMbFlag[ mbAddr ], cTrafo[ mbAddr ], sTCoeff[ mbAddr ], $rS_L$, and, when ChromaArrayType is not equal to 0, $rS_{Cb}$ and $rS_{Cr}$ as the inputs and the outputs are a modified version of $rS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $rS_{Cb}$ and $rS_{Cr}$.

b. The SVC decoding process for Inter prediction samples as specified in subclause G.8.4.2 is invoked with fieldMbFlag[ mbAddr ], mbType[ mbAddr ], subMbType[ mbAddr ], predFlagL0[ mbAddr ], predFlagL1[ mbAddr ], refIdxL0[ mbAddr ], refIdxL1[ mbAddr ], mvL0[ mbAddr ], mvL1[ mbAddr ], refLayerFieldMbFlag, refLayerMbType, refPicList0, refPicList1 (when available), $cS_L$, and, when ChromaArrayType is not equal to 0, $cS_{Cb}$ and $cS_{Cr}$ as the inputs and the outputs are a modified version of $cS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $cS_{Cb}$ and $cS_{Cr}$.

c. The sample array accumulation process as specified in subclause G.8.5.4 is invoked with fieldMbFlag[ mbAddr ], $rS_L$, $cS_L$, and, when ChromaArrayType is not equal to 0, $rS_{Cb}$, $rS_{Cr}$ $cS_{Cb}$, and $cS_{Cr}$ as the inputs and the outputs are a modified version of $cS_L$ and, when ChromaArrayType is not equal to 0, modified versions of $cS_{Cb}$ and $cS_{Cr}$.

4. The variable MvCnt for the macroblock mbAddr is set equal to mvCnt[ mbAddr ].

### G.8.2 SVC reference picture lists construction and decoded reference picture marking process

The SVC decoding process for picture order count is specified in subclause G.8.2.1.

The SVC decoding process for picture numbers is specified in subclause G.8.2.2.

The SVC decoding process for reference picture lists construction is specified in subclause G.8.2.3.

The SVC decoded reference picture marking process is specified in subclause G.8.2.4.

The SVC decoding process for gaps in frame_num is specified in subclause G.8.2.5.

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The decoding process for picture order counts is independently applied for different values of dependency_id. Syntax elements that are related to picture order count for a particular value of dependency_id do not influence the derivation of picture order counts for other values of dependency_id.

The reference picture marking is independently applied for different values of dependency_id. Syntax elements that are related to reference picture marking for a particular value of dependency_id do not influence the reference picture marking for other values of dependency_id.

The decoding process for gaps is frame_num is independently applied for different values of dependency_id.

Reference picture lists for different dependency representations are constructed independently. Syntax elements that are related to reference picture list construction for a particular value of dependency_id do not influence the reference picture list construction for other values of dependency_id. Reference picture list for a particular value of dependency_id are constructed based on the reference picture marking for this particular value of dependency_id. The reference picture marking for a particular value of dependency_id does not influence the reference picture list construction for a different value of dependency_id.

Only the elements of the reference picture lists for dependency_id equal to DependencyIdMax represent decoded pictures that are associated with decoded samples. Only the reference picture lists for dependency_id equal to DependencyIdMax are used for the derivation of inter prediction samples as specified in subclause G.8.4.2. The elements of the reference picture lists for dependency representation with dependency_id less than DependencyIdMax represent layer pictures, which are not associated with decoded samples. The elements of the reference picture lists for dependency_id equal to 0 are associated with the arrays fieldMbFlag, mbType, subMbType, predFlagL0, predFlagL1, refIdxL0, refIdxL1, mvL0, and mvL1 as specified in subclause G.8.1.2.1 that were derived when decoding the layer representation with dependency_id equal to 0 and quality_id equal to 0 for the corresponding access unit. These arrays are used for the derivation of motion vectors and reference indices for layer representation with dependency_id equal to 0 and quality_id equal to 0 as specified in subclause G.8.4.1.2. The elements of the reference picture lists for all dependency representations with dependency_id greater than 0 are associated with the variables ScaledRefLayerLeftOffset, ScaledRefLayerRightOffset, ScaledRefLayerTopOffset, and ScaledRefLayerBottomOffset. These variables are used for deriving inter-layer motion vector predictions as specified in subclause G.8.6.1.2.

