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INTERNATIONAL STANDARD

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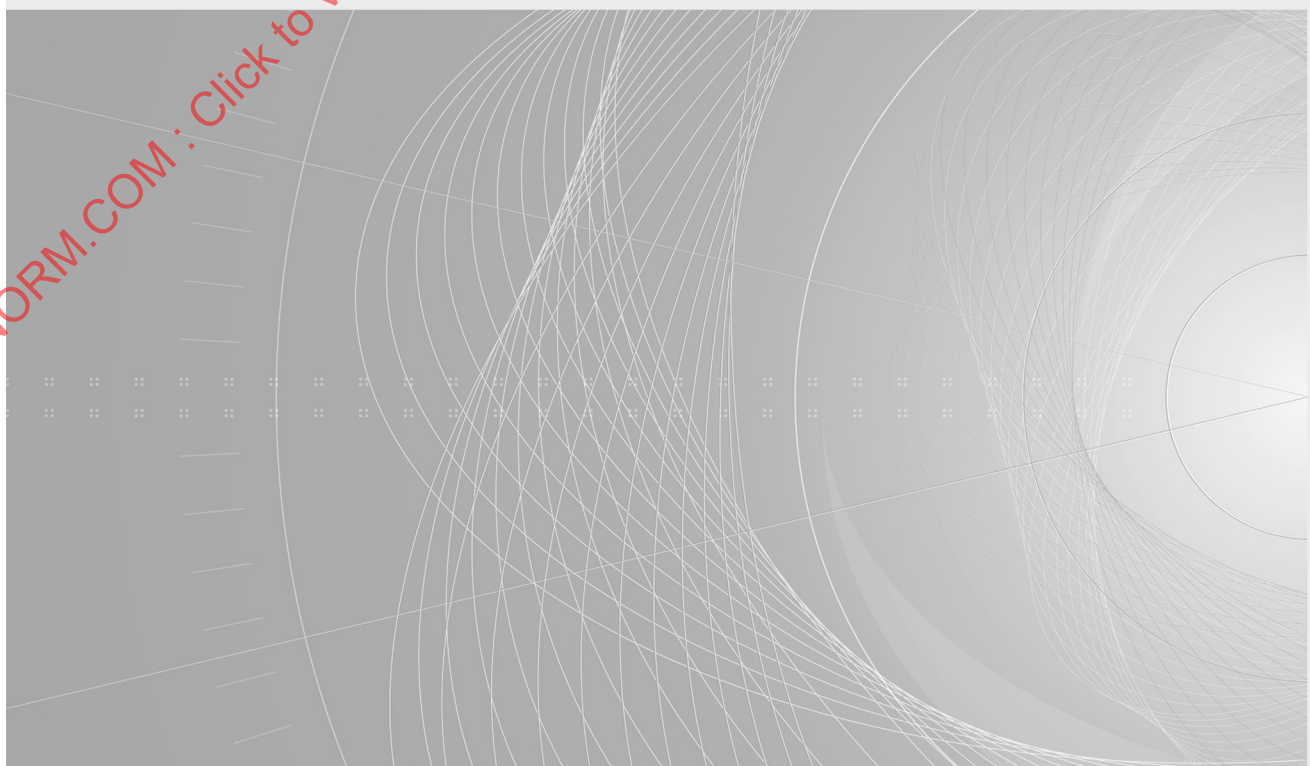
Low-voltage electrical installations –
Part 5-53: Selection and erection of electrical equipment – Devices for protection for safety, isolation, switching, control and monitoring



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LOW-VOLTAGE ELECTRICAL INSTALLATIONS –

Part 5-53: Selection and erection of electrical equipment – Devices for protection for safety, isolation, switching, control and monitoring

FOREWORD

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This consolidated version of the official IEC Standard and its amendments has been prepared for user convenience.

IEC 60364-5-53 edition 4.2 contains the fourth edition (2019-02) [documents 64/2352/FDIS and 64/2359/RVD], its amendment 1 (2020-12) [documents 64/2457/FDIS and 64/2465/RVD] and its amendment 2 (2024-12) [documents 64/2648/FDIS and 64/2738/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendments 1 and 2. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 60364 has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This fourth edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) revision of all clauses except 531 and 534;
b) introduction of a new Clause 537 Monitoring;
c) Clause 530 contains all normative references and all terms and definitions.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The reader's attention is drawn to the fact that Annex F lists all of the "in-some-country" clauses on differing practices relating to the subject of this standard.

A list of all parts in the IEC 60364 series, published under the general title *Low-voltage electrical installations*, can be found on the IEC website.

The committee has decided that the contents of this document and its amendments will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

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LOW-VOLTAGE ELECTRICAL INSTALLATIONS –

Part 5-53: Selection and erection of electrical equipment – Devices for protection for safety, isolation, switching, control and monitoring

530.1 Scope

This document provides requirements for:

a) isolation, switching, control and monitoring, and

b) selection and erection of:

1) devices for isolation, switching, control and monitoring, and

2) devices to achieve compliance with measures of protection for safety.

530.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60204-1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60269-2, *Low-voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to K*

IEC 60269-3, *Low-voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications) – Examples of standardized systems of fuses A to F*

IEC 60269-4, *Low-voltage fuses – Part 4: Supplementary requirements for use-links for the protection of semiconductor devices*

IEC 60309 (all parts), *Plugs, socket-outlets and couplers for industrial purposes*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*
IEC 60364-4-41:2005/AMD1:2017

IEC 60364-4-42:2010, *Low-voltage electrical installations – Part 4-42: Protection for safety – Protection against thermal effects*
IEC 60364-4-42:2010/AMD1:2014

IEC 60364-4-43:2008, *Low-voltage electrical installations – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-4-44:2007, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*
IEC 60364-4-44:2007/AMD1:2015

IEC 60364-5-55, *Electrical installations of buildings – Part 5-55: Selection and erection of electrical equipment – Other equipment*

IEC 60364-6:2016, *Low voltage electrical installations– Part 6: Verification*

IEC 60417 (all parts), *Graphical symbols for use on equipment*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60669-1, *Switches for household and similar fixed-electrical installations – Part 1: General requirements*

IEC 60669-2-1, *Switches for household and similar fixed electrical installations – Part 2-1: Particular requirements – Electronic switches*

IEC 60669-2-2, *Switches for household and similar fixed electrical installations – Part 2-2: Particular requirements – Electromagnetic remote-control switches (RCS)*

IEC 60669-2-3, *Switches for household and similar fixed electrical installations – Part 2-3: Particular requirements – Time-delay switches (TDS)*

IEC 60669-2-4, *Switches for household and similar fixed electrical installations – Part 2-4: Particular requirements – Isolating switches*

IEC 60669-2-5, *Switches for household and similar fixed electrical installations – Part 2-5: Particular requirements – Switches and related accessories for use in home and building electronic systems (HBES)*

IEC 60669-2-6, *Switches for household and similar fixed electrical installations – Part 2-6: Particular requirements – Fireman's switches for exterior and interior signs and luminaires*

IEC 60670-24, *Boxes and enclosures for electrical accessories for household and similar fixed electrical installations – Part 24: Particular requirements for enclosures for housing protective devices and other power dissipating electrical equipment*

IEC 60884 (all parts), *Plugs and socket-outlets for household and similar purposes*

IEC 60898 (all parts), *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations*

IEC 60906 (all parts), *IEC system of plugs and socket-outlets for household and similar purposes*

IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

IEC 60947-3, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-4-1, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

IEC 60947-4-2, *Low-voltage switchgear and controlgear – Part 4-2: Contactors and motor-starters – AC semiconductor motor controllers and starters*

IEC 60947-4-3, *Low-voltage switchgear and controlgear – Part 4-3: Contactors and motor-starters – AC semiconductor controllers and contactors for non-motor loads*

IEC 60947-5-1, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 60947-6-1, *Low-voltage switchgear and controlgear – Part 6-1: Multiple function equipment – Transfer switching equipment*

IEC 60947-6-2, *Low-voltage switchgear and controlgear – Part 6-2: Multiple function equipment – Control and protective switching devices (or equipment) (CPS)*

IEC 61008 (all parts), *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs)*

IEC 61009 (all parts), *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)*

IEC 61095, *Electromechanical contactors for household and similar purposes*

IEC 61439-2, *Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies*

IEC 61439-3, *Low-voltage switchgear and controlgear assemblies – Part 3: Distribution boards intended to be operated by ordinary persons (DBO)*

IEC 61439-6, *Low-voltage switchgear and controlgear assemblies – Part 6: Busbar trunking systems (busways)*

IEC 61534 (all parts), *Powertrack systems*

IEC 61557-8, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 8: Insulation monitoring devices for IT systems*

IEC 61557-9, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 9: Equipment for insulation fault location in IT systems*

IEC 61643-11, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*

IEC 61643-12, *Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles*

IEC 61984:2008, *Connectors – Safety requirements and tests*

IEC 61995 (all parts), *Devices for the connection of luminaires for household and similar purposes*

IEC 62020, *Electrical accessories – Residual current monitors for household and similar uses (RCMs)*

IEC 62208, *Empty enclosures for low-voltage switchgear and controlgear assemblies – General requirements*

IEC 62305 (all parts), *Protection against lightning*

IEC 62423, *Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses*

IEC 62606, *General requirements for arc fault detection devices*

IEC 62626-1, *Low-voltage switchgear and controlgear enclosed equipment – Part 1: Enclosed switch-disconnectors outside the scope of IEC 60947-3 to provide isolation during repair and maintenance work*

530.3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp.

530.3.1
disconnector
mechanical switching device which in the open position complies with the requirements specified for the isolating function

Note 1 to entry: A disconnector is capable of opening and closing a circuit when either negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the poles of the disconnector occurs. It is also capable of carrying currents under normal circuit conditions and carrying for a specified time currents under abnormal conditions such as those of short-circuit.

[SOURCE: IEC 60050-441:2000, 441-14-05, modified – Referring to isolating function instead of isolating distance.]

530.3.2
switch disconnector
switch which, in the open position, satisfies the isolating requirements specified for a disconnector

[SOURCE: IEC 60050-441:1984, 441-14-12]

530.3.3
mechanical switch
device capable of making, carrying and breaking currents through contacts controlled by mechanical operation under normal circuit conditions which may include specified operating overload conditions and also carrying for specified time currents under specified abnormal circuit conditions such as those of short-circuit

Note 1 to entry: A switch can be capable of making but not breaking short-circuit currents.

[SOURCE: IEC 60050-441:2000, 441-14-10, modified – "through contacts controlled by mechanical operation" has been added.]

530.3.4
switching-off for mechanical maintenance
opening operation of a switching device intended to inactivate an item or items of electrically powered equipment for the purpose of preventing a hazard, other than due to electric shock or to arcing, during non-electrical work on the equipment

[SOURCE: IEC 60050-826:2004, 826-17-02]

530.3.5
emergency switching-off
opening operation of a switching device intended to remove electric power from an electrical installation to avert or alleviate a hazardous situation

[SOURCE: IEC 60050-826:2004, 826-17-03]

530.3.6
emergency stopping
operation intended to stop as quickly as possible a movement which has become dangerous

[SOURCE: IEC 60050-826:2004, 826-17-04]

530.3.7
functional switching
operation intended to switch on or off or vary the supply of electric energy to an electrical installation or parts of it for normal operating purposes

[SOURCE: IEC 60050-826:2004, 826-17-05]

530.3.8
SPD assembly
one SPD or a set of SPDs, in both cases including all SPD disconnectors required by the SPD manufacturer, providing the required overvoltage protection for a type of system earthing

530.3.9
SPD disconnector
disconnector
device for disconnecting an SPD, or part of an SPD, from the power system

Note 1 to entry: This disconnecting device is not required to have isolating capability for safety purposes. It is to prevent a persistent fault on the system and is used to give an indication of an SPD's failure. Disconnectors can be internal (built in) or external (required by the manufacturer). There may be more than one disconnector function, for example an overcurrent protection function and a thermal protection function. These functions may be in separate units.

[SOURCE: IEC 61643-11:2011, 3.1.28]

530.3.10
mode of protection of an SPD
intended current path, between terminals that contains protective components, e.g. line-to-line, line-to-earth, line-to-neutral, neutral-to-earth

[SOURCE: IEC 61643-11:2011, 3.1.8]

530.3.11
follow current interrupt rating
I_{fi}
prospective short-circuit current that an SPD is able to interrupt without operation of a disconnector

[SOURCE: IEC 61643-11:2011, 3.1.39]

530.3.12
short-circuit current rating
I_{SCCR}
maximum prospective short-circuit current from the power system for which the SPD, in conjunction with the disconnector specified, is rated

[SOURCE: IEC 61643-11:2011, 3.1.27]

530.3.13
voltage protection level
U_P
maximum voltage to be expected at the SPD terminals due to an impulse stress with defined voltage steepness and an impulse stress with a discharge current with given amplitude and waveshape

Note 1 to entry: The voltage protection level is given by the manufacturer and may not be exceeded by:

- the measured limiting voltage determined for front-of-wave sparkover (if applicable) and the measured limiting voltage determined from the residual voltage measurements at amplitudes corresponding to I_n and/or I_{imp} respectively for test classes II and/or I;
- the measured limiting voltage at the open circuit voltage of the combination wave generator (U_{OC}), determined for the combination wave for test class III.

[SOURCE: IEC 61643-11:2011, 3.1.14]

530.3.14
rated impulse voltage
U_W
impulse withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against transient overvoltages

[SOURCE: IEC 60664-1:2007, 3.9.2]

530.3.15
maximum continuous operating voltage
U_C
maximum RMS voltage, which may be continuously applied to the SPD's mode of protection

Note 1 to entry: The U_C value covered by this document may exceed 1 000 V.

[SOURCE: IEC 61643-11:2011, 3.1.11]

530.3.16
nominal discharge current for class II test
I_n
crest value of the current through the SPD having a current waveshape of 8/20 µs

[SOURCE: IEC 61643-11:2011, 3.1.9]

530.3.17
impulse discharge current for class I test
I_{imp}
crest value of a discharge current through the SPD with specified charge transfer Q and specified energy W/R in the specified time

[SOURCE: IEC 61643-11:2011, 3.1.10]

530.3.18
two-port SPD
SPD having specific series impedance connected between separate input and output connections

[SOURCE: IEC 61643-11:2011, 3.1.3]

530.4 General and common requirements

530.4.1

Equipment for protection, isolation, switching, control and monitoring shall be selected and erected to provide for the safety and proper functioning for the intended use of the installation.

Such equipment shall be selected and erected so as to allow compliance with the requirements stated in this document and the relevant requirements in other parts of IEC 60364.

530.4.2

Except as provided in 536.2.2.7 and 536.5.1.2, an independently operated single-pole protective or switching device shall not be inserted in the neutral conductor.

530.4.3

Devices providing more than one function shall comply with all the requirements of this document appropriate to each separate function.

530.5 Erection of equipment

530.5.1

Equipment shall be erected in such a way that connections between wiring and equipment shall not be subject to undue stress or strain resulting from the foreseen use of the equipment.

530.5.2

Unenclosed type equipment shall be mounted in a suitable mounting box or enclosure in compliance with a relevant standard.

NOTE Examples of relevant standards are IEC 60670 (all parts), IEC 62208, IEC 61439 (all parts), and IEC 61084 (all parts).

~~531 Devices for protection against indirect contact by automatic disconnection of supply~~

~~531.1 Overcurrent protective devices~~

~~531.1.1 TN systems~~

~~In TN systems overcurrent protective devices shall be selected and erected according to the conditions specified in IEC 60364-4-41:2005, 434.2 and 431 and in 533.3 for devices for protection against short-circuit, and shall satisfy the requirements of IEC 60364-4-41:2005, 413.1.3.3.~~

~~531.1.2 TT systems~~

~~Under consideration.~~

~~**531.1.3 IT systems**~~

~~Where exposed-conductive-parts are interconnected, overcurrent protective devices for protection in the event of a second fault shall comply with 531.1.1 taking into account the requirements of IEC 60364-4-41:2005, 413.1.5.5.~~

~~**531.2 Residual current protective devices**~~

~~**531.2.1 General conditions of installation**~~

~~Residual current protective devices in DC systems shall be specially designed for detection of DC residual currents, and to break circuit currents under normal conditions and fault conditions.~~

~~**531.2.1.1** A residual current protective device shall ensure the disconnection of all live conductors in the circuit protected. In TN-S systems, the neutral need not be disconnected if the supply conditions are such that the neutral conductor can be considered to be reliably at earth potential.~~

~~NOTE The conditions for verification that the neutral conductor is reliably at earth potential are under consideration.~~

~~**531.2.1.2** No protective conductor shall pass through the magnetic circuit of a residual current protective device.~~

~~**531.2.1.3** Residual current protective devices shall be so selected, and the electrical circuits so subdivided, that any earth-leakage current which may be expected to occur during normal operation of the connected load(s) will be unlikely to cause unnecessary tripping of the device.~~

~~NOTE Residual current protective devices may operate at any value of residual current in excess of 50 % of the rated operating current.~~

~~**531.2.1.4 Influence of DC components**~~

~~Under consideration.~~

~~**531.2.1.5** The use of a residual current protective device associated with circuits not having a protective conductor, even if the rated operating residual current does not exceed 30 mA, shall not be considered as a measure sufficient for protection against indirect contact.~~

~~**531.2.2 Selection of devices according to their method of application**~~

~~**531.2.2.1** Residual current protective devices may or may not have an auxiliary source, taking into account the requirements of 531.2.2.2.~~

~~NOTE The auxiliary source may be the supply system.~~

~~**531.2.2.2** The use of residual current protective devices with an auxiliary source not operating automatically in the case of failure of the auxiliary source is permitted only if one of the two following conditions is fulfilled:~~

- ~~protection against indirect contact according to IEC 60364-4-41:2005, 413.1 is ensured even in the case of failure of the auxiliary supply;~~
- ~~the devices are installed in installations operated, tested and inspected by instructed persons (BA4) or skilled persons (BA5).~~

~~**531.2.3 TN systems**~~

~~If for certain equipment or for certain parts of the installation, one or more of the conditions stated in IEC 60364-4-41:2005, 413.1.3 cannot be satisfied, those parts may be protected by~~

~~a residual current protective device. In this case, exposed-conductive-parts need not be connected to the TN earthing system protective conductor, provided that they are connected to an earth electrode affording a resistance appropriate to the operating current of the residual current protective device. The circuit thus protected is to be treated as a TT system and IEC 60364-4-41:2005, 413.1.4 applies.~~

~~If, however, no separate earth electrode exists, connection of the exposed-conductive-parts to the protective conductor needs to be made on the source side of the residual current protective device.~~

~~531.2.4 TT systems~~

~~If an installation is protected by a single residual current protective device, this shall be placed at the origin of the installation, unless the part of the installation between the origin and the device complies with the requirement for protection by the use of class II equipment or equivalent insulation (see IEC 60364-4-41:2005, 413.2).~~

~~NOTE Where there is more than one origin, this requirement applies to each origin.~~

~~531.2.5 IT systems~~

~~Where protection is provided by a residual current protective device, and disconnection following a first fault is not envisaged, the residual non-operating current of the device shall be at least equal to the current which circulates on the first fault to earth of negligible impedance affecting a phase conductor.~~

~~531.3 Insulation monitoring devices~~

~~NOTE Insulation monitoring devices may operate with an appropriate response time.~~

~~An insulation monitoring device provided in accordance with IEC 60364-4-41:2005, 413.1.5.4 is a device continuously monitoring the insulation of an electrical installation. It is intended to indicate a significant reduction in the insulation level of the installation to allow the cause of this reduction to be found before the occurrence of a second fault, and thus avoid disconnection of the supply.~~

~~Accordingly, it is set at a value below that specified in IEC 60364-6:2006, 61.3.3 appropriate to the installation concerned.~~

~~Insulation monitoring devices shall be so designed or installed that it shall be possible to modify the setting only by the use of a key or a tool.~~

531 Equipment for protection against electric shock

531.1 General

Clause 531 deals with requirements for the selection and erection of equipment for the following protective measures in accordance with IEC 60364-4-41:

- automatic disconnection of supply,
- double or reinforced insulation,
- electrical separation,
- extra-low-voltage provided by SELV and PELV systems.

It also deals with requirements for the selection and erection of equipment for additional protection.

531.2 Devices for automatic disconnection of supply

531.2.1 General

Devices used for automatic disconnection of supply shall be placed at the origin or upstream of the circuit which is intended to be protected.

These devices shall be suitable for isolation in accordance with 536.

NOTE 1 Protective devices which require manual operation in order to achieve isolation are not excluded.

The following protective devices may be used:

– overcurrent protective devices in accordance with 531.2.2;
– residual current protective devices (RCDs) in accordance with 531.2.3.

Devices according to IEC 60947-2 identified with voltage value(s) followed by the symbol  (IEC 60417-6363:2016-07-16) or by the symbol shall not be used in IT systems for such voltage(s) or above.

Devices according to IEC 60947-2 identified with the symbol  (IEC 60417-6363:2016-07-16) or by the symbol with no associated voltage value, shall not be used in IT systems.

NOTE 2 The symbol  previously required will be progressively superseded by the preferred new symbol above.

531.2.2 Overcurrent protective devices

531.2.2.1 TN system

An overcurrent protective device shall be so selected that its operating characteristics meet the following requirement:

$$I_a \leq \frac{U_o}{Z_s}$$

where

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.3.

Z_s is the impedance in ohms (Ω) of the fault loop comprising
  – the source,
  – the line conductor up to the point of the fault, and
  – the protective conductor between the point of the fault and the source;

U_o is the nominal AC or DC line-to-earth voltage in volts (V).

531.2.2.2 TT system

According to IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD 1:2017, 411.5.2, RCDs shall generally be used for protection against electric shock in TT systems.

Overcurrent protective devices may alternatively be used for this purpose, provided a suitably low value of earth fault loop impedance is permanently and reliably ensured.

Where, exceptionally, an overcurrent protective device is used for this purpose, it shall be so selected that its operating characteristics meet the following requirement.

$$I_a \leq \frac{U_o}{Z_s}$$

where

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.4;

Z_s is the impedance in ohms (Ω) of the fault loop comprising

- the source,
- the line conductor up to the point of the fault,
- the protective conductor of the exposed-conductive-parts,
- the earthing conductor,
- the earth electrode of the installation, and
- the earth electrode of the source;

U_o is the nominal AC or DC line-to-earth voltage in volts (V).

531.2.2.3 IT system

Devices shall be suitable for IT systems in accordance with the manufacturer instructions.

The overcurrent protective devices shall be so selected that their operating characteristics comply with the following requirement:

a) Where exposed-conductive-parts are interconnected by a protective conductor collectively earthed to the same earthing arrangement, the following conditions shall be fulfilled:

- where the neutral or mid-point conductor is not distributed:

$$I_a \leq \frac{U}{2Z_s}$$

- or where the neutral or mid-point conductor is distributed:

$$I_a \leq \frac{U_o}{2Z'_s}$$

where

U is the nominal AC or DC voltage in volts (V) between line conductors;

U_o is the nominal AC or DC voltage in volts (V) between line conductor and neutral or mid-point conductor, as appropriate;

Z_s is the impedance in ohms (Ω) of the fault loop comprising the line conductor and the protective conductor of the circuit;

Z'_s is the impedance in ohms (Ω) of the fault loop comprising the neutral or mid-point conductor and the protective conductor of the circuit;

I_a is the current in amperes (A) causing operation of the protective device within the time required for TN systems in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.3.

NOTE The factor 2 in both formulas takes into account that in the event of the simultaneous occurrence of two faults, the faults may exist in different circuits.

b) Where the exposed-conductive-parts are earthed in groups or individually, the following condition applies:

- In alternating current

$$I_a \leq \frac{50}{R_A}$$

where

R_A is the sum of the resistances in ohms (Ω) of the earth electrode and the protective conductor to the exposed-conductive-parts;

I_a is the current in amperes (A) causing automatic disconnection of the protective device in a time complying to that for TT systems in IEC 60364-4-41:2005 and IEC 60364-4-41: 2005/AMD1:2017, 411.3.2.2 or 411.3.2.4.

In direct current, in accordance with IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.6.2, no requirement is needed.

531.2.3 Residual current protective devices

531.2.3.1 General conditions of installation

An RCD shall disconnect all live conductors in the circuit protected, except as permitted in 531.2.3.5.1.

For a multiphase supplied installation, where there is subdivision into single phase final circuits, protection by individual RCDs is recommended. Where time delayed RCDs (CBRs (circuit breaker incorporating residual current protection), and MRCD (modular residual current device) in conjunction with circuit-breakers, according to IEC 60947-2) are used, the setting of the time delay shall be in accordance with IEC 60364-4-41:2005 and IEC 60364-4-41:2005/
AMD1:2017, 411.3.2.

Where a modular RCD is used, an MRCD according to IEC 60947-2:2016, Annex M shall be selected and used in conjunction with a circuit breaker in accordance with IEC 60947-2.

A protective conductor shall not pass through the sensor of an MRCD. However, where such passing is unavoidable, for example in case of armoured cables, the protective conductor alone shall be passed again through the sensor but in the reverse direction. The protective conductor shall be insulated and shall not be earthed between the first and the second passing.

531.2.3.2 Unwanted tripping

To reduce the risk of unwanted tripping, the following shall be considered:

- subdivision of electrical circuits with individual associated RCDs so that the accumulated protective conductor currents and/or leakage currents likely to occur during normal operation downstream of an RCD is less than 0,3 times the value of the rated residual operating current ($I_{\Delta n}$) of the RCD. See also IEC 60364-1:2005, Clause 314 and IEC 60364-5-51:2005, Clause 516,
- coordination of general type RCDs, selective type RCDs (i.e. type S according to IEC 61008-1, IEC 61009-1 or IEC 62423) and time delayed RCDs (i.e. CBRs, MRCDs according to IEC 60947-2), and
- coordination of RCDs with surge protective devices (SPDs).

531.2.3.3 Types of RCDs

531.2.3.3.1 Selection of type of RCD

The type of RCD shall be selected according to the waveform of the expected AC and DC components of the residual current to be interrupted.

531.2.3.3.2 Selection of the types of RCDs connected in series

Wherever an RCD type A, F or B is installed downstream of another RCD, the upstream RCD

- shall comply at least with the requirements of the type of the downstream RCD, or
- shall be coordinated with the downstream RCD, in accordance with the manufacturer's instructions.

NOTE See Annex G for the different types of RCDs and their behaviour with fault currents.

531.2.3.4 Selection according to the accessibility to the installation

531.2.3.4.1

In AC installations where RCDs are accessible to ordinary persons (BA1), children (BA2) or handicapped persons (BA3), residual current protective devices shall comply with

- IEC 61008-2-1 for RCCBs, or
- IEC 61009-2-1 for RCBOs, or
- IEC 62423 for RCCBs and RCBOs.

531.2.3.4.2

In AC installations where RCDs are accessible only to instructed persons (BA4) or skilled persons (BA5), residual current protective devices shall comply with

- IEC 61008 (all parts) for RCCBs, or
- IEC 61009 (all parts) for RCBOs, or
- IEC 62423 for RCCBs and RCBOs, or
- IEC 60947-2 for CBRs and MRCDs.

NOTE

RCCB is a residual current operated circuit breaker without integral overcurrent protection.

RCBO is a residual current operated circuit breaker with integral overcurrent protection.

CBR is a circuit breaker incorporating residual current protection.

MRCD is a modular residual current device, in conjunction with a circuit-breaker.

531.2.3.4.3

In DC installations, IEC TS 63053 may be used as a reference for DC-RCDs.

531.2.3.5 Selection of RCD according to the type of system earthing

531.2.3.5.1 TN systems

A PEN conductor shall not be used on the load side of an RCD.

In a TN-S system and in the part of a TN-C-S system, where the neutral and protective functions are provided by separate conductors, the neutral conductor need not be disconnected if the neutral conductor is considered to be reliably at earth potential.

In TN-C systems RCDs shall not be used.

The characteristics of the RCD, except those selected according to IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.3, shall be such that:

$$I_a \leq \frac{U_o}{Z_s}$$

where

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.3;

Z_s is the impedance in ohms (Ω) of the fault loop comprising

- the source,
- the line conductor up to the point of the fault, and
- the protective conductor between the point of the fault and the source;

U_o is the nominal AC or DC line-to-earth voltage in volts (V).

531.2.3.5.2 TT systems

In AC installations the characteristics of the RCD, except those selected according to IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.3, shall be such that:

$$I_a \leq \frac{50}{R_A}$$

where

R_A is the sum of the resistance in ohms (Ω) of the earth electrode and the protective conductor to the exposed conductive-parts;

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.4.

NOTE The disconnecting times according to IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, Table 41.1 relate to prospective residual currents significantly higher than the rated residual operating current of the RCD (typically 5 $I_{\Delta n}$).

Where the value of R_A is not known, it shall be replaced by Z_s (see 531.2.2.2).

531.2.3.5.3 IT systems

531.2.3.5.3.1 Disconnection at first fault condition for IT public distribution systems

Where the disconnection at the first fault is to be achieved by an RCD, the rated residual operating current of the RCD shall be selected to be less or equal to the current which circulates on the first fault to earth.

NOTE Where the current circulating during the first fault is not known or cannot be calculated, the current in mA can, for IT installations connected to a network, be estimated to 0,5 times the value of the rated power of the transformer given in kVA.

531.2.3.5.3.2 Disconnection at second fault condition

Where the automatic disconnection of supply at a second fault is to be achieved by an RCD, that RCD shall be installed in the final circuit to be protected. The rated residual current of the RCD shall be greater than 2 times the current which circulates on the first fault to earth of negligible impedance affecting a line conductor.

After the occurrence of a first fault, conditions for automatic disconnection of supply in the event of a second fault occurring on a different live conductor shall be as follows:

a) Where exposed-conductive-parts are interconnected by a protective conductor collectively earthed to the same earthing arrangement, the following condition shall be fulfilled:

- where the neutral or mid-point conductor is not distributed:

$$I_a \leq \frac{U}{2Z_s}$$

- or where the neutral or mid-point conductor is distributed:

$$I_a \leq \frac{U_o}{2Z'_s}$$

where

U_o is the nominal AC or DC voltage, in volts (V) between line conductor and neutral conductor or mid-point conductor, as appropriate;

U is the nominal AC or DC voltage in volts (V) between line conductors;

Z_s is the impedance in ohms (Ω) of the fault loop comprising the line conductor and the protective conductor of the circuit;

Z'_s is the impedance in ohms (Ω) of the fault loop comprising the neutral conductor and the protective conductor of the circuit;

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.4.

The times stated in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, Table 41.1 for the TN system apply to IT systems with a distributed or non-distributed neutral conductor or mid-point conductor.

NOTE 1 The factor 2 in both formulas takes into account that in the event of the simultaneous occurrence of two faults, the faults can exist in different circuits.

b) In AC installations where the exposed-conductive-parts are earthed in groups or individually, the following condition applies:

$$I_a \leq \frac{50}{R_A}$$

where

R_A is the sum of the resistances in ohms (Ω) of the earth electrode and the protective conductor to the exposed-conductive-parts;

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.4.

NOTE 2 The disconnecting times according to IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, Table 41.1 relate to prospective residual fault currents significantly higher than the rated residual operating current of the RCD (typically 5 $I_{\Delta n}$)

531.3 Equipment for protection by double or reinforced insulation

531.3.1 General

For compliance with IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD 1:2017, Clause 412, electrical equipment shall be selected as follows:

a) electrical equipment marked with the symbol  (IEC 60417-5172:2003-02-18); or

b) electrical equipment declared in the relevant product standard or by the manufacturer as equivalent to Class II; or

c) electrical equipment with basic insulation only: supplementary insulation shall be provided by an enclosure of at least IPXXB or IP2X, or by a process of installation providing the equivalent level of safety; or

d) electrical equipment having uninsulated live parts shall have reinforced insulation provided by an enclosure of at least IPXXB or IP2X, or by a process of installation providing the equivalent level of safety.

In the case of equipment covered by c) or d) above, 531.3.2 to 531.3.6 apply.

531.3.2

The following requirements apply as specified:

– the insulating enclosure shall not be traversed by conductive parts likely to transmit a potential; and

– the insulating enclosure shall not contain any screws or other fixing means of insulating material which might need to be removed, or are likely to be removed, during installation and maintenance and whose replacement by metallic screws or other fixing means could impair the enclosure's insulation.

Where the insulating enclosure has to be traversed by mechanical joints or connections (e.g. for operating handles of built-in apparatus), these should be arranged in such a way that protection against shock in case of a fault is not impaired.

531.3.3

Where lids or doors in the insulating enclosure can be opened without the use of a tool or key, all conductive parts which are accessible if the lid or door is open shall be behind an insulating barrier (providing a degree of protection not less than IPXXB or IP2X) preventing persons from coming unintentionally into contact with those conductive parts. This insulating barrier shall be removable only by use of a tool or key.

531.3.4

Conductive parts enclosed in the insulating enclosure shall not be connected to a protective conductor. However, provision may be made for connecting protective conductors which necessarily run through the enclosure in order to serve other items of electrical equipment whose supply circuit also runs through the enclosure. Inside the enclosure, any such conductors and their terminals shall be insulated as though they were live parts, and their terminals shall be marked as PE terminals.

531.3.5

Accessible-conductive-parts and intermediate parts shall not be connected to a protective conductor unless specific provision for this is made in the specifications for the equipment concerned.

531.3.6

The enclosure shall not adversely affect the operation of the equipment protected in this way.

531.3.7

The installation of equipment mentioned in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 412.2.1 (fixing, connection of conductors, etc.) shall be effected in such a way as not to impair the protection afforded in compliance with the equipment specification.

531.4 Equipment for protection by electrical separation

The equipment selected for electrical separation, for example safety isolating transformer in accordance with IEC 61558-2-6, shall provide at least simple separation between incoming and outgoing terminals and the separated side shall be installed so that it is isolated from other circuits and earth.

531.5 Equipment for protection by extra-low-voltage provided by SELV and PELV systems

531.5.1 Sources for SELV or PELV systems

The following sources may be used for SELV or PELV systems:

- A safety isolating transformer in accordance with IEC 61558-2-6.
- A source of current providing a degree of safety equivalent to that of the safety isolating transformer specified above (e.g. motor generator with windings providing equivalent isolation).
- An electrochemical source (e.g. a battery) or another source independent of a higher voltage circuit (e.g. a diesel-driven generator).
- Certain electronic devices complying with appropriate standards where provisions have been taken in order to ensure that, even in the case of an internal fault, the voltage at the outgoing terminals cannot exceed the values specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 414.1.1. Higher voltages at the outgoing terminals are, however, permitted if it is ensured that, in case of contact with a live part or in the event of a fault between a live part and an exposed-conductive-part, the voltage at the output terminals is immediately reduced to those values or less.

  NOTE 1 Examples of such devices include insulation testing equipment and monitoring devices.

  NOTE 2 Where higher voltages exist at the outgoing terminals, compliance with 531.5 can be assumed if the voltage at the outgoing terminals is within the limits specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 414.1.1 when measured with a voltmeter having an internal resistance of at least 3 000 Ω.
- Mobile sources supplied at low voltage, for example safety isolating transformers or motor generators, shall be selected or erected in accordance with the requirements for protection by the use of double or reinforced insulation (see IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, Clause 412).

531.5.2 Selection of plugs and socket-outlets

Plugs and socket-outlets in SELV or PELV systems shall comply with the following requirements:

– plugs shall not be able to enter socket-outlets of other voltage systems;

– socket-outlets shall not admit plugs of other voltage systems;

– plugs and socket-outlets in SELV systems shall not have a protective contact.

NOTE For socket-outlets according to IEC 60884-1 the protective contact is referred to as earthing contact.

531.6 Devices for additional protection

A PEN conductor shall not be used on the load side of an RCD.

In AC installations, an RCD used for additional protection shall have a rated residual operating current not exceeding 30 mA and shall be selected according to the requirements of 531.2.3.1 to 531.2.3.4.

In AC installations, when installed at the origin of a final circuit, an RCD with a rated residual current not exceeding 30 mA may ensure simultaneously fault protection and additional protection. In this case, not all final circuits supplied by a common distribution circuit shall be disconnected by this RCD.

NOTE Correct assignment of the final circuits to the common RCD will contribute to continuity of the supply (see 531.3.2).

In AC installations, an RCD for protection of socket-outlets shall be installed at the origin of the final circuit except where this additional protection is provided by RCDs integral with all the socket-outlets of the circuit or associated with all fixed socket-outlets within the same mounting box or in the immediate vicinity, see for example IEC 62640.

RCDs for protection of luminaires shall be installed at the origin of the final circuit.

In DC installations, an RCD used for additional protection shall have a rated residual operating current not exceeding 80 mA, and shall be selected according to the requirements of 531.2.3.1 to 531.2.3.4.

531.7 Monitoring devices

In IT-systems the following monitoring devices may be used to detect insulation fault conditions:

– Insulation monitoring devices (IMDs) selected and erected in accordance with 537.1.2;
– residual current monitors (RCMs) selected and erected in accordance with 537.1.3;
– equipment for insulation fault location selected and erected in accordance with 537.2.1.

532 Devices and precautions for protection against thermal effects

532.1 General

Devices shall be mounted so as to allow, under all operating conditions to be expected at the point of installation, safe dissipation of heat or arcs/sparks which could cause harmful thermal effects.

Protective devices shall be installed as close as practically possible to the origin of the circuit to be protected.

532.2 Locations with a particular risk of fire

532.2.1 General

NOTE Locations with a particular risk of fire are defined in IEC 60364-4-42.

Devices in the fixed installation or in equipment incorporated in the fixed installation and used for protection against thermal effects shall not be provided with automatic re-closure.

532.2.2 Locations with external influences BD2, BD3 or BD4

With the exception of devices to facilitate evacuation, switchgear and controlgear devices in locations with external influences BD2, BD3 or BD4 shall be accessible only to authorized persons. Where installed in passages, switchgear and controlgear devices shall be placed within enclosures complying with IEC 60670-24, IEC 61439-2, IEC 61439-3 or IEC 62208.

532.2.3 Locations with external influences BE2

532.2.3.1 General

Switchgear for protection, control or isolation shall be placed outside locations presenting external condition BE2, unless it is in an enclosure providing a degree of protection appropriate for such a location of at least:

- IP4X, or
- IP5X in the presence of dust, or
- IP6X in the presence of conductive dust.

Unless specifically designed to be inherently heat-limiting, in all operational modes, motors shall be protected against excessive temperature by a motor protective device with manual reset.

532.2.3.2 Selection of residual current protective devices (RCD)

Where an RCD for protection against thermal effects is required, the rated residual operating current shall be in compliance with IEC 60364-4-42:2010 and IEC 60364-4-42:2010/AMD1:2014, 422.3.9.

RCDs shall comply with IEC 61008 (all parts), IEC 61009 (all parts), IEC 62423 or IEC 60947-2 and shall comply with the requirements of 531.2.2.

An RCD shall ensure the disconnection of all live conductors of the circuit protected.

532.2.3.3 Selection of residual current monitoring device (RCM) in IT systems

Where an RCM is selected preventing the risk of fire in compliance with IEC 60364-4-42:2010 and IEC 60364-4-42:2010/AMD1:2014, 422.3.9 b), the rated residual warning level shall not exceed 300 mA and shall be less than or equal to the expected first fault current.

It is recommended to set the response value to a reasonable lower value to indicate a fault as early as possible.

RCMs shall comply with IEC 62020.

532.2.3.4 Selection of insulation monitoring devices (IMDs) in IT systems

Where an IMD is selected preventing the risk of fire in compliance with IEC 60364-4-42:2010 and IEC 60364-4-42:2010/AMD1:2014, 422.3.9 b), the response value shall not be lower than:

- 100 Ω/V except in a public distribution system with a galvanic supply, the value shall not be lower than 40 Ω/V; or
- 50 % of the insulation resistance without insulation failure and full load.

It is recommended to set the response value to a reasonable higher value to indicate a fault as early as possible.

IMDs shall comply with IEC 61557-8.

532.3 Selection of arc fault detection devices (AFDD)

Where an AFDD is specified for the protection against arc faults in accordance with IEC 60364-4-42:2010 and IEC 60364-4-42:2010/AMD1:2014, 421.7, the following applies:

- the AFDD shall comply with IEC 62606;

- the AFDD shall be placed at the origin of the final circuit to be protected;
- the AFDD shall be erected and coordinated in accordance with the manufacturer's instructions.

NOTE AFDDs according to IEC 62606 can include other protective capabilities, i.e. overcurrent protection and/or residual current protection.

533 Devices for protection against overcurrent

533.1 General requirements

533.1.1 General

Clause 533 provides requirements for the selection and erection of overcurrent protective devices where required by IEC 60364-4-43.

A protective device that may be operated by persons other than instructed persons (BA4) and skilled persons (BA5) shall be so selected or installed that access to its overcurrent characteristic settings, if any, is only possible with a deliberate act involving the use of a key, padlock, tool, password or similar, and resulting in a visible indication of its setting.

533.1.2 Compliance with standards

533.1.2.1 General

Devices for protection against overcurrent shall comply with at least one of the following standards:

- IEC 60269-2;
- IEC 60269-3;
- IEC 60269-4;
- IEC 60898 (all parts);
- IEC 60947-2;
- IEC 60947-3;
- IEC 60947-6-2;
- IEC 61009 (all parts);
- IEC 62423.

533.1.2.2 Applicability of devices

Circuit-breakers according to IEC 60947-2 identified with voltage value(s) followed by the symbol IT (IEC 60417-6363:2016-07-16) or by the symbol shall not be used in IT systems for such voltage(s) or above.

Circuit-breakers according to IEC 60947-2 identified with the symbol IT (IEC 60417-6363:2016-07-16) or by the symbol with no associated voltage value, shall not be used in IT systems.

IEC 62423 is only applicable for residual current operated circuit-breakers with integral overcurrent protection (RCBOs).

IEC 60947-3 is only applicable for devices in combination with fuses, i.e. switch-fuses, fuse-switch, disconnector-fuse, fuse-disconnector, switch-disconnector-fuse and fuse-switch-disconnector.

The following devices provide protection against short-circuit current only and therefore shall not be used for overload protection:

- instantaneous trip circuit-breakers (ICB) complying with IEC 60947-2:2016, Annex O;
- aM and aR type fuses complying with IEC 60269-2 or IEC 60269-3.

533.1.3 Fuses

533.1.3.1 A fuse base using screw-in fuses shall be connected so that the centre contact is connected to the conductor from the supply and the shell contact is connected to the conductor to the load.

Fuse bases shall be arranged so as to exclude the possibility of the fuse carrier making contact between conductive parts belonging to adjacent fuse bases.

Fuse bases in accordance with IEC 60269-3 shall be used together with gauge pieces preventing the use of fuse-links of higher rated current. The gauge piece is superfluous in cases where the fuse-link with the highest rated current within the fuse system is acceptable for the purpose of protection.

For protection of DC circuits or DC applications, only fuse systems (e.g. fuse-holder, fuse base) that are marked by the manufacturer as suitable for direct current shall be used.

533.1.3.2 Fuses having fuse-links intended to be removed or replaced by persons other than instructed persons (BA4) or skilled persons (BA5), shall comply with IEC 60269-3.

Fuses or combination units having fuse-links intended to be removed and replaced only by instructed persons (BA4) or skilled persons (BA5), shall be installed in such a manner that it is ensured that the fuse-links can be removed or replaced without unintentional contact with live parts. These devices shall be erected in such a manner that they are not accessible to ordinary persons.

533.2 Selection of devices for protection against overload current

533.2.1 General

Protective devices shall be selected to fulfil the following requirements:

a) the rated current or the current setting of the protective device, I_n, is greater than or equal to the design current of the circuit, I_B; and

b) the rated current or the current setting of the protective device, I_n, is less than or equal to the current-carrying capacity of the cable, I_z; and

c) the current ensuring effective operation within the conventional time of the protective device I_2, is less than or equal to the current carrying capacity of the cable, I_z, multiplied by the factor 1,45.

Compliance with a), b) and c) may not ensure protection in certain cases, for example where sustained overcurrents less than I_2 occur. In such cases, consideration should be given to selecting a cable with a larger cross-sectional area or to selecting a device having a value of I_2 equal to or less than I_z.