NOTE – For each access unit, decoded samples only need to be stored for the dependency representation with dependency_id equal to DependencyIdMax, and motion data arrays only need to be stored for the dependency representation with dependency_id equal to 0.

The SVC decoding processes for picture order count, reference picture list construction, reference picture marking, and gaps in frame_num are specified using processes specified in subclause 8. The following modifications to the processes specified in this subclause and the processes of subclause 8 that are invoked from these processes apply with currDependencyId representing the value of dependency_id for the dependency representation for which the processes are invoked.

a) All syntax elements and derived upper-case variables that are referred to in this process or in a child process invoked from this process are syntax elements and upper-case variables for the dependency representation with dependency_id equal to currDependencyId.

b) When dependency_id is less than DependencyIdMax, the following applies.

   – A frame, field, top field, bottom field, picture, and decoded picture is interpreted as layer frame, layer field, layer top field, layer bottom field, layer picture, and decoded layer picture, respectively, that represent an intermediate decoding result for the dependency representation with dependency_id equal to currDependencyId.

   – An IDR picture is interpreted as layer picture with IdrPicFlag is equal to 1 for the dependency representation with dependency_id equal to currDependencyId.

   – A reference frame, reference field, and reference picture is interpreted as layer frame, layer field, and layer picture with nal_ref_idc greater than 0 for the dependency representation with dependency_id equal to currDependencyId.

   – A non-reference frame, non-reference field, and non-reference picture is interpreted as layer frame, layer field, and layer picture with nal_ref_idc equal to 0 for the dependency representation with dependency_id equal to currDependencyId.

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- A complementary non-reference field pair is interpreted as complementary non-reference layer field pair for the dependency representation with dependency_id equal to currDependencyId. A complementary non-reference layer field pair for a particular value of dependency_id is a pair of two layer fields with nal_ref_idc equal to 0 for the particular value of dependency_id that are in consecutive access units containing a dependency representation with the particular value of dependency_id as two coded layer field and have opposite parity where the first layer field is not already a paired layer field.
- A complementary reference field pair is interpreted as complementary reference layer field pair for the dependency representation with dependency_id equal to currDependencyId. A complementary reference layer field pair for a particular value of dependency_id is a pair of two layer fields with nal_ref_idc greater than 0 for the particular value of dependency_id that are in consecutive access units containing a dependency representation with the particular value of dependency_id as two coded layer fields and share the same value of frame_num where the second layer field in decoding order has IdrPicFlag equal to 0 and does not include a memory_management_control_operation syntax element equal to 5.
- A complementary field pair is interpreted as complementary layer field pair for the dependency representation with dependency_id equal to currDependencyId. A complementary layer field pair is a collective term for a complementary reference layer field pair and a complementary non-reference layer field pair.
- A non-paired non-reference field is interpreted as layer field with nal_ref_idc equal to 0 for the dependency representation with dependency_id equal to currDependencyId that is not part of a complementary non-reference layer field pair.
- A non-paired reference field is interpreted as layer field with nal_ref_idc greater than 0 for the dependency representation with dependency_id equal to currDependencyId that is not part of a complementary reference layer field pair.
- A non-paired reference field is interpreted as layer field for the dependency representation with dependency_id equal to currDependencyId that is not part of a complementary layer field pair.

### G.8.2.1 SVC decoding process for picture order count

Outputs of this process are the variables TopFieldOrderCnt (if applicable) and BottomFieldOrderCnt (if applicable) for all dependency representations of the current access unit.

For all dependency representations of the current access unit, the variables TopFieldOrderCnt (if applicable) and BottomFieldOrderCnt (if applicable) are derived by invoking the decoding process for picture order count as specified in subclause 8.2.1. For these invocations of the process specified in subclause 8.2.1, the modifications a) and b) specified in subclause G.8.2 apply with currDependencyId being equal to dependency_id of the corresponding dependency representation.

For all dependency representations of an access unit, either TopFieldOrderCnt or BottomFieldOrderCnt or both are derived. When both are derived in two or more dependency representations of an access unit, their difference shall be the same in these dependency representations of the access unit.