NOTE 1 By applying b), requirement c) is automatically fulfilled where protective devices are in compliance with IEC 60898 (all parts), IEC 60947-2, IEC 61009 (all parts) or RCBOs complying with IEC 62423.

The current I_2 ensuring effective operation of the protective device is provided by the manufacturer.

The current ensuring effective operation in the conventional time of protective devices may also be named I_r, I_t or I_f according to the product standards. Both I_t and I_f are multiples of I_n and attention should be given to the correct representation of values and indexes.

Where the copper equivalent cross-sectional area of the neutral conductor is less than that of the line conductors, overload protection for the neutral conductor shall be provided in accordance with IEC 60364-4-43. For the purposes of this requirement, the current carrying capacity for the neutral conductor shall be ascertained, for example by obtaining it from the manufacturer.

NOTE 2 The current-carrying capacity of the neutral conductor can be considered to be that of a circuit with conductors having the same cross-sectional area, construction and installation conditions (e.g. ambient temperature and grouping) as the neutral conductor, determined in accordance with IEC 60364-5-52:2009, Clause 523.

533.2.2 Presence of harmonic currents

Overload protective devices shall be selected in order to operate correctly in the presence of harmonic currents.

533.2.3 Unequal current sharing between parallel conductors

Where the currents in parallel conductors are unequal, each conductor shall be individually protected by an overload protective device according to 533.2.1.

533.3 Selection of devices for protection against short-circuit current

533.3.1 Thermal stresses

533.3.1.1 Cables and insulated conductors

In order to comply with the requirements of IEC 60364-4-43:2008, 434.5, for all currents caused by a short-circuit occurring at any point of the circuit, the operating times of the protective devices shall be equal to or lower than that which brings the insulation of the conductors to the highest permissible temperature, calculated using the formula:

$$t \leq (k \cdot S/I)^2$$

where

t is the operating time, in s, of the protective device;

I is the effective short-circuit current, in A, expressed as an RMS value;

S is the cross-sectional area of the conductor, in mm^2;

k is a factor taking account of the resistivity, temperature coefficient and heat capacity of the conductor material, and the appropriate initial and final temperatures.

NOTE 1 Refer to IEC 60364-4-43 for the description and values of the factor k used in the above formula.

For operating times of protective devices < 0,1 s (e.g. current-limiting devices) the application of the above requirement is achieved where the let-through energy (I^2t) of the protective device is less than or equal to the maximum withstand energy of the conductor (k^2S^2).

$$I^2t \leq k^2S^2$$

NOTE 2 The let-through energy of the protective device is given by the manufacturer.

533.3.1.2 Busbar trunking systems and powertracks

In order to comply with the requirements of IEC 60364-4-43:2008, 434.5.3, where busbar trunking systems complying with IEC 61439-6 or powertrack complying with IEC 61534 (all

parts) are used, the short-circuit protective device shall be selected according to one of the following conditions:

- the maximum operating time of the protective device shall not exceed the maximum time for which the I_{CW} (rated short-time withstand current) is defined for such busbar trunking or powertrack system, or
- the rated conditional short-circuit current, I_{CC}, of the busbar trunking or powertrack system associated with a protective device, selected according to the manufacturer of the busbar trunking or the powertrack system, is equal to or higher than the prospective short-circuit current at the point of installation.

533.3.2 Breaking capacity

The short-circuit breaking capacity (I_{CU} or I_{cn}) of the protective device shall be equal to or higher than the maximum prospective short-circuit current at the point where it is installed. However, a lower short-circuit capacity may be selected where permitted by IEC 60364-4-43:2008, 434.5.1.

In certain circumstances (e.g. where the protective device is intended to be fit for service after breaking a short-circuit current) it may be desirable to select the protective device on the service short-circuit breaking capacity (I_{CS}).

NOTE Breaking capacities are defined as follows:

in IEC 60947-2:

– service short-circuit breaking capacity (I_{CS}): a breaking capacity for which the conditions according to a specified test sequence include the capability of the circuit-breaker to carry its rated current continuously;

– ultimate short-circuit breaking capacity (I_{CU}): a breaking capacity for which the conditions according to a specified test sequence do not include the capability of the circuit-breaker to carry its rated current continuously.

in IEC 60898-1 and IEC 61009-1:

– service short-circuit breaking capacity (I_{cs}): the breaking capacity for which the conditions according to a specified test sequence include the capability of the circuit-breaker to carry 0,85 times its non-tripping current for the conventional time;

– rated short-circuit capacity (I_{cn}): the breaking capacity for which the conditions according to a specified test sequence do not include the capability of the circuit-breaker to carry 0,85 times its non-tripping current for the conventional time.

533.4 Positioning of overcurrent protection devices

533.4.1 General

Devices required by IEC 60364-4-43 for overload and/or short-circuit protection shall be installed at the origin of each circuit, unless the exceptions of 533.4.2 and/or 533.4.3 are applied, see Annex A.

533.4.2 Positioning of devices for overload protection

533.4.2.1 A device for protection against overload shall be placed at each point where there is a reduction in the value of current-carrying capacity of the conductors except where IEC 60364-4-43:2008, 533.4.2.2, 533.4.2.3, 533.4.2.4 or 433.3 apply.

The requirements in 533.4.2.2 to 533.4.2.4 shall not be applied to installations situated in locations presenting a fire risk or risk of explosion.

NOTE A reduction in the current-carrying capacity of the conductors could be due to a change in, for example:

- conductor cross-sectional area,
- conductor material,
- conductor insulation material,
- method of installation,

- external influences,
- grouping of conductors.

533.4.2.2 The device protecting the conductor against overload may be connected within the run of that conductor if:

a) the part of the run between the point where a reduction in the value of current-carrying capacity occurs (see note in 533.4.2.1) and the position of the protective device has neither a branch circuit nor a socket-outlet, and

b) it fulfils at least one of the following two conditions:

1) it is protected against short-circuit current in accordance with the requirements stated in IEC 60364-4-43:2008, Clause 434;

2) its length does not exceed 3 m, it is carried out in such a manner as to reduce the risk of short-circuit to a minimum, and it is installed in such a manner as to reduce to a minimum the risk of fire or danger to persons (see also 533.4.3.2).

NOTE For installations according to 1), see Figure A.1. For installation according to 2) see Figure A.2.

533.4.2.3 Devices for protection against overload need not be provided:

a) for a conductor situated on the load side of a reduction in the value of current-carrying capacity of the conductors, that is effectively protected against overload by a protective device placed on the supply side; or

b) at the origin of an installation where the distributor provides an overload device and agrees that it affords protection to the part of the installation between the origin and the main distribution point of the installation where further overload protection is provided.

533.4.2.4 In IT systems without a neutral conductor, the overload protective device may be omitted in one of the line conductors if a residual current protective device is installed in each circuit.

533.4.3 Positioning of devices for short-circuit protection

533.4.3.1 A device for protection against short-circuit shall be placed at the point where there is a reduction of the let through energy withstand capability (k^2S^2) of the conductor, except where IEC 60364-4-43:2008, 533.4.3.2, 533.4.3.3 or 434.3 applies.

NOTE The let through energy withstand capability (k^2S^2) of the conductor is determined in accordance with IEC 60364-4-43:2008, 434.5.

The requirements in 533.4.3.2 and 533.4.3.3 shall not be applied to installations situated in locations presenting a fire risk or risk of explosion.

533.4.3.2 Where permitted by IEC 60364-4-43:2008, 434.2.1, the device for protection against short-circuit may be placed other than as specified in 533.4.3, provided

a) the part of the run between the point where there is a reduction of the let through energy withstand capability (k^2S^2) and the position of the protective device has neither a branch circuit nor a socket-outlet, and

b) that part of the conductor

1) does not exceed 3 m in length, and

2) is installed in such a manner as to reduce the risk of a short-circuit to a minimum, and

NOTE 1 This condition can be obtained for example by reinforcing the protection of the wiring against external influences.

NOTE 2 See Figure B.1.

3) is not placed close to combustible material.

533.4.3.3 A protective device may be placed on the supply side of the point where there is a reduction of the let through energy withstand capability (k^2S^2), provided that it possesses an operating characteristic such that it protects the wiring situated on the load side of that point against short-circuit, in accordance with IEC 60364-4-43:2008, 434.5.2.

NOTE The requirements of 533.4.3.3 can be met by the method given in Annex B.

533.4.3.4 Devices for protection against short-circuit need not be provided at the origin of an installation where the distributor installs one or more devices providing protection against short-circuit and agrees that such a device affords protection to the part of the installation between the origin and the main distribution point of the installation where further short-circuit protection is provided.

533.5 Co-ordination of overload and short-circuit protective functions

533.5.1 Protective functions provided by one device

A protective device providing protection against overload and short-circuit currents shall fulfil the applicable requirements of 533.1 to 533.4.

533.5.2 Protective functions provided by separate devices

The requirements of 533.1 to 533.4 apply, respectively, to overload protective devices and short-circuit protective devices. In addition, those devices shall be coordinated according to manufacturer's instructions, if any, regarding the suitability of devices to be used in combination with each other.

534 Devices for protection against transient overvoltages

534.1 General

This clause contains provisions for the application of voltage limitation to obtain an insulation coordination in the cases described in IEC 60364-4-44, IEC 60664-1, IEC 62305-1, IEC 62305-4 and IEC 61643-12. See also Annex C.

This clause focuses mainly on the requirements for the selection and erection of SPDs for protection against transient overvoltages where required by Clause 443 of IEC 60364-4-44:2007, the IEC 62305 series, or as otherwise specified.

This *clause* does *not take* into account:

– surge protective components which may be incorporated in the appliances connected to the installation;

– portable SPDs.

NOTE Further information can be found in IEC 61643-12.

~~This clause applies to AC power circuits. As far as it is applicable, the requirements of this clause may be followed for DC power circuits.~~

Annex H provides additional information for the application of DC SPDs.

534.2 Void

534.3 Void

534.4 Selection and erection of SPDs

534.4.1 SPD location and SPD test class

SPDs shall at least be installed as close as possible to the origin of the installation. For protection against effects of lightning and against switching overvoltages, class II tested SPDs shall be used.

Where the structure is equipped with an external lightning protection system or protection against effects of direct lightning is otherwise specified, class I tested SPDs shall be used.

Where the structure is not equipped with an external lightning protection system and where the occurrence of direct lightning strike to the overhead lines between the last pole and the entrance of the installation is to be taken into consideration, class I tested SPDs at or near the origin of the electrical installation may be also selected according to Annex D.

NOTE 1 The origin of the installation could be the location where the supply enters the building or the main distribution board.

NOTE 2 Following the product standard, the marking of the product is as follows:

– for test class I: "test class I" and/or "T1" (T1 in a square);

– for test class II: "test class II" and/or "T2" (T2 in a square);

– for test class III: "test class III" and/or "T3" (T3 in a square).

Additional class II tested or class III tested SPDs may be needed to sufficiently protect the installation according to 534.4.4.2 and shall be located downstream in the fixed electrical installation, for example in the sub-distribution boards or at the socket outlets. These SPDs shall not be used without SPDs being installed at the origin of the installation and shall be coordinated with SPDs located upstream (see 534.4.4.5).

If a class I tested SPD is not able to provide protection according to 534.4.4.2, it shall be accompanied by a coordinated class II tested or class III tested SPD to ensure the required voltage protection level.

Additional class II tested SPDs or class III tested SPDs may be needed close to sensitive equipment to sufficiently protect the equipment according to ~~Table 1~~ IEC 60364-4-44:2024, Table 3 and ~~shall~~ be coordinated with SPDs located upstream.

NOTE 3 Such additional SPDs may be part of the fixed electrical installation or may be portable SPDs.

Additional SPDs may be necessary to provide transient overvoltage protection regarding threats coming from other sources such as:

– switching overvoltages produced by current using equipment located within the installation;

– overvoltages on other incoming services such as telephone lines, internet connections;

– overvoltages on other services feeding other structures such as secondary buildings, external installations/lighting, power lines feeding external sensors;

in which case one should consider installing SPDs located as close as possible to the origin of such threats. More information may be found in IEC 61643-12.

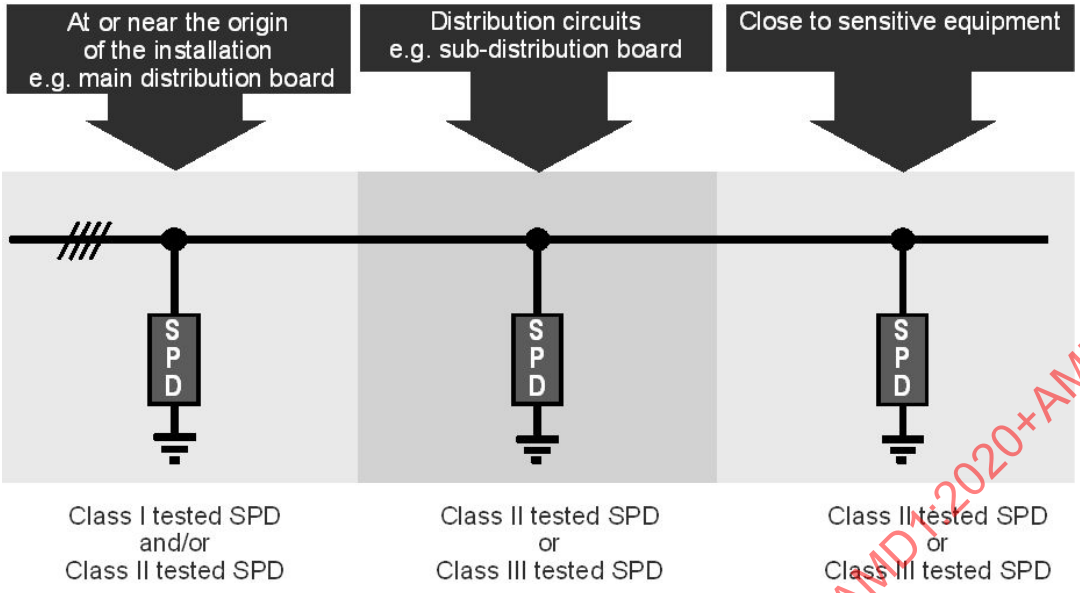


Figure 1 – Example of installation of class I, class II and class III tested SPDs

The presence of SPDs installed downstream of a distribution board (e.g. in a socket-outlet) shall be permanently indicated (e.g. by a label) in this distribution board.

534.4.2 Transient overvoltage protection requirements

Protection against transient overvoltages may be provided:

– between live conductors and PE (common mode protection);

– between live conductors (differential mode protection).

NOTE 1 Connection type CT1 provides primarily common mode protection. If differential mode protection is also necessary, this will in most cases require additional SPDs between live conductors.

NOTE 2 Connection type CT2 provides a combination of common mode protection and differential mode protection.

Protection between live conductors and PE (including neutral to PE if there is a neutral conductor) is compulsory.

Protection between line conductors and neutral (if there is a neutral conductor) is recommended to ensure equipment protection.

Protection between line conductors (in the case of multiple phases) is optional.

Some equipment may require both common mode protection (for impulse withstand) and differential mode protection (for impulse immunity).

NOTE 3 For example, electronic class I equipment or class II equipment with FE-connection requires common mode as well as differential mode protection to ensure overall protection against transient overvoltages due to switching or from atmospheric origin.

534.4.3 Connection types

Connection type CT1 (e.g. 3+0 or 4+0-configuration): SPD assembly providing a mode of protection between each live conductor (line and neutral conductors, if available) and PE or between each line conductor and PEN.

Two examples of connection type CT1 for application in a three-phase system are represented in Figure 2 and in Figure 3.

Connection type CT2 (e.g. 3+1-configuration): SPD assembly providing a mode of protection between each line conductor and the neutral conductor, and between the neutral conductor and PE.

An example of connection type CT2 for application in a three-phase system is represented in Figure 4.

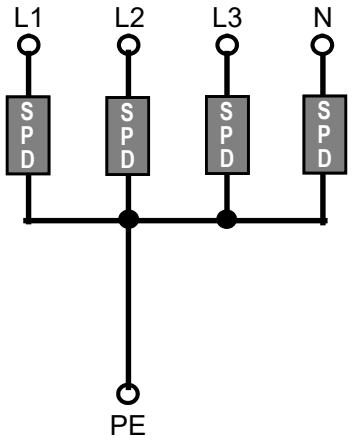


Figure 2 – Connection type CT1 (4+0-configuration) for a three-phase system with neutral

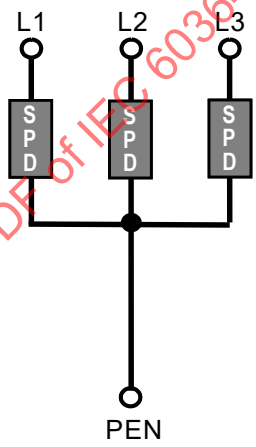


Figure 3 – Connection type CT1 (3+0-configuration) for a three-phase system

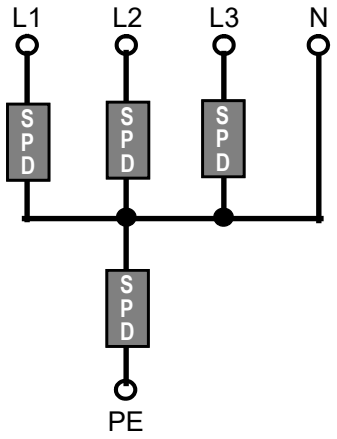


Figure 4 – Connection type CT2 (e.g. 3+1-configuration) for a three-phase system with neutral

When assembling SPDs, attention should be drawn to the selection of parameters for SPDs connected between N and PE, depending on the connection type.

In TN-S or TN-C-S systems, the SPD between neutral and PE may be omitted if the distance between the separation point of PE to N and the location of the installed SPDs is less than 0,5 m or if the separation point and the SPDs are located in the same distribution board.

If a line conductor is earthed, it is considered to be technically equivalent to a neutral conductor for the application of this subclause. However correct choice of the SPD parameters requires special considerations in such case.

534.4.4 Selection of SPDs

534.4.4.1 General

The selection of SPDs shall be based on the following parameters:

– voltage protection level (U_p) and rated impulse voltage (U_W) of equipment to be protected (see 534.4.4.2);
– continuous operating voltage (U_c), i.e. supply system (TT, TN, IT) (see 534.4.4.3);
– nominal discharge current (I_n) and impulse discharge current (I_{imp}) (see 534.4.4.4);
– SPD coordination (see 534.4.4.5);
– expected short-circuit current (see 534.4.4.6);
– follow current interrupting rating (see 534.4.4.7).

SPDs for use in AC circuits shall comply with the requirements of IEC 61643-11.

NOTE 1 Additional information regarding selection and application is given in IEC 61643-12.

NOTE 2 IEC 61643-41 Low-voltage surge protective devices – Part 41: Surge protective devices connected to DC low-voltage power systems – Requirements and test methods, is under development.

534.4.4.2 Selection of voltage protection level (U_p) as a function of equipment rated impulse voltage (U_W)

~~The voltage protection level U_p of SPDs shall be selected in accordance with required rated impulse voltage according to overvoltage category II of Table 1. In order to provide adequate protection of equipment, the voltage protection level between live conductors and PE shall in no case exceed the required rated impulse voltage of the equipment according to Table 1.~~

~~NOTE 1 Where only overvoltage category III or IV equipment is to be protected, reference is made to the required rated impulse voltage of Table 443.2.~~

The voltage protection level U_p of SPDs between live conductors and protective earthing conductors shall be selected in accordance with the required rated impulse voltage of the equipment and not exceed the value specified for overvoltage category II in accordance with IEC 60364-4-44:2024, Table 4.

Where protection between line conductors and PE is provided by a series connection of SPD protection modes (e.g. single mode SPDs, line-to-neutral + neutral-to-PE, according CT2), this series connection shall fulfill the above voltage protection level requirement.

Where such combined voltage protection level between line conductor and PE is not provided in the data sheet of the manufacturer, it shall be calculated by addition of the voltage protection levels given for the individual SPDs modes of protection, which are connected in series.

~~It is recommended that the voltage protection level provided by SPDs does not exceed 80 % of the required rated impulse voltage for equipment according to Table 1 and corresponding to overvoltage category II, but shall in no case exceed the required rated impulse voltage of the equipment.~~

The voltage protection level provided by SPDs should not exceed 80 % of the required rated impulse voltage of the equipment and the value specified for overvoltage category II in accordance with IEC 60364-4-44:2024, Table 4.

This safety margin is not necessary where one of the following cases applies:

– where the equipment is connected directly to the SPD terminals;
– where a protection scheme according Figure 9 is already applied;
– where the voltage drop across the overcurrent protection in the SPD branch circuit is already taken into account for the voltage protection level U_p;
– where protection according to overvoltage category II is provided but only overvoltage category III or IV equipment is installed at this location.

NOTE ~~2~~ IEC 61643-12 gives additional information about the rated impulse voltage of equipment and the given U_p for the SPD.

Table 1 – Required rated impulse voltage of equipment

Nominal voltage of the supply system[a] Three-phase systems	Nominal voltage of the supply system[a] Single-phase systems	Voltage line to neutral from nominal AC or DC voltages up to and including	Required rated impulse voltage[c] (U_W) of equipment for	
			Overvoltage category II (equipment with normal rated impulse voltage)	Overvoltage category I (equipment with reduced rated impulse voltage)
V	V	V	kV	kV
		50	0,5	0,33
		100	0,8	0,5
	120/240	150	1,5	0,8
230/400 277/480		300	2,5	1,5
400/690		600	4	2,5
1 000		1 000	6	4
		1 500 DC	8[b]	6[b]

[a] According to IEC 60038.

[b] Recommended values based on Annex D of IEC 60664-2-1:2011.

[c] The rated impulse voltage applies between live conductor and PE.

Additional SPDs between live conductors may be needed to avoid equipment malfunctions. An appropriate voltage protection level needs to be evaluated based on equipment immunity and availability requirements (see IEC 61643-12).

Where the required voltage protection level cannot be met with a single SPD assembly, additional coordinated SPDs shall be applied to ensure the required voltage protection level.

534.4.4.3 Selection of SPDs with regard to continuous operating voltage (U_c)

In AC, the maximum continuous operating voltage U_c of SPDs shall be equal to or higher than required in Table 2.

Table 2 – U_c of the SPD dependent on supply system configuration

SPD connected between (as applicable)	System configuration of distribution network		
	TN system	TT system	IT system
Line conductor and neutral conductor	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)
Line conductor and PE conductor	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)	1,1 × U
Line conductor and PEN conductor	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)	N/A	N/A
Neutral conductor and PE conductor	$\frac{U}{\sqrt{3}}$ [a]	$\frac{U}{\sqrt{3}}$ [a]	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)
Line conductors	1,1 × U	1,1 × U	1,1 × U

NOTE 1 N/A: not applicable.

NOTE 2 U is the line-to-line voltage of the low-voltage system.

[a] These values are related to worst-case fault conditions, therefore the tolerance of 10 % is not taken into account.

534.4.4.4 Selection of SPDs with regard to nominal discharge current (I_n) and impulse discharge current (I_{imp})

At or near the origin of the installation, SPDs shall comply with one of the following cases, as applicable:

– where the building is protected against direct lightning strike, SPDs at the origin of the installation shall be selected according to 534.4.4.4.2 and Table 4;

– in other cases, SPDs shall be selected according to 534.4.4.4.1.

Further SPDs installed downstream of the SPDs at or near the origin of the installation shall also comply with the coordination requirements in 534.4.4.5.

Overvoltages due to switching can be longer in duration and can contain more energy than the transient overvoltages of atmospheric origin. This has to be considered for the selection of SPDs with regard to nominal discharge current and impulse discharge current.

534.4.4.4.1 Class II tested SPDs

Where class II tested SPD are required at or near the origin of installation, their nominal discharge current shall be not less than that given in Table 3.

Table 3 – Nominal discharge current (I_n) in kA depending on supply system and connection type

Connection	Supply system			
	Single-phase		Three-phase	
	CT1	CT2	CT1	CT2
L – N		5		5
L – PE	5		5	
N – PE	5	10	5	20

534.4.4.4.2 Class I tested SPDs

Where class I tested SPDs are required at or near the origin of the installation, one of the following cases applies:

a) Where no risk analysis according to IEC 62305-2 has been carried out, the impulse discharge current (I_{imp}) shall be not less than as given in Table 4:

Table 4 – Selection of impulse discharge current (I_{imp}) where the building is protected against direct lightning strike

Connection	I_{imp} in kA			
	Supply system			
	Single phase		Three phase	
	CT1	CT2	CT1	CT2
L – N		12,5		12,5
L – PE	12,5		12,5	
N – PE	12,5	25	12,5	50
NOTE This table refers to lightning protection levels (LPL) III and IV.				

b) Where the risk analysis according to IEC 62305-2 has been carried out, the impulse discharge current (I_{imp}) shall be determined according to the IEC 62305 series.

534.4.4.5 Coordination of two or several SPDs

Coordination of SPDs in the installation needs to be ensured. The manufacturer's instructions on how to achieve coordination between SPDs shall be followed with reference IEC 61643-12.

534.4.4.6 Selection of SPDs with regard to the short-circuit current rating I_{SCCR}

In general, the short-circuit current rating I_{SCCR} of the SPD, as stated by the manufacturer, shall be not lower than the maximum prospective short-circuit current at the connection points of the SPD assembly. See Figure 5.

This requirement does not apply to SPDs connected between neutral conductor and PE in TN or TT systems, for which this is already covered by the product standard IEC 61643-11.

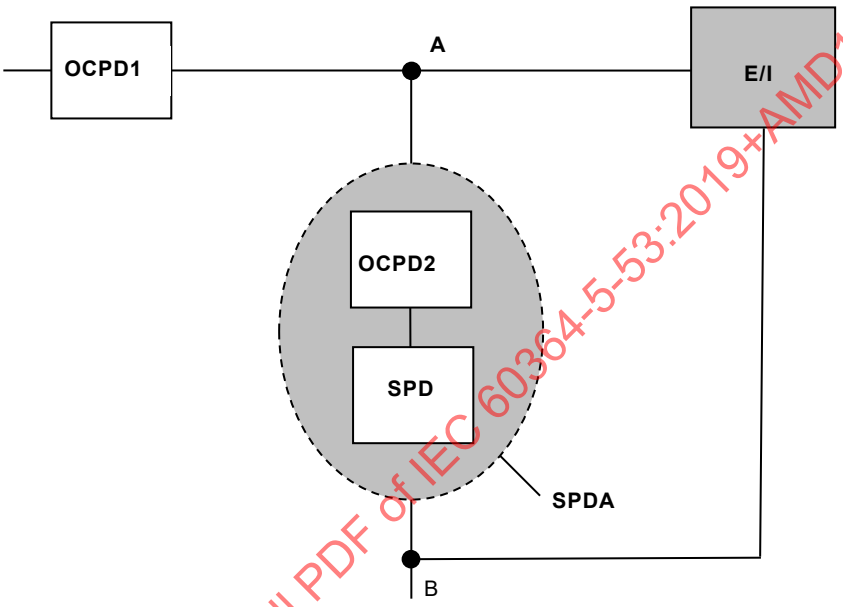
For SPDs connected between the neutral conductor and PE in IT systems, the short-circuit current rating I_{SCCR} of the SPD shall not be lower than the maximum prospective short-circuit current at the connection points of this SPD in case of a double earth fault under worst case conditions.

534.4.4.7 Selection of SPDs with regard to the follow current interrupting rating

In general, the follow current interrupting rating I_{fi} of the SPD, if declared by the manufacturer, shall not be lower than the maximum prospective short-circuit current at the connection points of the SPD assembly. See Figure 5.

This requirement does not apply to SPDs connected between neutral conductor and PE conductor in TN or TT systems, for which this is already covered by the product standard IEC 61643-11.

For SPDs connected between the neutral conductor and PE in IT systems, the follow current interrupting rating I_{fi} of the SPD if declared by the manufacturer shall not be lower than the maximum prospective short-circuit current at the connection points of this SPD in case of a double earth fault under worst case conditions.



Key

OCPD1	overcurrent protective device in the installation
OCPD2	overcurrent protective device (SPD disconnector) required by the SPD manufacturer
SPD	surge protective device
SPDA	SPD assembly
A & B	connection points of SPD assembly
E/I	equipment or installation to be protected

Figure 5 – Connection points of an SPD assembly

534.4.5 Protection of the SPD against overcurrent

534.4.5.1 General

SPD installations shall be protected against overcurrent with respect to short-circuit currents. This protection may be internal and/or external to the SPD according to the manufacturer's instructions.

The ratings and characteristics of external overcurrent protective device(s) (OCPD) for protecting the SPD assembly shall be selected:

– according to Clause 434; and

– as high as possible, to ensure a high surge current capability for the complete assembly

but not exceeding the ratings and characteristics as required in the SPD manufacturer's installation instructions for the maximum overcurrent protection.

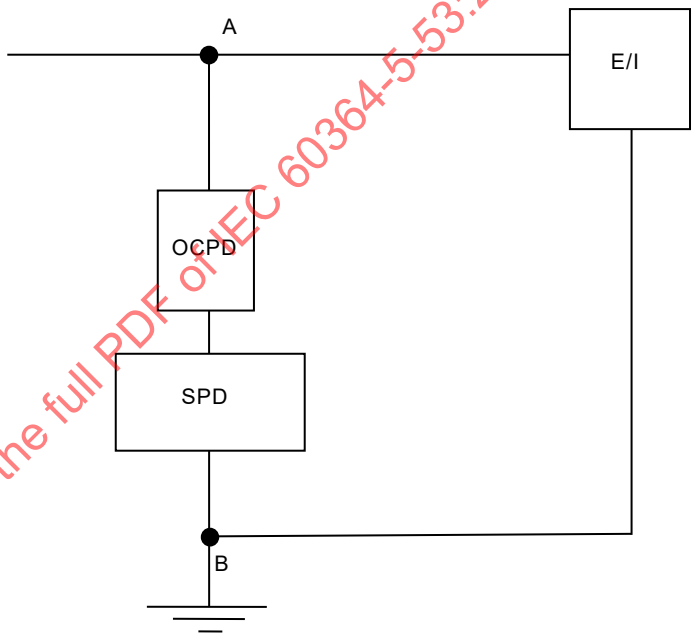
534.4.5.2 Arrangement of SPDs with relation to overcurrent protection

The location of overcurrent protective devices used to protect the SPDs may have an influence on the continuity of supply of the installation and the effective voltage protection level within the installation.

NOTE 1 National committees may decide which of the following arrangement is to be preferred, depending on the type of installation.

a) If the overcurrent protective device for the SPD is located in the SPD branch circuit, the continuity of the supply is unaffected in case of SPD failure, but neither the installation nor the equipment is protected against possible further overvoltages (see Figure 6) after tripping of such protective devices. In such an arrangement, the effective voltage protection level within the installation is increased due to the voltage drop at the external overcurrent protective device connected in series with the SPD.

NOTE 2 If the protection against overcurrent is internal to the SPD the voltage drop of the overcurrent protective device is already included in the SPD's voltage protection level U_p.



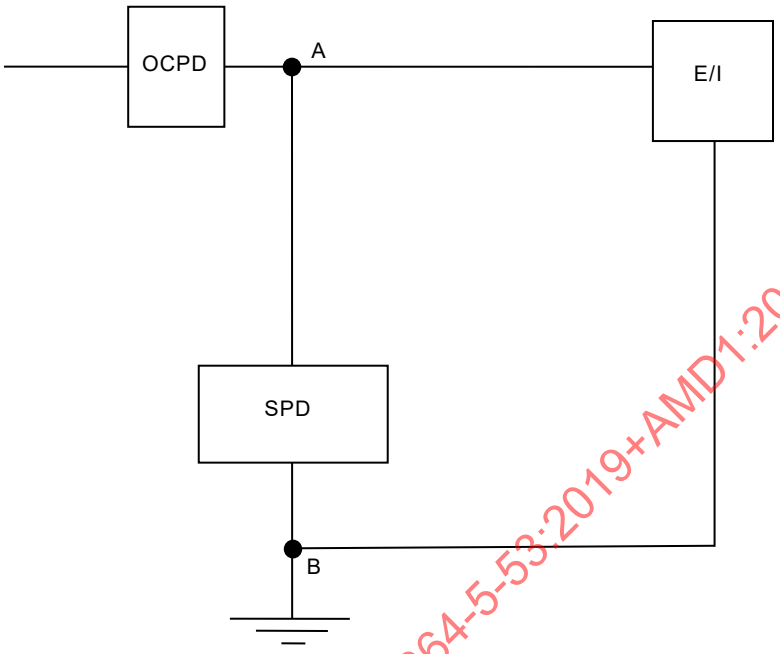
Key

OCPD	overcurrent protective device (SPD disconnector) required by the SPD manufacturer
SPD	surge protective device
A and B	connection points of SPD assembly
E/I	equipment or installation to be protected

Figure 6 – Example of overcurrent protection in the SPD branch by using a dedicated external overcurrent protective device

b) If the overcurrent protective device for the SPD is installed upstream of the SPD branch circuit, continuity of the supply is not likely to be provided in the event of SPD failure (see Figure 7). Nevertheless, in such an arrangement, the effective voltage protection level within the installation is kept to a minimum.

However, protection according to Figure 6 shall also be applied whenever the rating of the upstream overcurrent protective device (OCPD) is higher than the maximum overcurrent protection recommended by the SPD manufacturer.



Key

OCPD	overcurrent protective device of the installation used to protect the SPD
SPD	surge protective device
A and B	connection points of SPD assembly
E/I	equipment or installation to be protected

Figure 7 – Protective device, which is a part of the installation, also used to protect the SPD

534.4.5.3 Selectivity between overcurrent protective devices

Where required, the need for selectivity between overcurrent protective devices shall be considered according to the installation conditions at the point of installation of the SPD and the information provided by the manufacturer (see Clause 535 of IEC 60364-5-53:2002).

534.4.5.4 Surge current withstand capability of upstream devices

For most installation devices (e.g. meters, terminals, protective devices, switches, etc.) which are installed upstream of the SPD, there is no dedicated surge current withstand capability required by the relevant product standards.

The installation of SPDs as close as possible to the origin of the installation, according to 534.4.1, reduces surge currents flowing through downstream installation devices.

For further information, see IEC 61643-12 as well as the manufacturer's information.

534.4.6 Fault protection

Fault protection, as defined in IEC 60364-4-41, shall remain effective in the protected installation even in the event of SPD failures.

In case of automatic disconnection of supply:

– in TN systems, this may generally be fulfilled by the overcurrent device on the supply side of the SPD;

– in TT systems, this may be fulfilled by:

  a) the installation of SPDs downstream of an RCD; or

  b) the installation of SPDs upstream of the main RCD. Because of the possibility of a failure of an SPD connected between neutral conductor and PE, the conditions of 411.4.1 of IEC 60364-4-41:2005 shall be met and the SPDs shall be installed in accordance with connection type CT2.

– in IT systems, no additional measure is needed.

Surge protective devices at or near the origin of installation shall be connected according to Table 5.

Table 5 – Connection of the SPD dependent on supply system

Supply system at the connection point of the SPD assembly	Connection type	
	CT1	CT2
TN system	X	X
TT system	SPD only downstream of RCD	X
IT system with neutral	X	X
IT system without neutral	X	N/A
NOTE 1 X = applicable. NOTE 2 N/A = not applicable.		

NOTE Additional requirements might apply for SPDs installed in the area of influence of applications such as railway systems, HV power systems, mobile units, etc.

534.4.7 SPDs installation in conjunction with RCDs

If SPDs are installed in accordance with 534.4.1 and are located on the load side of a residual current device, RCD(s) may be with or without a time delay but shall have an immunity to surge currents of at least 3 kA 8/20.

NOTE 1 S-type RCDs in accordance with IEC 61008-1 and IEC 61009-1 satisfy this requirement.

NOTE 2 In the case of surge current higher than 3 kA 8/20, the RCD may trip causing interruption of the power supply.

NOTE 3 This may not be applicable for RCDs installed upstream of additional SPDs provided to protect sensitive equipment.

Installation of class I tested SPDs downstream of an RCD is not recommended.

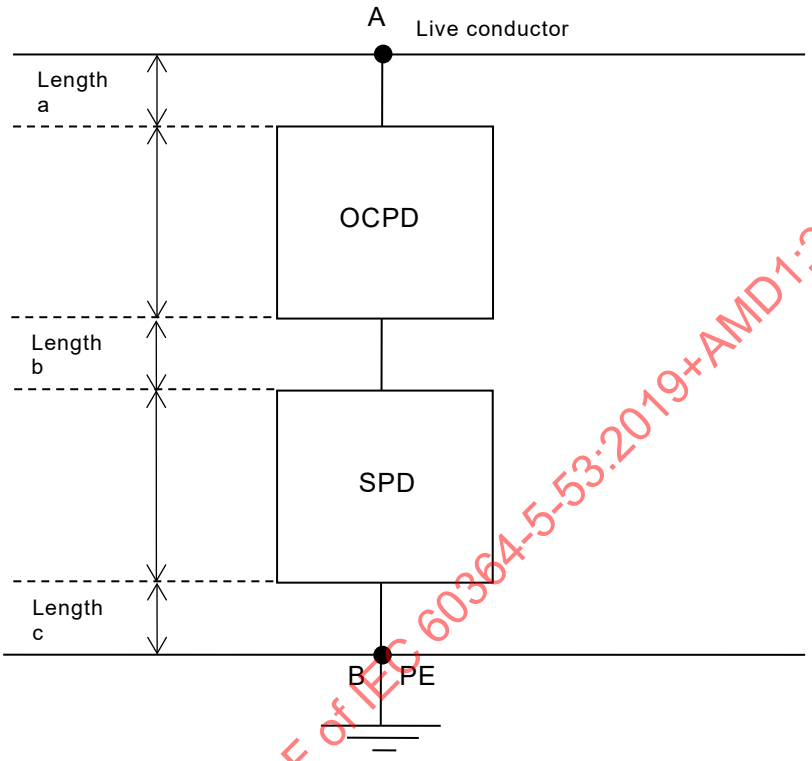
534.4.8 Connections of the SPD

The effective voltage protection level within the installation depends significantly on the connection and the wiring length and arrangement of the SPD itself and the required SPD disconnectors.

All conductors and interconnections to the relevant line to be protected as well the connections between the SPD and any external SPD disconnector shall be kept as short and as straight as possible and any unnecessary cable loop shall be avoided.

The length of the connecting conductors is defined by the sum of the path length of conductors used from the live conductor to the PE in between connection points A and B as defined in Figure 8.

Consideration shall be given to limit the total wiring length of conductors between connection points of the SPD assembly (see Figure 8 below) to a value not greater than 0,5 m.



Key

OCPD	overcurrent protective device
SPD	surge protective device
PE conductor	protective earthing conductor
A and B	connection points of SPD assembly

NOTE When OCPD is not present, length b is equal to 0.

Figure 8 – Connection of the SPD

To meet these requirements, the main protective conductor shall be connected to the earthing terminal located as near as possible to the SPD by adding, if necessary, an intermediate earthing terminal (see diagrams in Figure 9).

To determine the total length of the connecting conductors according to Figure 9, the following cable lengths:

– from the main earthing terminal to the intermediate earthing terminal;

– from the intermediate earthing terminal to the PE-conductor;

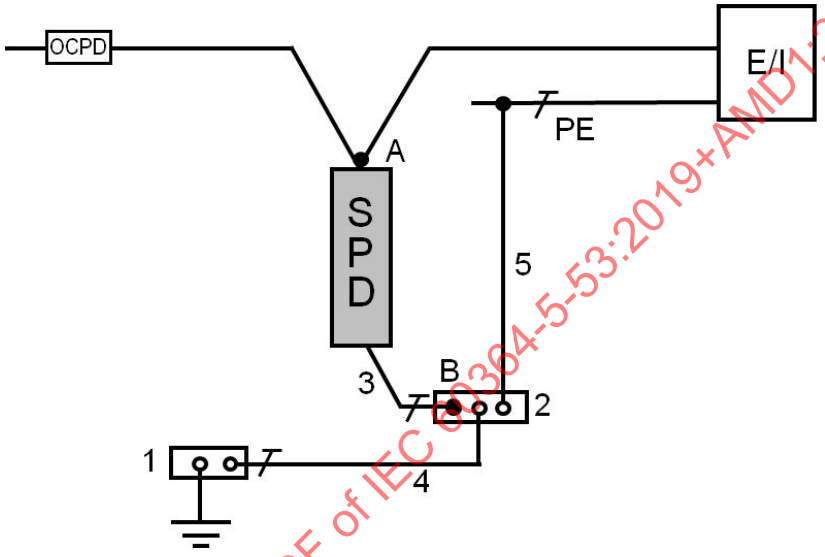
shall not be taken into account.

The length (and therefore inductance) of the cables between the SPDs and the main earthing terminal shall be kept to a minimum. SPDs may be connected to the main earthing terminal or to the protective conductor via metallic parts, e.g. the metallic enclosures of the assembly (see 543.4.2), provided it is connected to PE and meets the requirements for a protective

conductor in accordance with IEC 60364-5-54. Connection of the relevant SPD(s) to the main earthing terminal, and in addition to the main protective conductor, may improve the voltage protection level.

If the total wiring length (a + b + c) as defined in Figure 8 exceeds 0,5 m, at least one of the following options shall be chosen:

- select an SPD with a lower voltage protection level U_p (a 1 m length of rectilinear cable carrying a discharge current of 10 kA (8/20) adds a voltage drop of about 1 000 V);
- install a second coordinated SPD close to the equipment to be protected so as to adapt the voltage protection level U_p to the rated impulse voltage of the equipment to be protected;
- use the installation described in Figure 9.



Key

OCPD	overcurrent protective device
SPD	surge protective device
PE	protective earthing
E/I	equipment/installation
1	main earthing terminal
2	intermediate earthing terminal
3	length c (to be considered)
4	cable lengths need not be considered
5	cable lengths need not be considered
A and B	connection points of the SPD assembly

Figure 9 – Example of installation of an SPD in order to decrease lead length of SPD supply conductors

534.4.9 Effective protective distance of SPDs

Where the distance between the SPD and the equipment to be protected is greater than 10 m, additional protective measures should be provided such as:

– an additional SPD installed as close as possible to the equipment to be protected; its voltage protection level U_P shall in no case exceed the required rated impulse voltage U_W of the equipment; or

– the use of one-port SPDs at or near the origin of the installation; their voltage protection level U_P shall in no case exceed 50 % of the required rated impulse voltage U_W of the

equipment to be protected; This measure should be implemented together with other measures such as the use of shielded wiring in the whole protected circuit(s); or

– the use of two-port SPDs at or near the origin of the installation; their voltage protection level U_P shall in no case exceed the required rated impulse voltage U_W of the equipment to be protected. This measure should be implemented together with other measures such as the use of shielded wiring in the whole protected circuit(s).

534.4.10 Connecting conductors of SPDs

Conductors between the SPD and the main earthing terminal or the protective conductor shall have a cross-sectional area not less than:

– 6 mm^2 copper or equivalent for class II tested SPDs installed at or near the origin of the installation;

– 16 mm^2 copper or equivalent for class I tested SPDs installed at or near the origin of the installation.

Referring to 433.3.1 b) of IEC 60364-4-43:2008, conductors connecting SPDs and the overcurrent protective devices to live conductors shall be rated to withstand the prospective short-circuit current to be expected and shall have a cross-sectional area not less than:

– 2,5 mm^2 copper or equivalent for class II tested SPDs installed at or near the origin of the installation;

– 6 mm^2 copper or equivalent for class I tested SPDs installed at or near the origin of the installation.

535 Co-ordination of protective devices

535.1 Selectivity between overcurrent protective devices

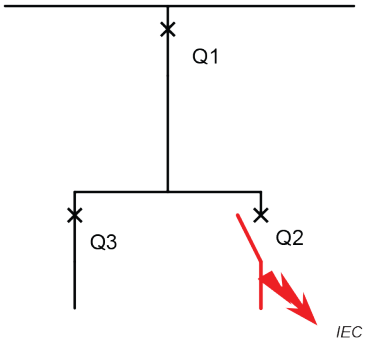
535.1.1 General

Selectivity between several overcurrent protective devices (OCPDs) in series is provided if, in case of an overload, short-circuit, or earth fault, only the OCPD (Q2) directly on the supply side of the fault or overload operates without affecting the supply to parallel circuits (Q3) (see Figure 10).