The values of TopFieldOrderCount and BottomFieldOrderCount are restricted as follows.

- For each access unit, the one-dimensional array picOrderCnt is derived as follows.
  - If TopFieldOrderCnt is derived in all dependency representations of an access unit, the variable picOrderCnt[ dId ] is set equal to TopFieldOrderCnt of the dependency representation with dependency_id being equal to dId.
  - Otherwise (TopFieldOrderCnt is not derived in all dependency representations of an access unit), the variable picOrderCnt[ dId ] is set equal to BottomFieldOrderCnt of the dependency representation with dependency_id being equal to dId.
- Let au0 and au1 be any pair of access units in the bitstream with au1 being later in decoding order than au0.
- Let the flag idrConditionFlag be derived for each dependency representation in an access unit as follows.
  - If the dependency representation in the access unit has IdrPicFlag equal to 1 or a memory_management_control_operation syntax element equal to 5, idrConditionFlag is set equal to 1.

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  - Otherwise (the dependency representation in the access unit has IdrPicFlag equal to 0 and does not have a memory_management_control_operation syntax element equal to 5), idrConditionFlag is set equal to 0.
- Let the set dIdSet0 be the set of all dependency_id values in au0.
- Let the set dIdSet1 be the set of all dependency_id values in au1 for which idrConditionFlag is not equal to 1 in any access unit in decoding order between the access unit that follows au0 and the access unit au1, inclusive.
- For all values of dId that are present in both sets dIdSet0 and dIdSet1, the differences between the value picOrderCnt[ dId ] in au0 and the value picOrderCnt[ dId ] in au1 shall be the same.

#### G.8.2.2 SVC decoding process for picture numbers

This process is invoked when the SVC decoding process for reference picture lists construction specified in subclause G.8.2.3 is invoked or when the SVC reference picture marking process for a dependency representation as specified in subclause G.8.2.4.1 is invoked.

Inputs to this process are

- a variable currDependencyId specifying a dependency representation,
- a variable useRefBasePicFlag specifying whether this process refers to reference base pictures or decoded pictures.

Outputs of this process are variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and LongTermPicNum assigned to all pictures marked as "used for short-term reference" or "used for long-term reference".

From here to the end of this subclause, the modifications a) and b) specified in subclause G.8.2 apply.

The variable maxFrameNum is derived by

$$maxFrameNum = ( 1 << ( log2_max_frame_num_minus4 + 4 ) ) \quad \text{(G-88)}$$

To each short-term and long-term reference picture a variable useFlag is assigned as follows.

- If useRefBasePicFlag is equal to 0, the following applies.
  - If the reference picture is not marked as "reference base picture", useFlag is set equal to 1.
  - Otherwise (the reference picture is marked as "reference base picture"), useFlag is set equal to 0.
- Otherwise, if the reference picture is a short-term reference picture, the following applies.
  - If the short-term reference picture is marked as "reference base picture" or if there does not exist a short-term reference picture with an identical value frame_num coded in slice header(s) with dependency_id equal to currDependencyId that is marked as "reference base picture", useFlag is set equal to 1.
  - Otherwise (the short-term picture is not marked as "reference base picture" and there exist a short-term reference picture with an identical value frame_num coded in slice header(s) with dependency_id equal to currDependencyId that is marked as "reference base picture"), useFlag is set equal to 0.
- Otherwise (useRefBasePicFlag is equal to 1 and the reference picture is a long-term reference picture), the following applies.
  - If the long-term reference picture is marked as "reference base picture" or if there does not exist a long-term reference picture with an identical value of LongTermFrameIdx that is marked as "reference base picture", useFlag is set equal to 1.
  - Otherwise (the long-term picture is not marked as "reference base picture" and there exist a long-term reference picture with an identical value of LongTermFrameIdx that is marked as "reference base picture"), useFlag is set equal to 0.

To each short-term reference picture the variables FrameNum and FrameNumWrap are assigned as follows.