The OCPD on the load side (Q2) provides protection up to the level of overcurrent selectivity limit I_s, without causing the upstream OCPD (Q1) to operate (see Figure 10).

To determine the selectivity limit current I_s, reference shall be made to the instructions of the manufacturer of the downstream and upstream OCPDs. Where no information about this combination is available from the manufacturer, the selectivity limit current I_s may be defined by comparison of operating time-current curves of the OCPDs.

The selectivity limit current I_s shall be evaluated taking into account energy values, such as let-through energy for circuit-breakers and melting energy for fuses. See also relevant product standards.



Key

Q1, Q3 no trip

Q2 trips

Figure 10 – Example of selectivity

535.1.2 Partial selectivity

The selectivity limit current I_s is lower than the maximum prospective short-circuit current I_{sc_max} at the installation point of the OCPD on the load side (see Figure 11).

$$I_s < I_{sc\_max}$$

535.1.3 Full selectivity

The selectivity limit current I_s is equal to or higher than the maximum prospective short-circuit current I_{sc_max} at the installation point of the OCPD on the load side and lower than its breaking capacity I_{cu} according to IEC 60947-2 or I_{cn} according to IEC 60898 (all parts) or IEC 61009-1 (see Figure 11).

$$I_{sc\_max} \leq I_s < I_{cu} \text{ or } I_{cn}$$

535.1.4 Total selectivity

The selectivity limit current I_s is equal to or higher than the maximum prospective short-circuit current I_{sc_max} at the installation point of the OCPD on the load side and equal to its breaking capacity I_{cu} according to IEC 60947-2 or I_{cn} according to IEC 60898 (all parts) or IEC 61009-1 (see Figure 11).

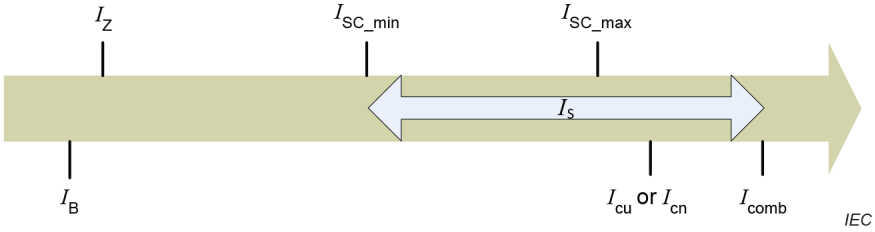
$$I_{sc\_max} \leq I_s = I_{cu} \text{ or } I_{cn}$$

535.1.5 Enhanced selectivity

The selectivity limit current I_s is equal to or higher than the maximum prospective short-circuit current at the installation point of the OCPD on the load side (Q2) and lower than or equal to the combined current I_{comb} of this combination. The breaking capacity I_{cu} according to IEC 60947-2 or I_{cn} according to IEC 60898 (all parts) or IEC 61009-1 of the OCPD on the load side (Q2) is lower than the maximum prospective short-circuit current at its installation point.

$$I_{cu} \text{ or } I_{cn} < I_{sc\_max} \leq I_s \leq I_{comb}$$

Enhanced selectivity can only be designed with respective information from the manufacturer of the devices.



Key

I_Z	continuous current-carrying capacity of the cable
I_{SC_min}	minimum prospective short-circuit current (at load side of circuit)
I_{SC_max}	maximum prospective short-circuit current (at supply side of circuit)
I_B	design current of the circuit
I_s	selectivity limit current
I_{cu}	ultimate short-circuit breaking capacity
I_{cn}	rated short-circuit capacity
I_{comb}	combined current of the combination

Figure 11 – Example of currents and their correlation to selectivity

535.2 Co-ordination between residual current protective devices and OCPDs

A residual current protective device without integral overcurrent protection requires overcurrent protection. This overcurrent protection shall be selected according to the residual current protective device manufacturer's instructions.

535.3 Selectivity between residual current protective devices

Selectivity between residual current protective devices installed in series may be required for service reasons, particularly when safety is involved, to provide continuity of supply to the parts of the installation not involved in the fault, if any.

This selectivity can be achieved by selecting and erecting residual current protective devices such that, in the event of a fault, only the RCD closest to the fault on its supply side operates.

To ensure selectivity between two residual current protective devices in series, these devices shall satisfy both the following conditions:

a) the residual current protective device located on the supply side (upstream) shall be selected according to IEC 61008 (all parts), IEC 61009 (all parts), or IEC 62423 as type S or according to IEC 60947-2 as time delay type;

b) the rated residual operating current of the device located on the supply side shall be at least three times greater than that of the residual current protective device located on the load side.

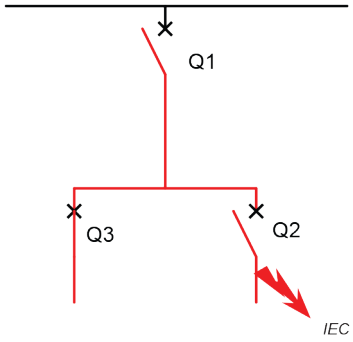
535.4 Selectivity of RCD and OCPD

Under consideration.

535.5 Combined short-circuit protection of OCPDs

Where an OCPD (Q2) has to break a prospective short-circuit current higher than its own breaking capacity I_{cu} according to IEC 60947-2 or I_{cn} according to IEC 60898 (all parts) or IEC 61009-1, it shall be assisted through the additional limiting of the short-circuit current and short-circuit energy of an upstream OCPD (Q1) (see Figure 12).

The upstream OCPD (Q1) may also trip, so that the supply to the other circuits (Q3) would be interrupted.



Key

Q1 and Q2 trip: I_{CN} or I_{CU} Q2 ≤ I_{SC_max}

Q3 no trip

Figure 12 – Example of combined short-circuit protection of OCPDs

When selecting two OCPDs for combined short-circuit protection of OCPDs, reference shall be made to the instructions of the manufacturer of the downstream OCPD. Where no information is available from the manufacturer, this combined short-circuit protection shall not be used, and each OCPD shall have the required short-circuit capability at the point of installation.

If declared by the manufacturer of both devices, the short-circuit capability of the combination of two OCPDs in series may be higher than the breaking capacity of either OCPD. In such cases, the conductors between the two OCPDs shall

- be made in such a way as to reduce the risk of a short-circuit to a minimum (see IEC 60364-4-43:2008, 434.2.1 b)), and
- not be placed close to combustible material.

If declared by the manufacturer of both devices, the combined short-circuit capability of the combination of two OCPDs in series may be higher than the breaking capacity of either OCPD. In this case, the conductors between the two OCPDs shall

- be protected by the combination of OCPDs according to IEC 60364-4-43:2008, 434.5.2,
- not exceed 3 m in length,
- be installed in such a manner as to reduce the risk of a short-circuit to a minimum, and

  NOTE This condition can be obtained for example by reinforcing the protection of the wiring against external influences.

- not be placed close to combustible material.

Co-ordination of an OCPD with a separate current limiter to increase the short-circuit breaking capacity of an OCPD may be used according to the manufacturer's instructions.

536 Isolation and switching

536.2 Isolation

536.2.1 General

536.2.1.1 Every circuit shall be capable of being isolated from all live conductors.

Provisions may be made for isolation of a group of circuits by a common means, if the service conditions allow this.

Each supply shall have a means of isolation.

536.2.1.2 Suitable means shall be provided to prevent any equipment from being unintentionally energized.

Such precaution may include one or more of the following measures:

- selection of device suitable for padlocking in the off position;
- location of the suitable means within a lockable space or lockable enclosure.

NOTE Earthing can be used as a supplementary measure.

536.2.1.3 Where an item of equipment or enclosure contains live parts connected to more than one supply, a warning notice shall be placed in such a position that any person gaining access to live parts will be warned of the need to isolate those parts from the various supplies unless an interlocking arrangement is provided to ensure that all the circuits concerned are isolated from all supplies.

The interlocking mechanism shall be both

- capable of being reliably secured in the off position so that none of the circuits can be independently energized, and
- simultaneously provide isolation for all of the circuits so that one or more circuits will not remain energized longer than any of the other protected circuits.

536.2.1.4 Where necessary, suitable means shall be provided for the discharge of stored electrical energy (see details in IEC 60364-5-55).

536.2.2 Devices for isolation

536.2.2.1 Some devices suitable for isolation are identified with the symbol  (IEC 60417-6169-1:2012-08). This symbol may be combined with symbols for other functions.

Devices shall be selected according to overvoltage category III or IV only, whichever is applicable for the point of installation.

Devices used for isolation shall be selected from Table E.1, Annex E, and in accordance with 536.2.2.2 to 536.2.2.7.

536.2.2.2 Devices for isolation shall be so selected and erected that the position of the contacts is clearly and reliably indicated.

EXAMPLE "Off", "off" or "OFF" marking or symbol "O" to indicate the open position; "On", "on", or "ON" marking or symbol "I" to indicate the closed position.

536.2.2.3 Semiconductor devices shall not be used as isolating devices.

536.2.2.4 Devices for isolation shall be designed and/or installed so as to prevent unintentional closure.

This may be achieved by locating the device in a lockable space or lockable enclosure or by padlocking.

NOTE Such closure can be caused for example by shocks and vibrations.

536.2.2.5 Provision shall be made to prevent the inadvertent and/or unauthorized opening of a disconnector, unless the device for isolation is capable of making and breaking currents under normal conditions.

This may be achieved by locating the device in a lockable space or lockable enclosure or by padlocking. Alternatively, a disconnector may be interlocked with a switch or a protective device.

536.2.2.6 Where a link is inserted in the neutral conductor, the following shall apply:

- it is accessible to skilled persons only;
- it is designed to prevent the inadvertent and/or unauthorized removal;
- it cannot be removed without the use of a tool.

536.2.2.7 Means of isolation shall be provided preferably by a multipole switching device which disconnects all poles of the relevant supply; however, single-pole devices, situated adjacent to each other for multi-phase circuits, are not excluded.

Single-pole protective devices (e.g. circuit-breakers or fuses) shall not be used in the neutral conductor only.

536.2.2.8 All devices used for isolation shall be clearly identified, for example by marking, to indicate the circuit which they isolate.

536.2.2.9 Subclauses 536.2.2.1 to 536.2.2.8 do not apply to plugs and socket-outlets, connectors and devices for connection of luminaires.

536.3 Switching-off for mechanical maintenance

536.3.1 General

536.3.1.1 Means of switching-off shall be provided where mechanical maintenance may involve a risk of physical injury other than due to electric shock or to arcing.

Where electrically powered mechanical equipment is within the scope of IEC 60204-1, the requirements for switching-off for mechanical maintenance of IEC 60204-1 apply.

Systems powered by non-electrical means, e.g. pneumatic, hydraulic or steam, are not covered by 536.3.1. In such cases, switching-off any associated supply of electricity may not be a sufficient measure.

536.3.1.2 Suitable means shall be provided to prevent electrically powered equipment from becoming unintentionally reactivated during mechanical maintenance, unless the means of switching-off is continuously under the control of any person performing such maintenance.

EXAMPLE

- selection of device suitable for padlocking in the off position;
- location within a lockable space or lockable enclosure.

The switching-off shall cause the disconnection of all line conductors by a device suitable for isolation.

536.3.2 Devices for switching-off for mechanical maintenance

536.3.2.1 Devices for switching-off for mechanical maintenance shall comply with 536.2.2 and shall fulfil all the other requirements of 536.3.2.

A device for switching-off for mechanical maintenance shall be inserted preferably in the supply circuit of the current using equipment to be maintained.

Where for this purpose switches are provided, they shall be capable of cutting off the full-load current of the relevant part of the installation. They shall not necessarily interrupt all line conductors.

Interruption of a control circuit where the device is not inserted in the supply circuit of the current using equipment to be maintained shall be used only where:

- supplementary safeguards, such as mechanical restrainers, are provided; or
- requirements for the control devices used provide a condition equivalent to the direct interruption of the main supply.

EXAMPLE Switching-off for mechanical maintenance can be achieved, by means of:

- multipole switches;
- circuit-breakers;
- control switches operating contactors;
- plugs and socket outlets.

536.3.2.2 Devices for switching-off for mechanical maintenance shall be placed and marked so as to be readily identifiable and convenient for their intended use.

536.4 Emergency switching

536.4.1 General

536.4.1.1 Where electrically powered equipment is within the scope of IEC 60204-1, the requirements for emergency switching of IEC 60204-1 apply.

Emergency switching is either emergency switching-on or emergency switching-off.

536.4.1.2 Means shall be provided for emergency switching of any part of an installation where it may be necessary to control the supply to remove an unexpected danger.

536.4.1.3 Means for emergency switching shall act as directly as possible as one single action on all relevant supply conductors.

536.4.1.4 The arrangement of the emergency switching shall be such that its operation does not introduce a further danger or interfere with the complete operation necessary to remove the danger.

536.4.2 Devices for emergency switching-off

536.4.2.1 Devices used for emergency switching shall be selected from Table E.1 and in accordance with 536.4.2.1 to 536.4.2.6.

The emergency switching-off device shall interrupt all live conductors.

The devices for emergency switching-off shall be capable of breaking the full-load current of the relevant parts of the installation taking account of stalled motor currents where appropriate.

536.4.2.2 Means for emergency switching-off shall consist of:

- one switching device suitable for isolation, capable of directly interrupting the appropriate supply, or
- a combination of equipment suitable for isolation activated by a single action for the purpose of interrupting the appropriate supply.

Hand-operated switching devices for direct interruption of the main circuit shall be selected where practicable.

A switching device suitable for isolation operated by remote control shall open on de-energization of coils, or other equivalent failure-to-safety techniques shall be employed.

EXAMPLE Failure-to-safety techniques are pneumatic actuators, or a shunt trip relay provided that the continuity of the actuating circuit is indicated (e.g. by a lamp).

536.4.2.3 The means of operating (handles, push-buttons, etc.) devices for emergency switching-off shall be clearly identified, preferably coloured red, with a contrasting background, preferably yellow.

Text shall not be used as the sole identification of such devices.

536.4.2.4 The means of operating shall be readily accessible at places where a danger might occur and, where appropriate, at any additional remote position from which that danger can be removed.

536.4.2.5 The release of an emergency switching-off device shall not result in re-energizing the relevant electrically powered equipment and/or relevant part of the installation.

536.4.2.6 Devices for emergency switching-off shall be so placed and marked as to be readily identifiable and convenient for their intended use.

536.4.3 Devices for emergency stopping

NOTE IEC 60204-1 provides requirements for the selection and erection of devices for emergency stopping.

Retention of the supply may be necessary, for example, for braking of moving parts.

536.5 Functional switching (control)

536.5.1 General

536.5.1.1 A functional switching device shall be provided for each part of a circuit which may require to be controlled independently of other parts of the installation.

536.5.1.2 Functional switching devices need not necessarily control all live conductors of a circuit.

A single-pole switching device shall not be placed in the neutral conductor, except where it is essential for the operation of a control device (e.g. sensor, luminaire control device, dimmer, remote control switch (RCS)) that the line conductor is not switched.

536.5.1.3 Current-using equipment requiring control shall be controlled by an appropriate functional switching device.

A single functional switching device may control several items of equipment intended to operate simultaneously.

536.5.2 Devices for functional switching

536.5.2.1 Devices used for functional switching shall be selected from Table E.1 and in accordance with 536.5.2.2 to 536.5.2.3

536.5.2.2 Functional switching devices shall be selected and erected for the most onerous duty they may be called upon to perform.

536.5.2.3 Functional switching devices may control the current without necessarily opening the corresponding poles.

NOTE Semiconductor switching devices are examples of devices capable of interrupting the current in the circuit but not opening the corresponding poles.

536.5.2.4 Links shall not be used for functional switching.

536.5.2.5 Plugs and socket-outlets rated at not more than 16 A may be used for functional switching.

537 Monitoring

537.1 General

537.1.1 Monitoring devices

Monitoring devices are not intended to provide protection against electric shock.

537.1.2 Selection of insulation monitoring devices (IMDs)

IMDs shall be in accordance with IEC 61557-8.

IMDs shall be installed at or near the origin of the part of the installation to be monitored, as practicable.

537.1.3 Selection of residual current monitoring devices (RCMs)

RCMs shall comply with IEC 62020.

RCMs shall be installed at or near the origin of the part of the installation to be monitored, as practicable.

Where a residual current protective device (RCD) is installed upstream of the RCM, it is recommended to set the RCM to a residual actuating current not higher than a third of the rated residual operating current $I_{\Delta n}$ of the RCD.

537.2 IT systems for continuity of supply

537.2.1 General

An IMD is intended to permanently monitor the insulation resistance of an IT system and provides an alarm where the insulation resistance R_F is below the response value R_a.

An IMD shall be installed in IT systems in accordance with the requirement of IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.6.3.1.

Instructions shall be provided indicating that when the IMD detects an insulation fault to earth, the insulation fault shall be located and eliminated in order to restore normal operating conditions with the shortest practicable delay.

Where IT systems are used for continuity of service, the alarm indicating detection of the first insulation fault shall be located so it is audible and/or visible by instructed (BA4) or skilled (BA5) persons.

It is recommended to use an IMD that signals an interruption of the measurement connections to the system conductors and earth.

Where IT systems are used for continuity of service, it is recommended to combine the IMD with devices enabling the fault location on-load, and equipment for insulation fault location shall be selected in accordance with IEC 61557-9.

537.2.2 Insulation monitoring devices (IMDs)

In multiphase systems, IMDs shall be selected to withstand at least line to line voltage.

Where the system to be monitored contains DC components (due to electronic equipment, e.g. rectifiers or converters), IMDs shall be selected accordingly.

537.2.3 Installation of IMDs

Where an IMD is connected to the neutral conductor, no OCPD shall be inserted in the connection between the IMD and the neutral conductor.

The setting of the IMD shall only be adjusted by instructed (BA4) or skilled (BA5) persons. Access to the setting means may be achieved through use of a key, a tool or a password.

NOTE A value of 100 Ω/V (300 Ω/V for pre-warning) of the rated system voltage is an example of typical setting values.

Where the installation is supplied from more than one power supply, one IMD per supply shall be used.

For power supplies temporarily connected in parallel, the associated IMDs shall be interlocked in such a way that only one IMD remains connected to the IT system.

If the IMD is also intended to monitor the disconnected part of an installation, the IMD shall be supplied by an auxiliary source

537.3 IT public distribution system

For installations connected to an IT public distribution network and where more than one installation is intended to be connected to the same distribution network, the following apply:

Where interruption of the supply in case of a first insulation fault to earth is not required or not permitted, a monitoring device shall be selected and erected to indicate the occurrence of a first insulation fault from a live part to exposed-conductive-parts or to earth in accordance with 411.6.3.1 of IEC 60364-4-41:2005/AMD1:2017.

Such monitoring devices may be:

- IMDs, or,
- where the residual fault current is sufficiently high, residual current monitoring devices (RCMs).

It is recommended to use directionally discriminating RCMs in order to avoid unwanted signalling of leakage current when high leakage capacitances are liable to exist downstream from the point of installation of the RCM.

NOTE In IT systems the measuring principle of an RCM is not able to detect double or symmetrical insulation faults on different live conductors downstream of the RCM.

537.4 Off-line systems in TN, TT and IT systems

Where insulation monitoring of off-line systems is needed, it may be achieved by using insulation monitoring devices (IMDs).

IMDs used for off-line system monitoring shall automatically be deactivated whenever the system is switched on.

NOTE As an example, this can be applicable for systems which are normally de-energized, such as a fire pump or a fire ventilation.

The reduction of the insulation level shall be indicated locally by either a visual or an audible signal with the option of remote indication. The alarm indicating detection of the first insulation fault shall be located so it is audible and/or visible by instructed (BA4) or skilled (BA5) persons.

The alarm threshold should be above 300 kΩ, as the insulation levels measured are generally very high.

Annex A
(informative)

Position of devices for overload protection

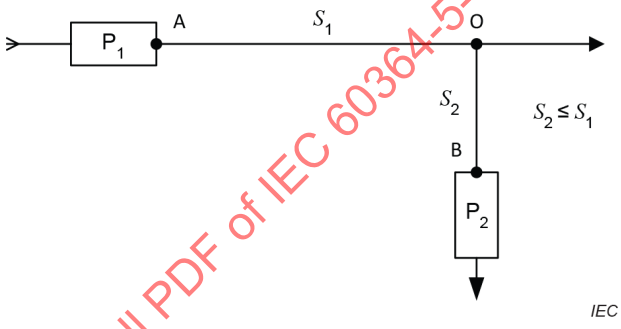
A.1 General

Devices for overload protection and devices for short-circuit protection have to be installed for each circuit. These protective devices generally need to be placed at the origin of each circuit.

For some application one of the devices for overload protection or for short-circuit protection may not follow this general requirement, provided the other protection remains operative.

A.2 Cases where overload protection need not be placed at the origin of the branch circuit

a) In accordance with the requirements of 533.4.2.2 a) and Figure A.1, an overload protective device P_2 may be moved from the origin (O) of the branch circuit (B) provided that there is no other connection or socket-outlet on the supply side of P_2 – the protective device of this branch circuit – and, in accordance with the requirements of 533.4.2.2 b) 1), short-circuit protection for this part of the branch circuit is provided.



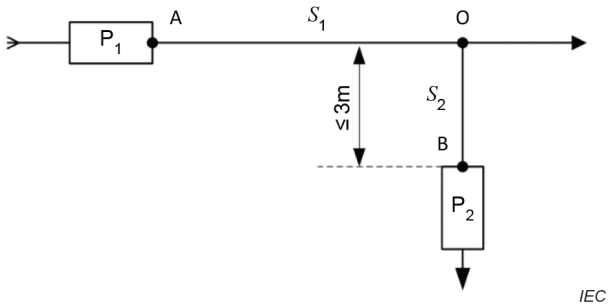
Key

S cross-sectional area of the conductor

Figure A.1 – Overload protective device (P_2) not at the origin of branch circuit (B)

The overload protective device is to protect the wiring system. Only current-using equipment may generate overload; therefore, the overload protective device may be moved along the run of the branch circuit to any place provided short-circuit protection of the branch circuit remains operational.

b) In accordance with the requirements of 533.4.2.2 a) and Figure A.2, an overload protective device P_2 may be moved from the origin (O) of the branch circuit (B) provided that there is no other connection or socket-outlet on this length of the branch circuit, and, in accordance with the requirements of 533.4.2.2 b) 2), its length does not exceed 3 m, and the risk of short-circuit, fire and danger to persons is reduced to a minimum for this length.