- If useFlag is equal to 0, FrameNum and FrameNumWrap for the short-term picture are marked as "unspecified".
- Otherwise, FrameNum is set equal to the syntax element frame_num that has been decoded in the slice header(s) with dependency_id equal to currDependencyId of the corresponding short-term reference picture. And the variable FrameNumWrap is derived by

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```
if( FrameNum > frame_num )
        FrameNumWrap = FrameNum – maxFrameNum                    (G-89)
else
        FrameNumWrap = FrameNum
```

where the value of frame_num used in Equation G-89 is the frame_num in the slice header(s) with dependency_id equal to currDependencyId for the current access unit.

NOTE – The values of FrameNum and FrameNumWrap are dependent on the value of currDependencyId. For the calculation of FrameNum and FrameNumWrap only syntax elements of NAL units with dependency_id equal to currDependencyId are used.

Each long-term reference picture has an associated value of LongTermFrameIdx (that was assigned to it as specified in subclause 8.2.5). When useFlag is equal to 0 for a long-term picture, LongTermFrameIdx is temporarily marked as "unspecified". This marking is removed after the invocation of the SVC decoding process for reference picture lists construction as specified in subclause G.8.2.3 or the invocation of the SVC decoded reference picture marking process as specified in subclause G.8.2.4.

To each short-term reference picture a variable PicNum is assigned, and to each long-term reference picture a variable LongTermPicNum is assigned. The values of these variables depend on the value of field_pic_flag and bottom_field_flag for the current slice with dependency_id equal to currDependencyId and they are set as follows.

– If field_pic_flag is equal to 0, the following applies.
  – For each short-term reference frame or complementary reference field pair the following applies
    – If FrameNumWrap is marked as "unspecified", PicNum is marked as "unspecified".
    – Otherwise (FrameNumWrap is not marked as "unspecified"), PicNum is derived by

      PicNum = FrameNumWrap (G-90)

  – For each long-term reference frame or long-term complementary reference field pair the following applies
    – If LongTermFrameIdx is marked as "unspecified", LongTermPicNum is marked as "unspecified".
    – Otherwise (LongTermFrameIdx is not marked as "unspecified"), LongTermPicNum is derived by

      LongTermPicNum = LongTermFrameIdx (G-91)

– Otherwise (field_pic_flag is equal to 1), the following applies.
  – Let current field refer to the slices of the current access unit with dependency_id equal to currDependencyId.
  – For each short-term reference field the following applies.
    – If FrameNumWrap is marked as "unspecified", PicNum is marked as unspecified.
    – Otherwise (FrameNumWrap is not marked as "unspecified"), the following applies.
      – If the reference field has the same parity as the current field

        PicNum = 2 * FrameNumWrap + 1 (G-92)

      – Otherwise (the reference field has the opposite parity of the current field),

        PicNum = 2 * FrameNumWrap (G-93)

  – For each long-term reference field the following applies.
    – If LongTermFrameIdx is marked as "unspecified", LongTermPicNum is marked as "unspecified".
    – Otherwise (LongTermFrameIdx is not marked as "unspecified"), the following applies.
      – If the reference field has the same parity as the current field

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LongTermPicNum = 2 * LongTermFrameIdx + 1 (G-94)

– Otherwise (the reference field has the opposite parity of the current field),

LongTermPicNum = 2 * LongTermFrameIdx (G-95)

### G.8.2.3 SVC decoding process for reference picture lists construction

This process is invoked at the beginning of decoding each P, EP, B, or EB slice.

Inputs to this process are

– a variable currDependencyId

– a variable useRefLayerRepFlag

– the current slice currSlice

Outputs of this process are

– a reference picture list refPicList0

– for B and EB slices, a reference picture list refPicList1

After applying the process described in this subclause, the output reference picture lists refPicList0 and refPicList1 (when applicable) shall not contain any pictures for which the syntax element temporal_id is greater than the syntax element temporal_id of the current picture.

From here to the end of this subclause, the modifications a) and b) specified in subclause G.8.2 apply.

A variable biPred is derived as follows:

– If the current slice currSlice is a B or EB slice, biPred is set equal to 1.

– Otherwise, biPred is set equal to 0.