Key

S cross-sectional area of the conductor

Figure A.2 – Overload protective device (P_2) installed within 3 m of the origin of the branch circuit (B)

It is accepted that for a length of 3 m, the branch circuit is not protected against short-circuit, but some precautions have to be taken to ensure safety. See 533.4.2.2 b). In addition it may be possible that the short-circuit protection of the supply circuit also provides short-circuit protection to the branch circuit up to the point where P_2 is installed (see Annex B).

Annex B
(informative)

Position of devices for short-circuit protection

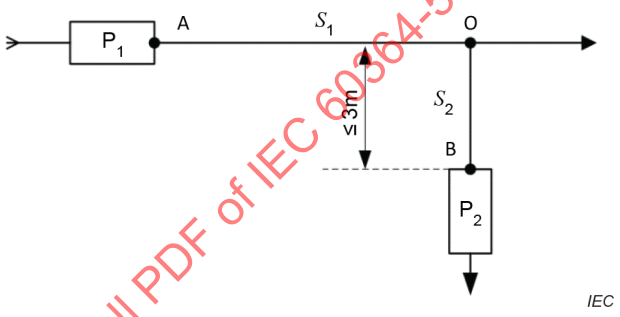
B.1 General

Devices for overload protection and devices for short-circuit protection have to be installed for each circuit. These protective devices generally need to be placed at the origin of each circuit.

For some applications, one of the devices for overload protection or for short-circuit protection may not follow this general requirement, provided the other protection remains operative.

B.2 Cases where short-circuit protection need not be placed at the origin of branch circuit

a) In accordance with the requirements of 533.4.3.2 and Figure B.1, short-circuit protective device P_2 may be moved up to 3 m from the origin (O) of the branch circuit (B) provided that there is no other connection or socket-outlet on this length of the branch circuit, and in the case of 533.4.3.2 the risk of short-circuit, fire and danger to persons is reduced to a minimum for this length.



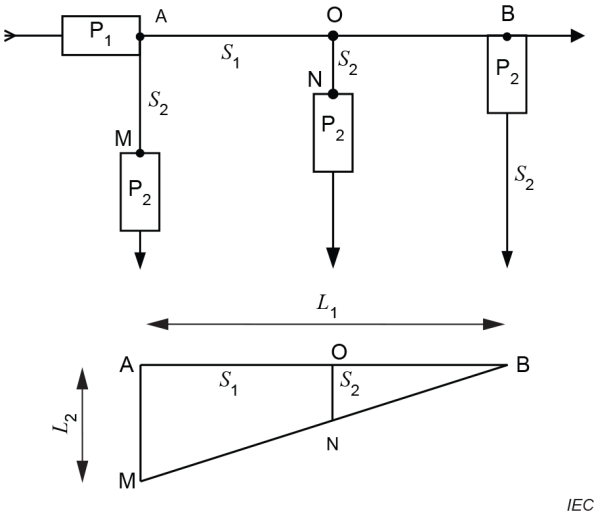
Key

S cross-sectional area of conductor

Figure B.1 – Limited change of position of short-circuit protective device (P_2) on a branch circuit

The 3 m length of conductor in the branch circuit is not protected against short-circuit, but short-circuit protection provided for the supply circuit may still provide short-circuit protection to the branch circuit up to the point where P_2 is installed.

b) In accordance with the requirements of 533.4.3.3 and Figure B.2, the short-circuit protective device P_2 may be installed at a point on the supply side of the origin (O) of the branch circuit (B) provided that, in conformity with 533.4.3.3, the maximum length between the origin of the branch circuit and the short-circuit-protective device of this branch circuit respect the specification proposed by the “triangular rule”.



Key

AB maximum length L_1 of the conductor of the cross-sectional area S_1 protected against short-circuit by the protective device P_1 placed at A.

AM maximum length L_2 of the conductor of the cross-sectional area S_2 protected against short-circuit by the protective device P_1 placed at A.

Figure B.2 – Short-circuit protective device P_2 installed at a point on the supply side of the origin of a branch circuit

The maximum length of conductor branched off at O, with the cross-sectional area S_2, that is protected against short-circuits by the protective device P_1 placed at A, is given as length ON in the triangle BON.

Clause B.2 may be used in the case where only protection against short-circuit is provided. Protection against overload is not considered in this example.

These maximum lengths correspond to the minimum short-circuit capable of activating the protective device P_1. This protective device protecting branch circuit S_1 up to the length AB also protects the branch circuit S_2. The maximum length of branch circuit S_2 protected by P_1 depends on the location where the branch circuit S_2 is connected to S_1.

The length of branch circuit S_2 cannot exceed the value determined by the triangular diagram. In this case the protective device P_2 may be moved along branch circuit S_2 up to the point N.

NOTE 1 This method can also be applied in the case of three successive conductor runs of different cross-sectional area.

NOTE 2 If, for section S_2, the lengths of wiring differ according to the nature of insulation, the method is applicable by taking the length:

$$AB = L_2 S_1 / S_2$$

If, for section S_2 the lengths of wiring are the same whatever the nature of insulation, the method is applicable by taking the length:

$$AB = L_1$$

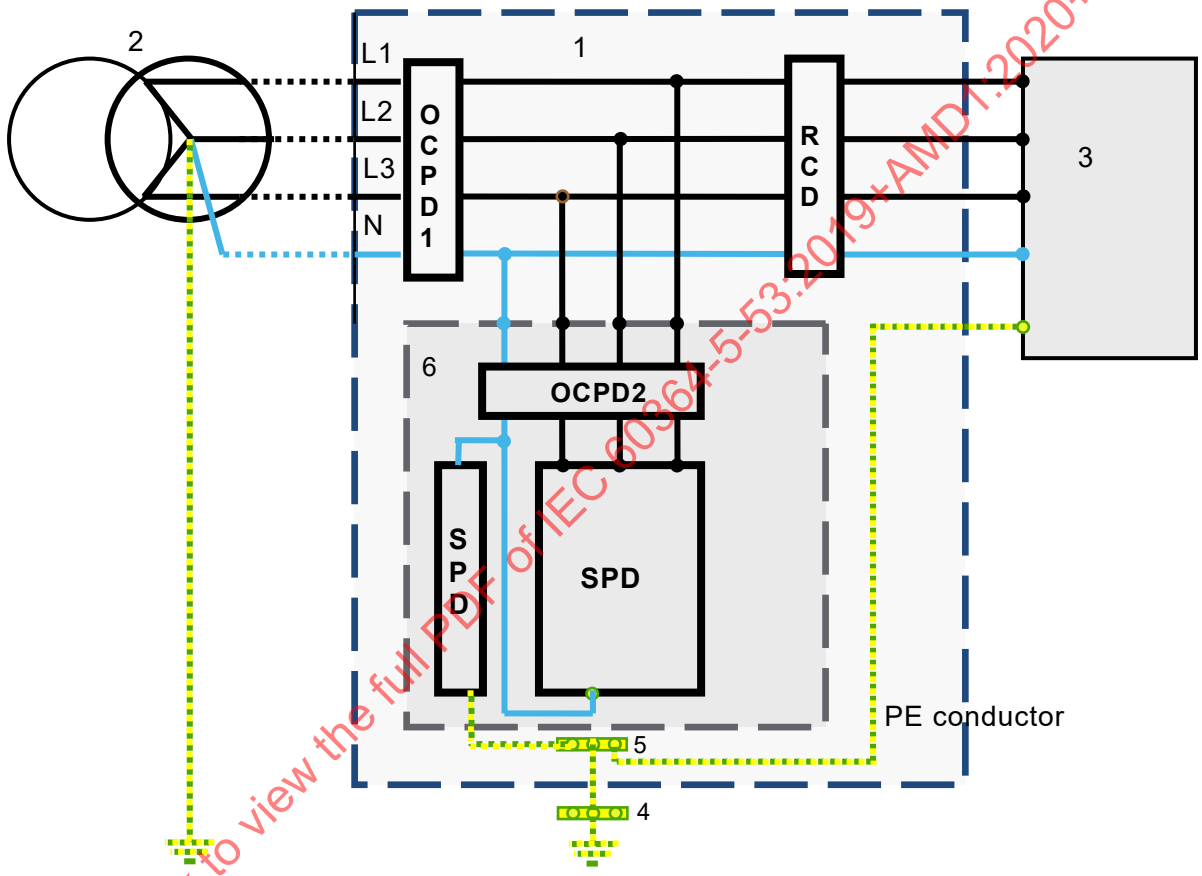
Annex C
(informative)

SPD installation – Examples of installation diagrams according to system configurations

NOTE 1 National Committees may choose the preferred diagrams for their country.

NOTE 2 OCPDs may be single pole or multi pole devices according to IEC 60364.

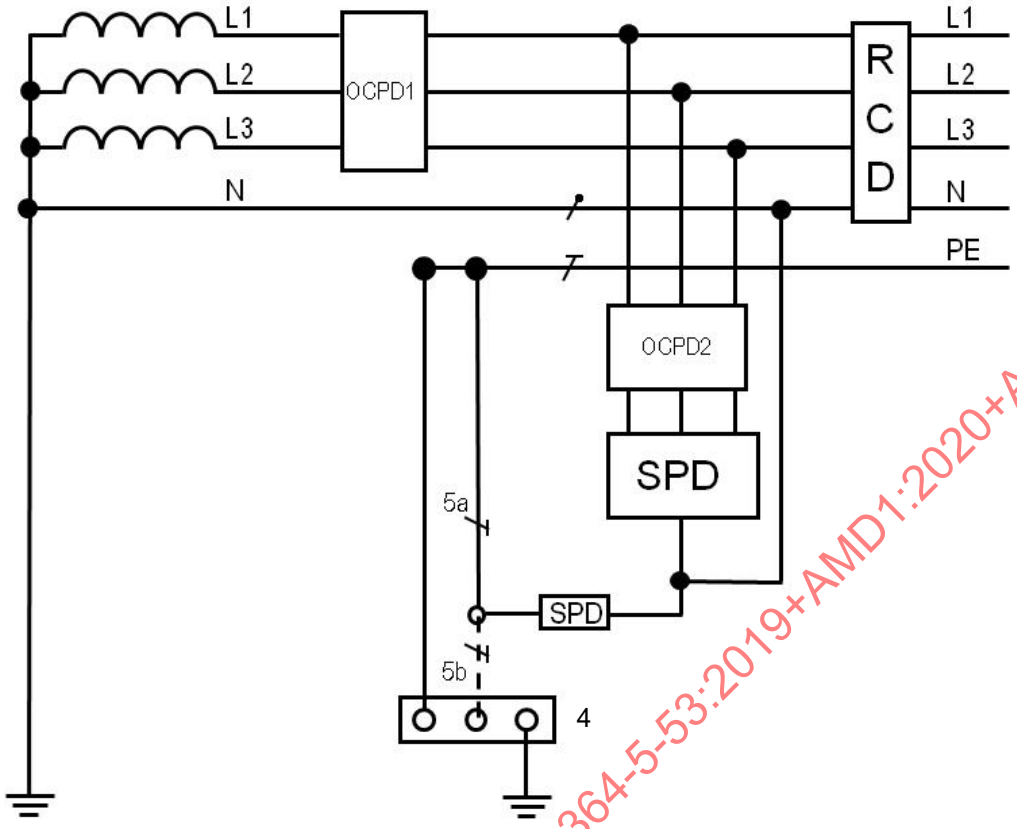
C.1 TT system – 3 phase supply plus neutral



Key

1	LV switchboard
2	HV/LV transformer
3	equipment/installation
4	main earthing terminal
5	intermediate earthing terminal
6	SPDA
OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
OCPD2	overcurrent protective device(s) if required
RCD	residual current device

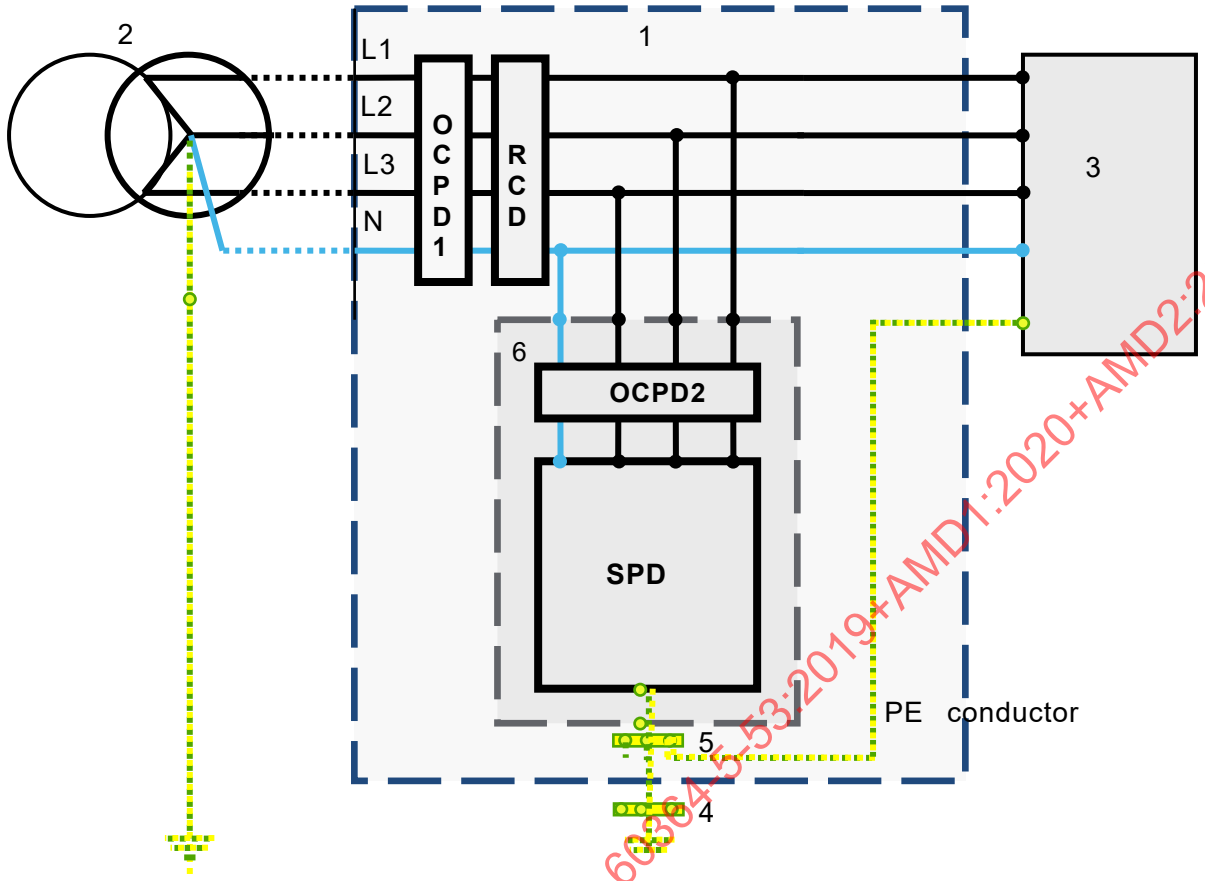
Figure C.1 – Example of SPDA installation with connexion type CT2 on the supply side (upstream) of the main RCD in TT system



Key

OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
OCPD2	overcurrent protective device(s) if required
4	main earthing terminal
5a, 5b	earthing connection of surge protective devices, either 5a and/or 5b (if required)
RCD	residual current device

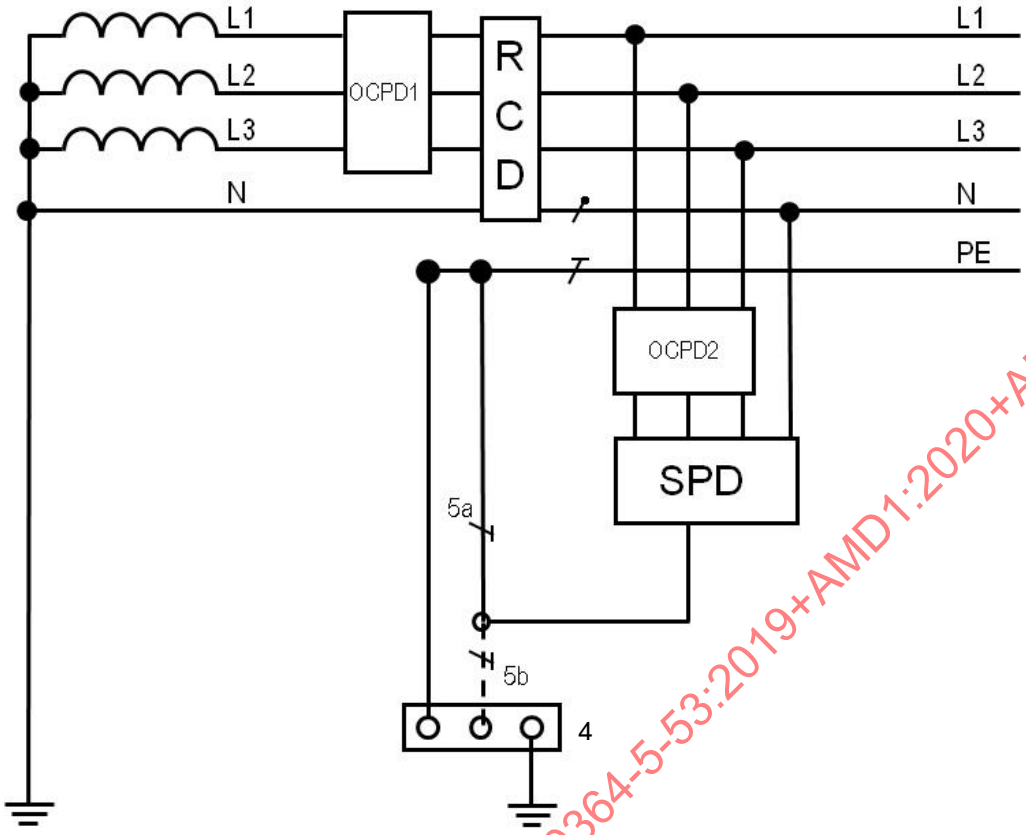
Figure C.2 – Example of SPD installation with connexion type CT2 on the supply side (upstream) of the main RCD in TT system



Key

1	LV switchboard
2	HV/LV transformer
3	equipment/installation
4	main earthing terminal
5	intermediate earthing terminal
6	SPDA
OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
OCPD2	overcurrent protective device(s) if required
RCD	residual current device

Figure C.3 – Example of SPDA installation on the load side (downstream) of the main RCD in TT system

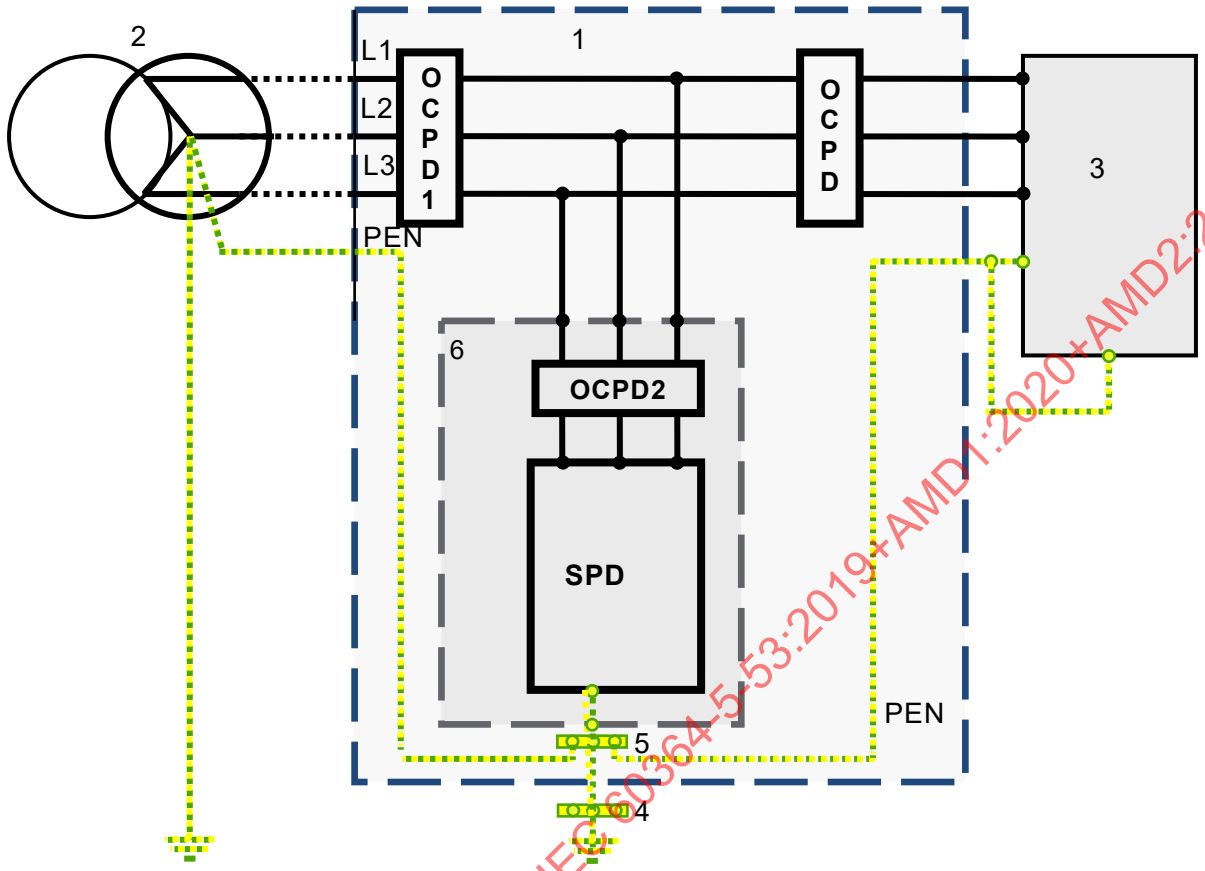


Key

OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
OCPD2	overcurrent protective device(s) if required
4	main earthing terminal
5a, 5b	earthing connection of surge protective devices, either 5a and/or 5b (if required)
RCD	residual current device