Decoded reference pictures are marked as "used for short-term reference" or "used for long-term reference" as specified by the bitstream and specified in subclause G.8.2.4. Short-term reference pictures are identified by the value of frame_num that is decoded in the slice header(s) with dependency_id equal to currDependencyId. Long-term reference pictures are identified by a long-term frame index as specified by the bitstream and specified in subclause G.8.2.4.

Subclause G.8.2.2 is invoked with currDependencyId and useRefBasePicFlag as inputs to specify

– the assignment of variables FrameNum, FrameNumWrap, and PicNum to each of the short-term reference pictures, and

– the assignment of variables LongTermPicNum to each of the long-term reference pictures

NOTE – During the invocation of subclause G.8.2.2 the variables FrameNum, FrameNumWrap, PicNum, and LongTermPicNum can be marked as “unspecified”. Furthermore, the variables LongTermFrameIdx can be temporarily marked as “unspecified” for this subclause and all invocations inside this subclause.

Reference pictures are addressed through reference indices as specified in subclause 8.4.2.1. A reference index is an index into a reference picture list. When biPred is equal to 0, a single reference picture list refPicList0 is constructed. When decoding a B or EB slice (biPred is equal to 1), a second independent reference picture list refPicList1 is constructed in addition to refPicList0.

At the beginning of decoding of each slice, reference picture list refPicList0, and for biPred equal to 1 refPicList1, are derived as follows.

– Initial reference picture lists RefPicList0 and, for biPred equal to 1, RefPicList1 are derived by invoking the initialization process for reference picture lists as specified in subclause 8.2.4.2. During the initialization process in subclause 8.2.4.2 all short-term reference pictures for which FrameNum, FrameNumWrap, and PicNum have been marked as “unspecified” by the invocation of subclause G.8.2.2 and all long-term pictures for which LongTermFrameIdx and LongTermPicNum have been marked as “unspecified” by the invocation of subclause G.8.2.2 are considered as non-existing. The reference picture lists are constructed by using only short-term pictures with values of FrameNum, FrameNumWrap, and PicNum that are not marked as “unspecified” and long-term pictures with values of LongTermFrameIdx and LongTermPicNum that are not marked as “unspecified”.

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– The initial reference picture list RefPicList0 and for biPred equal to 1 RefPicList1 are modified by invoking the reordering process for reference picture lists as specified in subclause 8.2.4.3. During the reordering process in subclause 8.2.4.2 all short-term reference pictures for which FrameNum, FrameNumWrap, and PicNum have been marked as "unspecified" by the invocation of subclause G.8.2.2 and all long-term pictures for which LongTermFrameIdx and LongTermPicNum have been marked as "unspecified" by the invocation of subclause G.8.2.2 are considered as non-existing. Short-term pictures with values of FrameNum, FrameNumWrap, and PicNum that are marked as "unspecified" and long-term pictures with values of LongTermFrameIdx and LongTermPicNum that are marked as "unspecified" shall not be referred to by reference picture list reordering commands.

– RefPicList0 is assigned to refPicList0.

– When biPred is equal to 1, RefPicList1 is assigned to refPicList1.

NOTE – By the invocation of the process in subclause G.8.2.2 the parameters of some reference picture might have been marked as "unspecified". Since, these pictures are not considered in the construction process for reference picture lists, the reference picture lists refPicList0 and for biPred equal to 1 refPicList1 are dependent on the value of the input parameter currDependencyId.

The number of entries in the modified reference picture list refPicList0 is num_ref_idx_l0_active_minus1 + 1, and for biPred equal to 1 the number of entries in the modified reference picture list refPicList1 is num_ref_idx_l1_active_minus1 + 1. A reference picture may appear at more than one index in the modified reference picture lists refPicList0 or refPicList1.

For all long-term reference pictures for which LongTermFrameIdx has been marked as "unspecified" during the invocation of subclause G.8.2.2, this marking of LongTermFrameIdx is removed.

### G.8.2.4 SVC decoded reference picture marking process

For all dependency representations of the current access unit, when nal_ref_idc is greater than 0 for the slice data NAL units of the dependency representation, the SVC reference picture marking process for a dependency representation as specified in subclause G.8.2.4.1 is invoked. For these invocations of the process specified in subclause G.8.2.4.1, the modifications a) and b) specified in subclause G.8.2 apply with currDependencyId being equal to dependency_id for the corresponding dependency representation.