Figure C.4 – Example of SPD installation on the load side (downstream) of the RCD in TT system

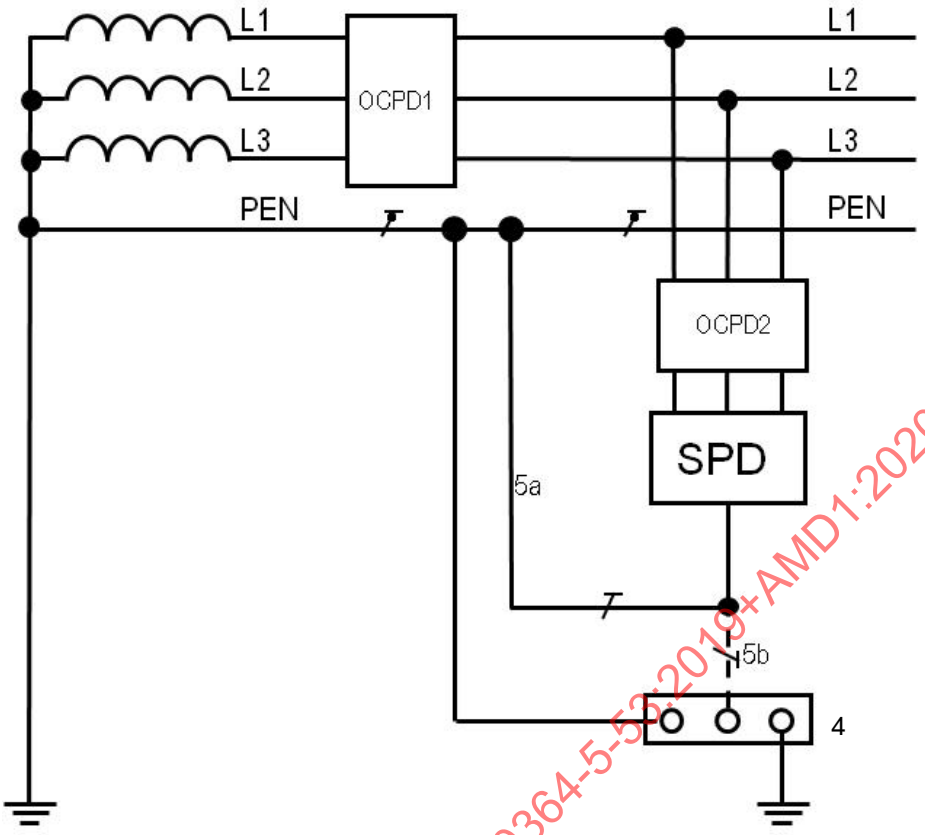
C.2 TN-C and TN-C-S systems – 3 phase supply



Key

1	LV switchboard
2	HV/LV transformer
3	equipment/installation
4	main earthing terminal
5	intermediate earthing terminal
6	SPDA
OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
OCPD2	overcurrent protective device(s) if required

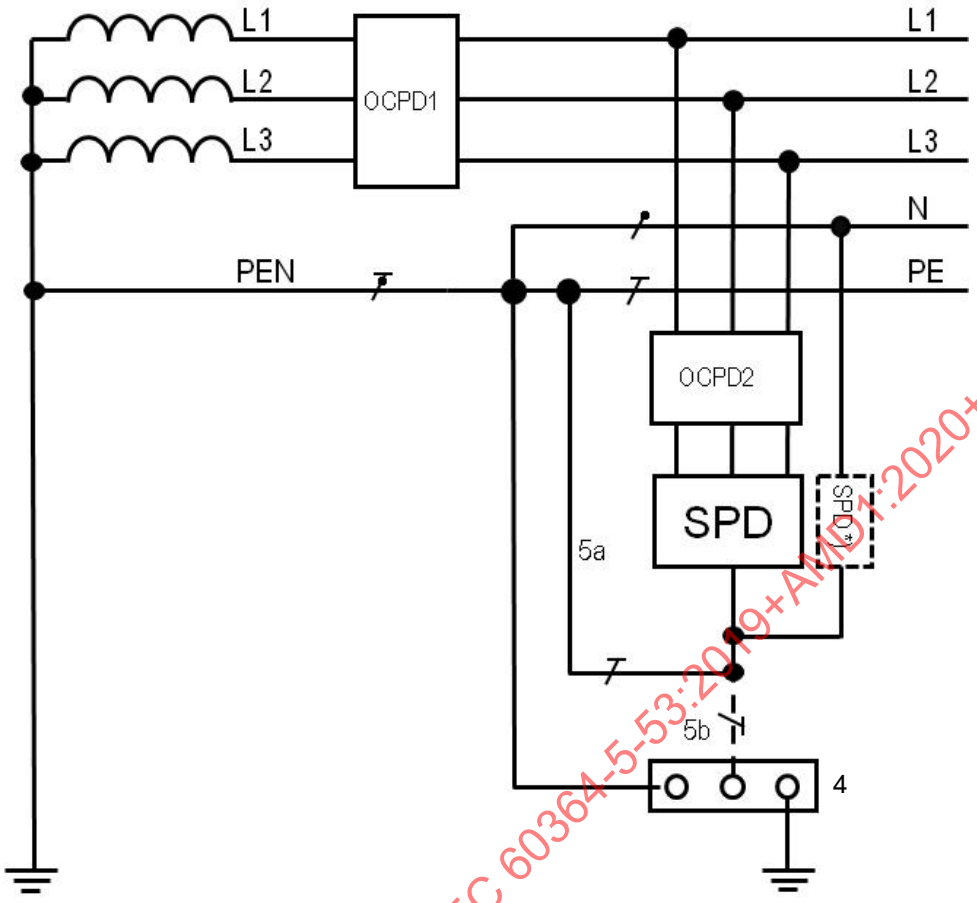
Figure C.5 – Example of SPDA installation in TN-C system



Key

OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
OCPD2	overcurrent protective device(s) if required
4	main earthing terminal
5a, 5b	earthing connection of surge protective devices, either 5a and/or 5b (if required)

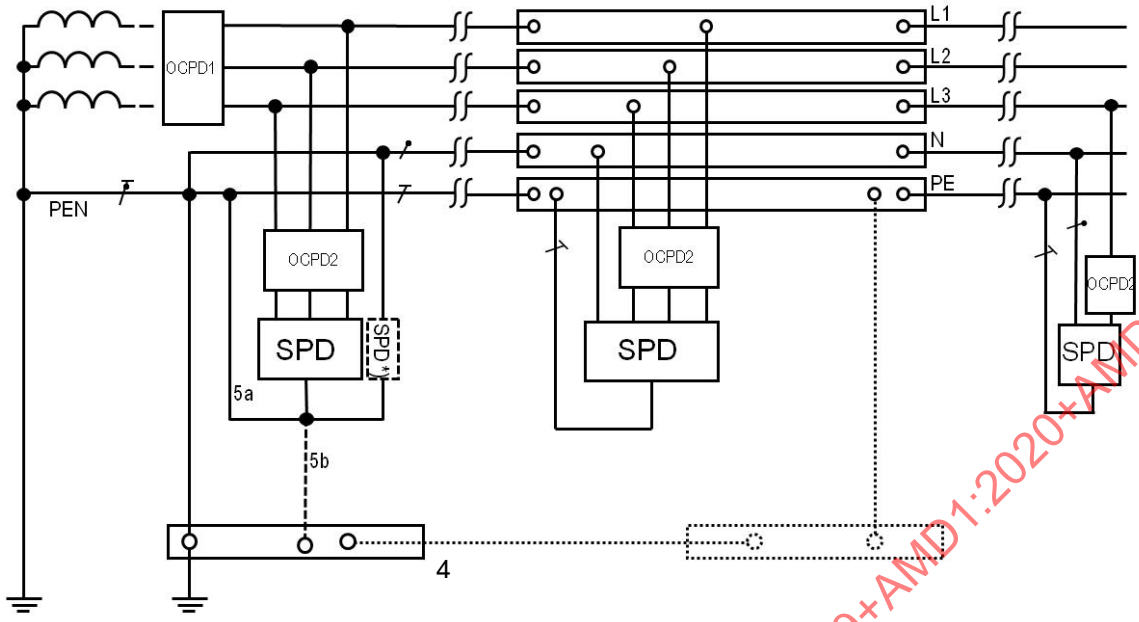
Figure C.6 – Example of SPD installation with connexion type CT1 in TN-C system



Key

OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
*)	See 534.4.3
OCPD2	overcurrent protective device(s) if required
4	main earthing terminal
5a, 5b	earthing connection of surge protective devices, either 5a and/or 5b (if required)

Figure C.7 – Example of SPD installation in TN-C-S system where the PEN is separated into PE and N at the origin of the installation (upstream of the SPD)

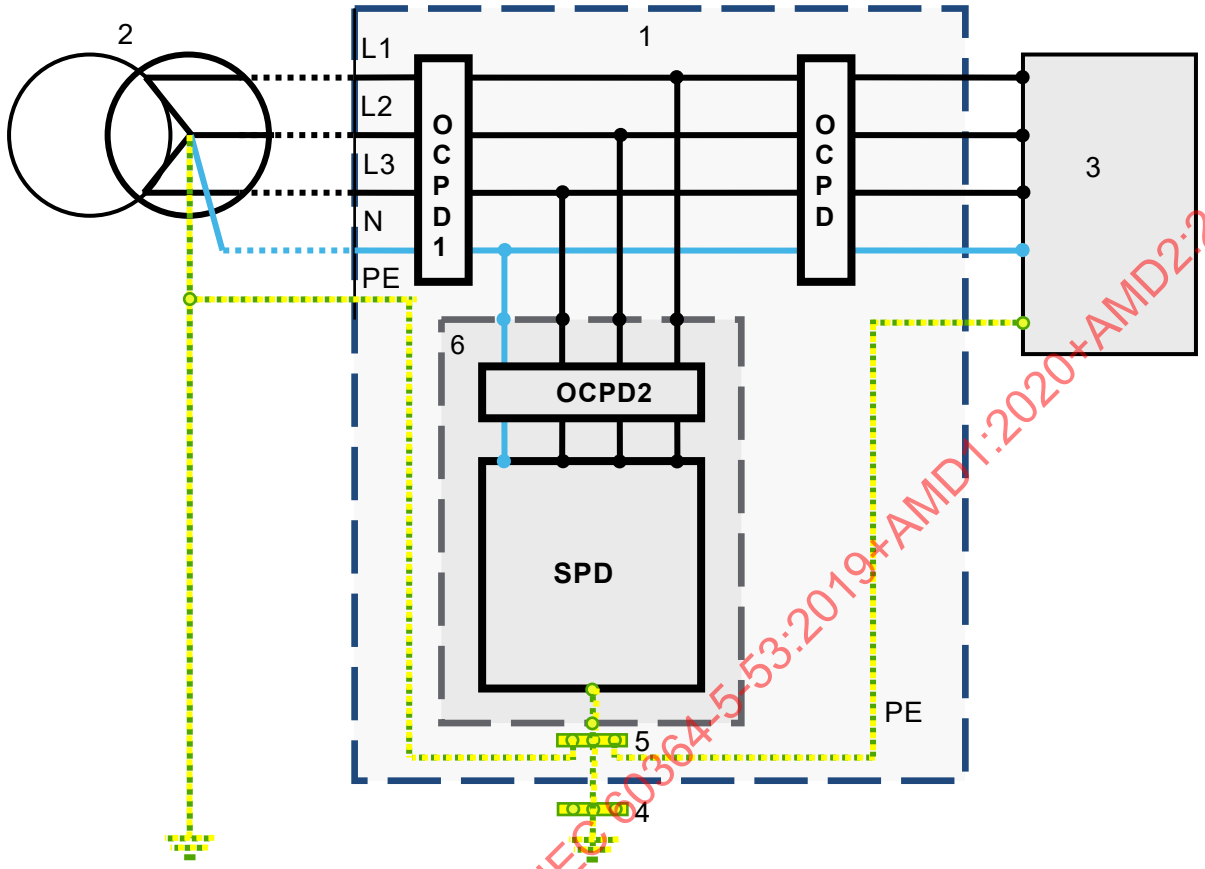


Key

OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
*)	See 534.4.3
OCPD2	overcurrent protective device(s) if required
4	main earthing terminal
5a, 5b	earthing connection of surge protective devices, either 5a and/or 5b (if required)

Figure C.8 – Example of SPDs installation in TN-C-S in different distribution boards

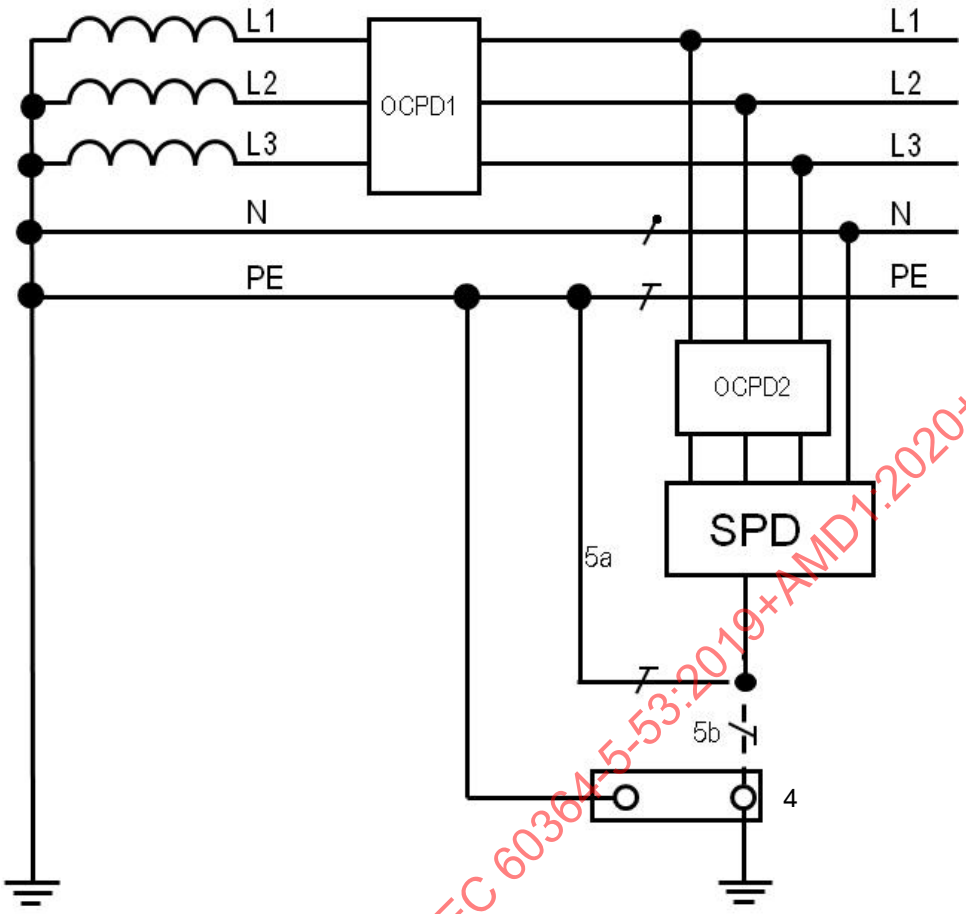
C.3 TN-S system – 3 phase supply plus neutral



Key

1	LV switchboard
2	HV/LV transformer
3	equipment/installation
4	main earthing terminal
5	intermediate earthing terminal
6	SPDA
OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
OCPD2	overcurrent protective device(s) if required

Figure C.9 – Example of SPDA installation in TN-S system

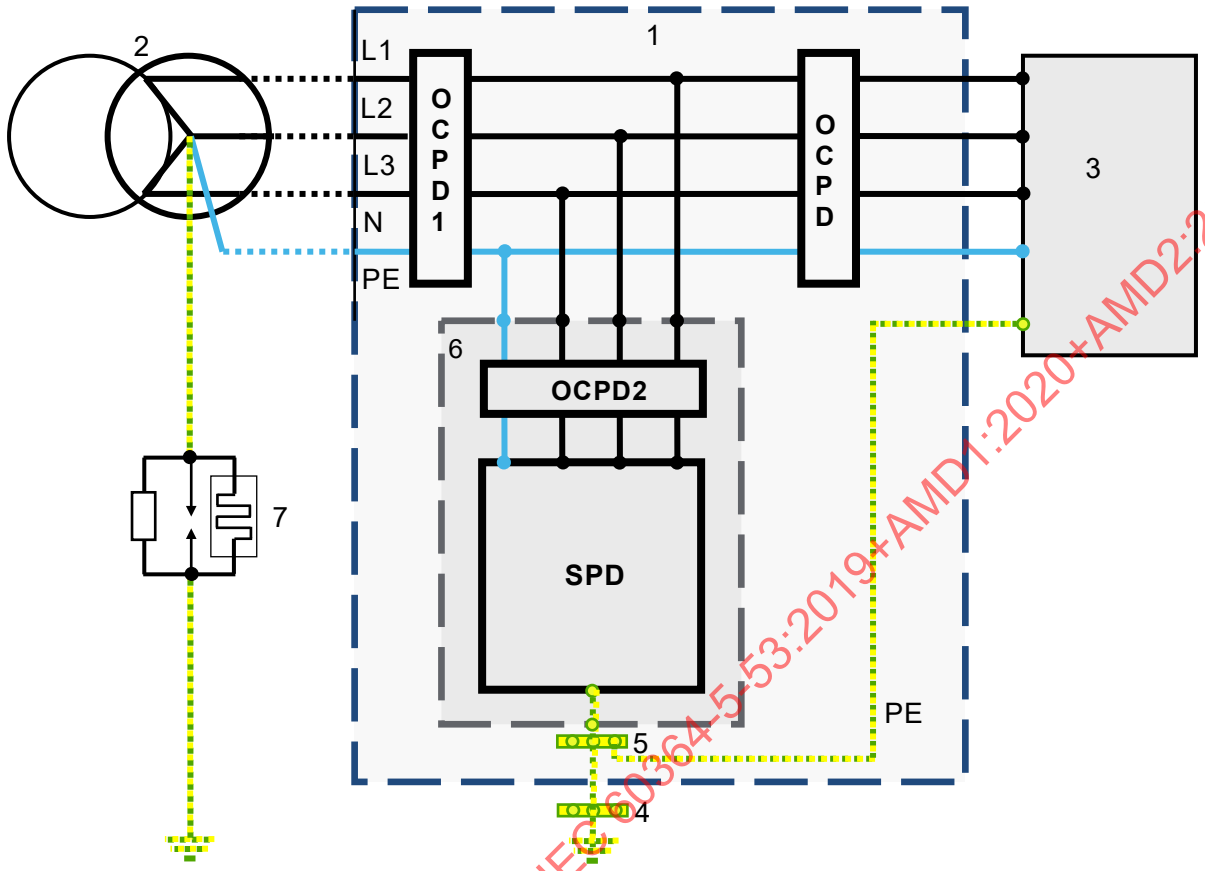


Key

OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
OCPD2	overcurrent protective device(s) if required
4	main earthing terminal
5a, 5b	earthing connection of surge protective devices, either 5a and/or 5b (if required)

Figure C.10 – Example of SPDs installation in TN-S

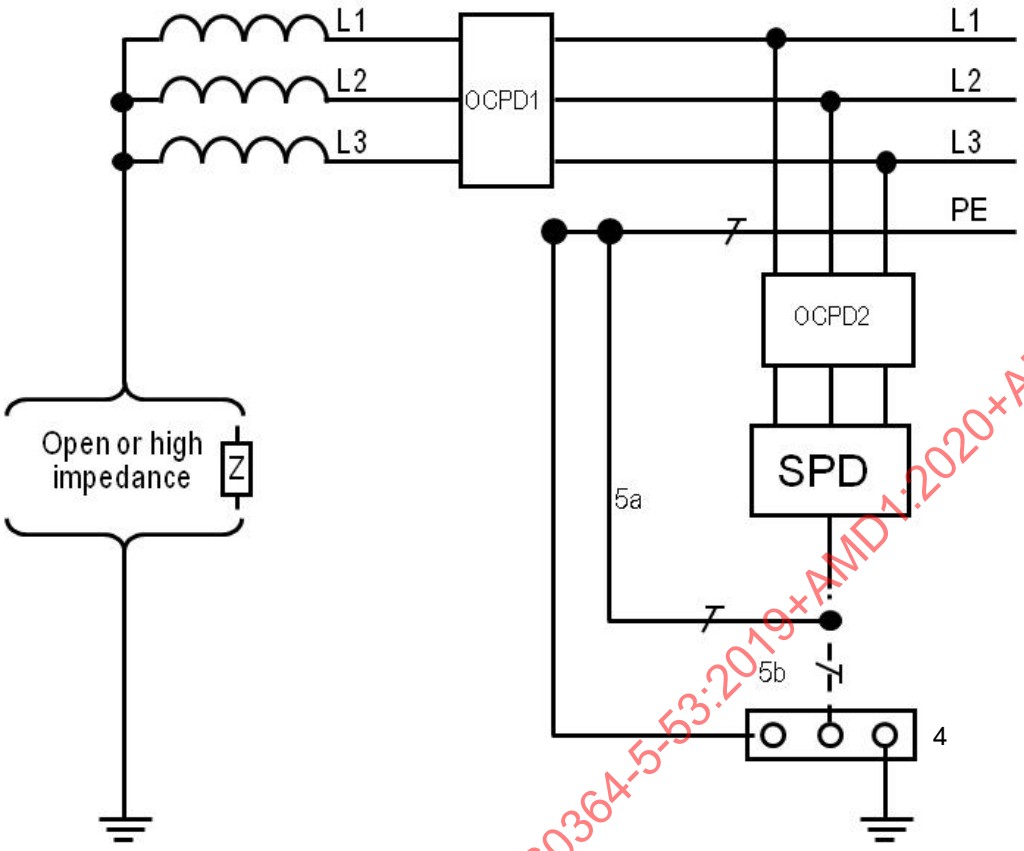
C.4 IT system – 3 phase supply with or without neutral



Key

1	LV switchboard
2	HV/LV transformer
3	equipment/installation
4	main earthing terminal
5	intermediate earthing terminal
6	SPDA
7	impedance
OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
OCPD2	overcurrent protective device(s) if required