#### G.8.2.4.1 SVC reference picture marking process for a dependency representation

Input to this process is a variable currDependencyId.

Output of this process is a modified reference picture marking for dependency representations with dependency_id equal to currDependencyId.

This process is invoked for a decoded picture when nal_ref_idc is not equal to 0 for the dependency representation with dependency_id being equal to currDependencyId.

All syntax elements of the dec_ref_pic_marking( ) syntax structure and the dec_ref_base_pic_marking( ) syntax structure that are referred to by the process specified in this subclause and all child processes invoked from this process are syntax elements of the slice headers with dependency_id equal to currDependencyId and quality_id equal to 0.

NOTE – Coded slice NAL units with quality_id greater than 0 do not contain the syntax structures dec_ref_pic_marking( ) and dec_ref_base_pic_marking( ). For these NAL units, the syntax elements specifying the decoded reference picture marking are inferred from coded slice NAL units with dependency_id equal to DependencyIdMax and quality_id equal to 0. Coded slice NAL units with dependency_id equal to 0 and quality_id equal to 0 do not contain the syntax structure dec_ref_base_pic_marking( ). For these NAL units, the syntax elements of the syntax structure dec_ref_base_pic_marking( ) are inferred from the associated prefix NAL units, which directly precedes the coded slice NAL unit in decoding order.

A decoded picture with nal_ref_idc not equal to 0, referred to as a reference picture, is marked as "used for short-term reference" or "used for long-term reference". When store_ref_base_pic_flag is equal to 1, a second representation of the decoded picture also referred to as reference base picture is marked as "used for short-term reference" or "used for long-term reference" and additionally marked as "reference base picture". Pictures that are marked as "reference base picture" are only used as references for inter prediction of following pictures with use_ref_base_pic_flag equal to 1. These pictures are not used for inter prediction of pictures with use_ref_base_pic_flag equal to 0, and these pictures do not represent an output of the decoding process.

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For a decoded reference frame, both of its fields are marked the same as the frame. For a complementary reference field pair, the pair is marked the same as both of its fields. A picture that is marked as "used for short-term reference" is identified by its FrameNum and, when it is a field, by its parity, and, when it is a reference base picture, by the marking "reference base picture". A picture that is marked as "used for long-term reference" is identified by its LongTermFrameIdx and, when it is a field, by its parity, and, when it is a reference base picture, by the marking "reference base picture".

While decoded pictures are represented by the sample arrays $S_L$ and, when ChromaArrayType is not equal to 0, $S_{Cb}$ and $S_{Cr}$, reference base pictures are represented by the sample arrays $B_L$ and, when ChromaArrayType is not equal to 0, $B_{Cb}$ and $B_{Cr}$. When reference base pictures are referenced in the inter prediction process via subclause 8.4.2.1, the samples arrays $B_L$, $B_{Cb}$, and $B_{Cr}$ are referred to as $S_L$, $S_{Cb}$, and $S_{Cr}$, respectively. Reference base pictures are associated with the same descriptive information such as the variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and LongTermPicNum as the corresponding decoded picture that is marked by the same invocation of the decoded reference picture marking process.

Frames or complementary field pairs marked as "used for short-term reference" or as "used for long-term reference" can be used as a reference for inter prediction when decoding a frame until the frame, the complementary field pair, or one of its constituent fields is marked as "unused for reference". A field marked as "used for short-term reference" or as "used for long-term reference" can be used as a reference for inter prediction when decoding a field until marked as "unused for reference".

A picture can be marked as "unused for reference" by the sliding window reference picture marking process, a first-in, first-out mechanism specified in subclause 8.2.5.3, or by the adaptive memory control reference picture marking process, a customised adaptive marking operation specified in subclause 8.2.5.4.

A short-term reference picture is identified for use in the decoding process by its variables FrameNum and FrameNumWrap and its picture number PicNum, and, when it is a reference base picture, by the marking as "reference base picture". A long-term reference picture is identified for use in the decoding process by its variable LongTermFrameIdx, its long-term picture number LongTermPicNum, and, when it is a reference base picture, by the marking as "reference base picture". When the current picture is not an IDR picture, the assignment of the variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and LongTermPicNum for the reference pictures is specified as follows.

– The variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and LongTermPicNum are assigned to all reference pictures marked as "reference base pictures" by invoking subclause G.8.2.2 with currDependencyId set equal to DependencyIdMax and useRefBasePicFlag set equal to 1 as the inputs.

  NOTE – By this first invoking of subclause G.8.2.2 the variables may be also assigned to reference pictures not marked as "reference base picture". For these pictures, the variables are again assigned by the following invoking of subclause G.8.2.2 and the variables that are assigned in both invocations of subclause G.8.2.2 are identical.

– The variables FrameNum, FrameNumWrap, PicNum, LongTermFrameIdx, and LongTermPicNum are assigned to all reference pictures not marked as "reference base picture" by invoking subclause G.8.2.2 with currDependencyId set equal to DependencyIdMax and useRefBasePicFlag set equal to 0 as the inputs.

Decoded reference picture marking proceeds in the following ordered steps.

– All slices of the current access unit are decoded.

– Depending on the current picture, the following applies.

  – If the current picture is an IDR picture, the following applies.

    – All reference pictures are marked as "unused for reference".

    – Depending on long_term_reference_flag, the following applies.

      – If long_term_reference_flag is equal to 0, the following applies.

        – The IDR picture is marked as "used for short-term reference" and MaxLongTermFrameIdx is set equal to "no long-term frame indices"

        – When store_ref_base_pic_flag is equal to 1, the reference base picture of the IDR picture is marked as "used for short-term reference" and as "reference base picture".

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- Otherwise (long_term_reference_flag is equal to 1), the following applies.
  - The IDR picture is marked as "used for long-term reference", the LongTermFrameIdx for the IDR picture is set equal to 0, and MaxLongTermFrameIdx is set equal to 0.
  - When store_ref_base_pic_flag is equal to 1, the reference base picture of the IDR picture is marked as "used for long-term reference" and as "reference base picture", and the LongTermFrameIdx for the IDR picture is set equal to 0.

- Otherwise (the current picture is not an IDR picture), the following applies.
  - When store_ref_base_pic_flag is equal to 1, the following applies.
    - If adaptive_ref_base_pic_marking_mode_flag is equal to 1, the adaptive memory control decoded reference picture marking process as specified in subclause 8.2.5.4 is invoked with the syntax elements from the syntax structure dec_ref_base_pic_marking( ) and adaptive_ref_base_pic_marking_mode_flag replacing adaptive_ref_pic_marking_mode_flag. Only the reference pictures that are marked as "reference base picture" are considered in this invocation of the process.
    - Otherwise (adaptive_ref_base_pic_marking_mode_flag is equal to 0), the sliding window decoded reference picture marking process as specified in subclause 8.2.5.3 is invoked with adaptive_ref_base_pic_marking_mode_flag replacing adaptive_ref_pic_marking_mode_flag. When during the invocation of this process there is a decoded picture not marked as "reference base picture" and a reference base picture marked as "reference base picture", and both of which have the smallest value of FrameNumWrap, then only the picture marked as "reference base picture" is marked as "unused for reference".
    - The reference base picture of the current decoded picture is be marked as "used for short-term reference" and as "reference base picture".
  - Depending on adaptive_ref_pic_marking_mode_flag, the following applies.
    - If adaptive_ref_pic_marking_mode_flag is equal to 0, the following applies.
      - The sliding window decoded reference picture marking process as specified in subclause 8.2.5.3 is invoked. When during the invocation of this process there is a decoded picture not marked as "reference base picture" and a reference base picture marked as "reference base picture", and both of which have the smallest value of FrameNumWrap, then only the reference base picture is marked as "unused for reference".
      - The current decoded picture is marked as "used for short-term reference".
    - Otherwise (adaptive_ref_pic_marking_mode_flag is equal to 1), the following applies.
      - The adaptive memory control decoded reference picture marking process as specified in subclause 8.2.5.4 with the syntax elements from the dec_ref_pic_marking( ) syntax structure is invoked. Only the reference pictures that are not marked as "reference base picture" are considered in the invocation of the process. Additionally, the following applies.
        - All pictures for which LongTermFrameIdx is greater than MaxLongTermFrameIdx and that are marked as "used for long-term reference" and "reference base picture" are marked as "unused for reference".
        - When during the invocation of this process a LongTermFrameIdx is assigned to a picture and there exists a "reference base picture" with the same value of PicNum (before assigning the long-term frame index), the LongTermFrameIdx is also assigned to the reference base picture, and the marking is changed from "used for short-term reference" to "used for long-term reference".
      - When the current picture was not marked as "used for long-term reference" by memory_management_control_operation equal to 6, it is marked as "used for short-term reference".

NOTE – When store_ref_base_pic_flag is equal to 1, num_ref_frames shall be greater than or equal to 2.

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When the adaptive memory control decoded reference picture marking process as specified in subclause 8.2.5.4 is invoked to mark reference pictures as "unused for reference" after decoding of a reference picture with temporal_id equal to tL, no reference picture with temporal_id less than tL shall be marked as "unused for reference".

For all long-term reference pictures for which LongTermFrameIdx has been marked as "unspecified" during the invocation of subclause G.8.2.2, this marking of LongTermFrameIdx is removed.

#### G.8.2.5 SVC decoding process for gaps in frame_num

For all dependency representations of the current access unit, the following applies.

– The syntax elements gaps_in_frame_num_value_allowed_flag and frame_num and the derived variables PrevRefFrameNum and MaxFrameNum are the syntax elements and derived upper-case variables for the considered dependency representation.

– When gaps_in_frame_num_value_allowed_flag is equal to 0, the bitstream shall not contain data that result in frame_num not being equal to PrevRefFrameNum or ( PrevRefFrameNum + 1 ) % MaxFrameNum.

NOTE – When gaps_in_frame_num_value_allowed_flag is equal to 0 and frame_num is not equal to PrevRefFrameNum and is not equal to ( PrevRefFrameNum + 1 ) % MaxFrameNum, the decoding process should infer an unintentional loss of pictures.

– When frame_num is not equal to PrevRefFrameNum and is not equal to ( PrevRefFrameNum + 1 ) % MaxFrameNum, the decoding process for gaps in frame_num as specified in subclause 8.2.5.2 is invoked. For this invocation of the process specified in subclause 8.2.5.2, the modifications a) and b) specified in subclause G.8.2 apply with currDependencyId being equal to dependency_id for the considered dependency representation.

### G.8.3 SVC intra decoding processes

Subclause G.8.3.1 specifies the SVC derivation process for intra prediction modes.

Subclause G.8.3.2 specifies the SVC intra sample prediction and construction process.

#### G.8.3.1 SVC derivation process for intra prediction modes

This process is only invoked when base_mode_flag is equal to 0 and mbType[ CurrMbAddr ] specified as input to this process is equal to I_PCM, I_16x16, I_8x8, or I_4x4.

Inputs to this process are

– a one-dimensional array sliceIdc with PicSizeInMbs elements specifying slice identifications for the macroblocks of the current layer representation,

– a list fieldMbFlag with PicSizeInMbs elements specifying which macroblocks of the current layer representation are coded as field macroblocks and which macroblocks are coded as frame macroblocks,

– a list mbType with PicSizeInMbs elements specifying macroblock types for the macroblocks of the current layer representation,

– a (PicSizeInMbs)x16 array ipred4x4 specifying Intra_4x4 prediction modes for macroblocks of the current layer representation,

– a (PicSizeInMbs)x4 array ipred8x8 specifying Intra_8x8 prediction modes for macroblocks of the current layer representation,

– a list intra16x16 with PicSizeInMbs elements specifying Intra_16x16 prediction modes for macroblocks of the current layer representation,

– when ChromaArrayType is equal to 1 or 2, a list intraChroma with PicSizeInMbs elements specifying intra chroma prediction modes for macroblocks of the current layer representation.

Outputs of this process are

– a modified version of the array ipred4x4,

– a modified version of the array ipred8x8,

– a modified version of the array ipred16x16,

– when ChromaArrayType is equal to 1 or 2, a modified version of the array ipredChroma.

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