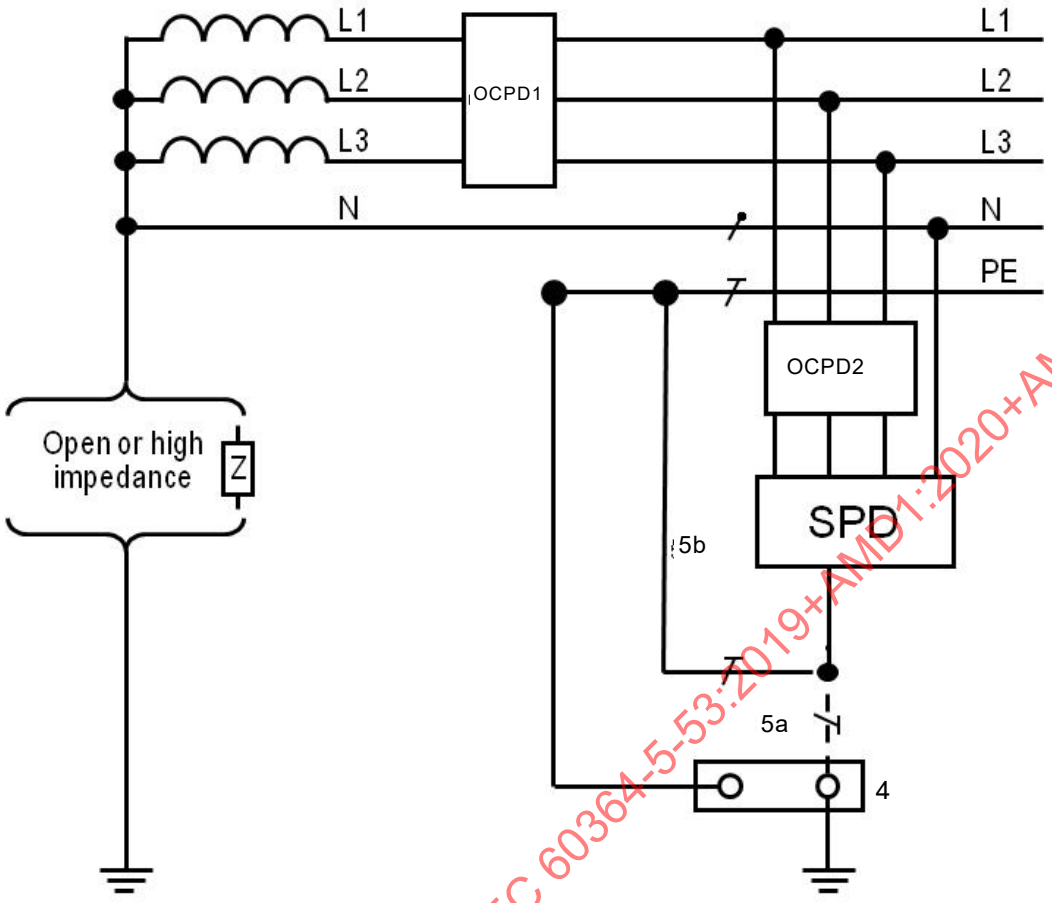
Figure C.11 – Example of SPDA installation in IT system with neutral



Key

OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
OCPD2	overcurrent protective device(s) if required
4	main earthing terminal
5a, 5b	earthing connection of surge protective devices, either 5a and/or 5b (if required)

Figure C.12 – Example of SPD installation in IT system without neutral



Key

OCPD1	overcurrent protective device(s) at the origin of the installation
SPD	surge protective device(s)
OCPD2	overcurrent protective device(s) if required
4	main earthing terminal
5a, 5b	earthing connection of surge protective devices, either 5a and/or 5b (if required)

Figure C.13 – Example of SPD installation in IT system with neutral

Annex D
(informative)

Installation supplied by overhead lines

Where overvoltage protection according to Clause 443 of IEC 60364-4-44:2007/AMD1:2015 is required, where the lines entering the building are overhead and where the case of lightning strike to the last pole of the overhead lines close to the building is taken into account, SPDs at the origin of the installation shall be selected according to Table D.1.

Further information can be found in IEC 62305 (all parts).

Table D.1 – Selection of impulse discharge current (I_{imp})

Connection	I_{imp} (kA)			
	Supply system			
	Single-phase		Three-phase	
	CT1	CT2	CT1	CT2
L – N		5		5
L – PE	5		5	
N – PE	5	10	5	20
NOTE This table refers to lightning protection levels III and IV.				

Annex E
(normative)

Reference standards for devices for isolation and switching

Table E.1 – Devices for isolation and switching

Device	Standard	Suitable for		
		Isolation	Functional switching and control	Emergency switching-off
Switch disconnectors	IEC 60947-3 [a]	Yes	Yes	Yes
	IEC 62626-1 [a]	Yes	Yes	Yes
	IEC 60669-2-4	Yes	Yes	Yes
	IEC 60669-2-6	Yes	No	Yes
Disconnectors	IEC 60669-2-4 [b]	Yes	No	No
	IEC 60947-3 [b]	Yes	No	No
Switches	IEC 60669-1	No	Yes	No
	IEC 60669-2-1	No	Yes	No
	IEC 60669-2-2	No	Yes	No
	IEC 60669-2-3	No	Yes	No
	IEC 60669-2-5	No	Yes	No
	IEC 60947-3 [c]	No	Yes	No
	IEC 60947-5-1	No	Yes	No
Contactors	IEC 60947-4-1	No	Yes	No
	IEC 61095	No	Yes	No
Starters	IEC 60947-4-1	Yes [b]	Yes	Yes [b]
	IEC 60947-4-2	No	Yes	No
	IEC 60947-4-3	No	Yes	No
Circuit-breakers	IEC 60898-1	Yes	No	Yes
	IEC 60898-2	Yes	No	Yes
	IEC 60947-2	Yes [b]	No	Yes [b]
Residual current protective devices (RCDs)	IEC 60947-2	Yes [b]	No	Yes [b]
	IEC 61008 (all parts)	Yes	No	Yes
	IEC 61009 (all parts)	Yes	No	Yes
	IEC 62423	Yes	No	Yes
Arc fault detection devices	IEC 62606	Yes	No	Yes
Plugs and socket-outlets	IEC 60309 (all parts)	Yes	Yes [d]	No
	IEC 60884 (all parts)	Yes	Yes [d]	No
	IEC 60906 (all parts)	Yes	Yes [d]	No
Devices for the connection of luminaires	IEC 61995 (all parts)	Yes [e]	No	No
Transfer switching equipment	IEC 60947-6-1	Yes [b]	Yes	Yes [b]
Control and protective switching devices for equipment (CPS)	IEC 60947-6-2	Yes [b]	Yes	Yes [b]

Device	Standard	Suitable for		
		Isolation	Functional switching and control	Emergency switching-off
Fuse	IEC 60269-2	Yes [f]	No	No
	IEC 60269-3	Yes [f]	No	No
	IEC 60269-4	Yes [f]	No	No
Fuse-combination units	IEC 60947-3	Yes [b]	No [a]	Yes [a,b]
Connectors [g]	IEC 61984	Yes [h]	No	No

Key

Yes function provided.

No function not provided.

[a] If marked with the symbol  or a combination with other symbols as given in IEC 60947-3 or IEC 62626-1.

[b] Function provided only if the device is suitable for isolation and marked with the symbol  (IEC 60417-6169-1:2012-08).

[c] If marked with the symbol  or a combination with other symbols as given in IEC 60947-3.

[d] Only AC plugs and socket-outlets rated at not more than 16 A may be used for functional switching.

[e] Device is suitable for on-load isolation.

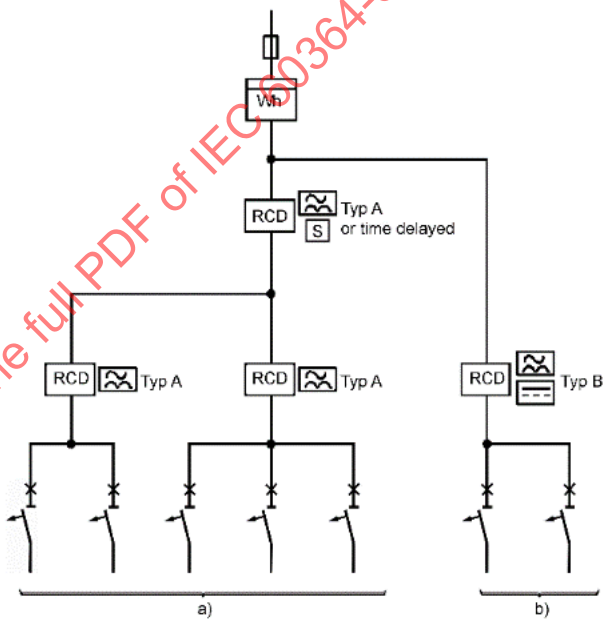
[f] If indicated by the manufacturer.

[g] Link and wiring terminals may provide an isolation function according to the manufacturer's or designer's documentation.

[h] Only a connector with breaking capacity (CBC) is designed to be engaged and disengaged when live or under load (see IEC 61984:2008, 3.8).

Annex F
(informative)

List of notes concerning certain countries

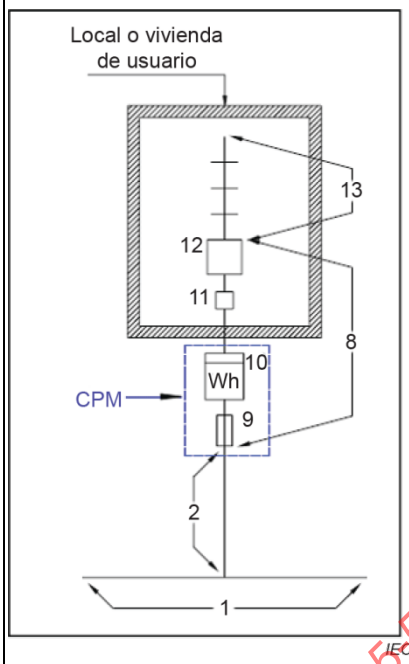
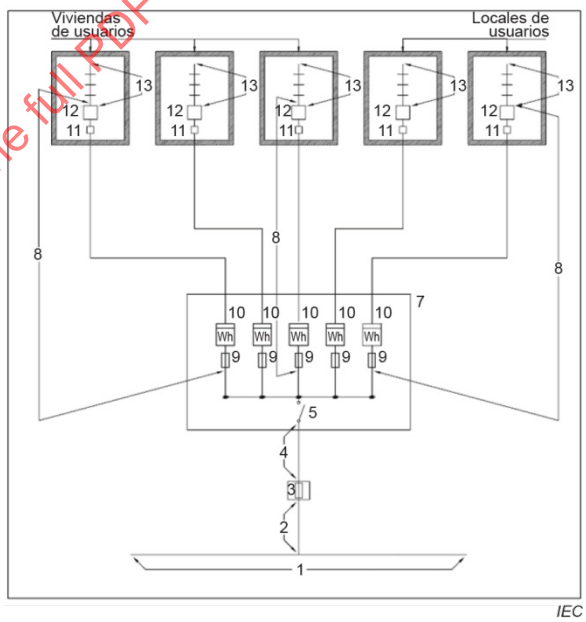
Country	Subclause	Wording
IT	531.2.2.	In Italy only RCDs shall be used for protection against electric shock in TT systems
IT	531.2.2.3	531.2.2.3 In Italy point b) of 531.2.2.3 is not applicable.
AT	531.2.2.3	531.2.2.3 In Austria point b) of 531.2.2.3 is not applicable.
AT	531.2.3.1	NOTE In Austria the recommendation for multiphase supplied installations does not apply.
DE	531.2.3.2	In Germany, the use of short time-delayed residual current devices (RCDs) is acceptable, provided the applicable requirements of IEC 60364-4-41 are met.
DE	531.2.3.3	In Germany, Type AC RCDs are not permitted.
FI	531.2.3.3	In Finland, Type AC RCDs are not permitted.
BE	531.2.3.3.2	In Belgium, the use of an RCD type A upstream of a type B downstream is not allowed in residential installations.
DE	531.2.3.3.2	In Germany, the following figure is applicable:  **Key** a) Circuits with appliances where sinusoidal and/or residual pulsating direct and/or residual pulsating direct fault currents superimposed on a smooth direct current of up to 0,006 A may appear. b) Circuits with appliances where in addition to case a) sinusoidal including high frequencies currents and/or smooth direct current exceeding 0,006 A may appear.
AT	531.2.3.4.1	In Austria, residual current devices shall comply with • IEC 61008 series for RCCBs; or • IEC 61009 series for RCBOs; or • IEC 62423 for RCCBs and RCBOs
CZ	531.2.3.4.1	In the Czech Republic, add IEC 61008-2-2 and IEC 61009-2-2 to 531.2.3.4.1.

Country	Subclause	Wording
GB	531.2.3.4.1	In the United Kingdom, add IEC 61008-2-2 and IEC 61009-2-2 to 531.2.3.4.1.
JP	531.2.3.4.1	In Japan, residual current devices shall comply with: • IEC 61008-1 for RCCBs, or • IEC 61009-1 for RCBOs.
NL	531.2.3.4.1	In the Netherlands, add IEC 61008-2-2 and IEC 61009-2-2 to 531.2.3.4.1.
NO	531.2.3.4.1	In Norway, residual current devices shall comply with: • IEC 61008 (all parts) for RCCBs, or IEC 61009 (all parts) for RCBOs, or • IEC 62423 for RCCBs and RCBOs.
SE	531.2.3.4.1	In Sweden the subclause is replaced by the following: 531.2.3.4.1 In AC installations where RCDs are accessible to ordinary persons (BA1), children (BA2) or handicapped persons (BA3) residual current protective devices shall comply with: • IEC 61008 (all parts) for RCCBs, or • IEC 61009 (all parts) for RCBOs, or • IEC 62423 for RCCBs and RCBOs.
DE	531.2.3.4.2	In Germany, replace the first two bullets with: • IEC 61008-2-1 for RCCBs, or • IEC 61009-2-1 for RCBOs, or
FI	531.2.3.4.2	In Finland replace the first two bullets with: • IEC 61008-2-1 for RCCBs, or • IEC 61009-2-1 for RCBOs, or
FR	531.2.3.4.2	In France replace the first two bullets with: • IEC 61008-2-1 for RCCBs, or • IEC 61009-2-1 for RCBOs, or
GR	531.2.3.4.2	In Greece, replace the first two bullets with: • IEC 61008-2-1 for RCCBs, or • IEC 61009-2-1 for RCBOs, or
IT	531.2.3.4.2	In Italy, in AC installations, where RCDs are accessible only to instructed persons (BA4) or skilled persons (BA5) residual current protective devices shall comply with • IEC 61008-2-1 for RCCBs, or • IEC 61009-2-1 for RCBOs, or • IEC 62423 for RCCBs and RCBOs, or IEC 60947-2 for CBRs and MRCDs.
PL	531.2.3.4.2	In Poland, in AC installations, where RCDs are accessible only to instructed persons (BA4) or skilled persons (BA5) residual current protective devices shall comply with • IEC 61008-2-1 for RCCBs, or • IEC 61009-2-1 for RCBOs, or • IEC 62423 for RCCBs and RCBOs, or • IEC 60947-2 for CBRs and MRCDs.
AT	531.2.3.4.3	NOTE In Austria IEC TS 63053 may not be used as a reference for DC-RCDs.
FR	531.2.3.5.1 531.2.3.5.2 531.2.3.5.3	In France, all live conductors shall be disconnected.

Country	Subclause	Wording
GB	531.2.3.5.1	In the United Kingdom, except in certain special installations or locations (IEC 60364-7 (all parts)), for protection against electric shock, there is no requirement to disconnect/switch the neutral in a TN system.
NO	531.2.3.5.1	In Norway, the neutral conductor is not considered to be reliable at earth potential.
GB	531.2.3.5.2	In the United Kingdom, except in certain special installations or locations ((IEC 60364-7 (all parts)), for protection against electric shock, there is no requirement to disconnect/switch the neutral in a TT system.
IT	531.2.3.5.2	In Italy, only the RCDs are admitted in a TT system.
IT	531.2.3.5.2	In Italy, the formula is replaced by the following formula: $R_E \times I_{dn} \leq U_L$ where: R_E is the resistance in ohms (Ω) of the earth electrode; I_{dn} is the rated residual operating current in amperes (A) of the RCD; U_L is the limit of the conventional touch voltage (V).
AT	531.3.4	In Austria, when there is a protective measure with automatic disconnection of supply already operative upstream an enclosure with double or reinforced insulation, such conductive parts enclosed in the insulating enclosure may be connected to the protective conductor and may be used as protective conductors, if the requirements regarding corrosion resistance and current carrying capacity are satisfied
AT	531.6	In Austria IEC TS 63053 may not be used as a reference for DC-RCDs.
DE	531.6	In Germany, in AC installations, an RCD for protection of socket-outlets shall be installed at the origin of the final circuit except where this protection is provided by RCDs incorporated in or intended for association with socket-outlets.
IT	532.2	In Italy, 532.2 is not applicable. In Italy, the classification and the requirements for the locations with a particular risk of fire are given in Clause 751 "Ambienti a maggior rischio in caso di incendio" of the national standard CEI 64-8.
DE	532.2.2	In Germany, the requirements according to the national "Muster-Richtlinie über brandschutztechnische Anforderungen an Leitungsanlagen (Muster-Leitungsanlagen-Richtlinie MLAR)" apply.
DE	532.2.3.2	In Germany, RCDs type AC are not permitted.
ZA	532.2.3.2	In South Africa, the use of products complying with IEC 61008 and IEC 61009 is prohibited.
DE	532.2.3.3	In Germany, the paragraph is replaced with: **532.2.3.3 Selection of residual current monitoring devices (RCMs) in TN- and TT-Systems** Residual current monitoring devices (RCMs) shall comply with IEC 62020. Where a residual current monitoring device (RCM) is selected for prevention of the risk of fire, the rated residual warning level shall not exceed 300 mA. It is recommended to set the response value to a reasonable lower value to indicate a fault as early as possible.
DE	533.1.2.1	In Germany, IEC 61009-2-2 does not apply

Country	Subclause	Wording
GB	533.1.2.1	In the United Kingdom, a device for protection against overcurrent shall comply with one or more of the following standards: – BS 88 series – BS 646 – BS 1362 – BS 3036 – BS EN 60898-1 and -2 – BS EN 60947-2, -3 and -6-2 – BS EN 60947-4-1, -6-1 and -6-2 – BS EN 61009-1, -2-1 and BS IEC 61009-2-2 – BS EN 62423. The use of another device is not precluded provided that its time/current characteristics provide a level of protection not less than that given by the devices listed above. The following protective devices may be used only for protection against short-circuit current and earth fault current: – instantaneous trip circuit-breakers (ICB) in accordance with BS EN 60947-2:2017, Annex O; – aM and aR type fuses in accordance with HD 60269-2 or HD 60269-3.
DE	533.1.2.1, 1st paragraph	In Germany, DIN VDE 0641-21 (VDE 0641-21) also applies.
US	533.2.1	In the United States, the requirements for overcurrent and overload protection are specified in the NEC, NFPA 70.
NO	533.2.1, 1st paragraph	In Norway, the following apply in addition to the requirements of a) –c): When the protective device is protecting a wiring system insulated with PVC and with cross-sectional area not exceeding 4 mm^2, the rated current shall be: – 10 A or less for a wiring system with cross-sectional area 1,5 mm^2 installed in accordance to reference installation method A1 or A2 in IEC 604364-5-52:2009, Table B.52.1; – 13 A or less for a wiring system with cross-sectional area 1,5 mm^2 installed in accordance to reference installation method different from A1 and A2 of IEC 604364-5-52:2009, Table B.52.1; – 16 A or less for wiring system with cross-sectional area 2,5 mm^2; – 20 A or less for wiring system with cross-sectional area 4 mm^2 installed in accordance to reference installation method A1 or A2 of IEC 604364-5-52:2009, Table B.52.1; – 25 A or less for wiring system with cross-sectional area 4 mm^2 installed in accordance to reference installation method different from A1 and A2 of IEC 604364-5-52:2009, Table B.52.1.
DE	533.2.1, Note 1	In Germany, DIN VDE 0641-21 (VDE 0641-21) also applies.
DE	533.2.1	In Germany, the following requirement is not applicable: Where the copper equivalent cross-sectional area of the neutral conductor is less than that of the line conductors, overload protection for the neutral conductor shall be provided in accordance with IEC 60364-4-43. For the purposes of this requirement, the current carrying capacity for the neutral conductor shall be ascertained, for example by obtaining it from the manufacturer. NOTE 2 The current-carrying capacity of the neutral conductor can be considered to be that of a circuit with conductors having the same cross-sectional area, construction and installation conditions (e.g. ambient temperature and grouping) as the neutral conductor, determined in accordance with IEC 60364-5-52:2009, Clause 523.
DE	533.3.1.1	In Germany, the following Note is added at the end of the subclause: NOTE 3 If circuit-breakers are used for overcurrent protection, this condition is met if the circuit-breakers fulfil the requirements of the energy limiting class 3 according to EN 60898-1.

Country	Subclause	Wording
DE	533.3.1.1	In Germany, the following requirement is added at the end of the subclause: Circuit-breakers shall have a making and breaking capacity of at least 6 kA. If applicable, these circuit-breakers shall fulfil the requirements of energy limiting class 3 according to EN 60898-1.
DE	533.3.2	In Germany, circuit-breakers shall have a making and breaking capacity of at least 6 kA. If applicable, these circuit-breakers shall fulfil the requirements of energy limiting class 3 according to EN 60898-1.
DE	533.4.2.2	In Germany, Annex A is not applicable,
DE	533.4.2.3	In Germany, devices for protection against overload need not be provided also in the following situation: c) in distribution circuits comprising cables laid in the ground or overhead lines where overloading of the circuits will not cause danger
DE	533.4.3.2	In Germany, NOTE 1 is as follows: NOTE 1 This condition may be obtained for example by reinforcing the protection of the wiring against external influences, ensuring inherently short-circuit and earth fault proof installation.
DE	533.4.3.2	In Germany, Annex B is not applicable.
DE	533.4.3.4	In Germany, the omission of devices for protection against short-circuit is additionally allowed in distribution circuits comprising cables laid in the ground or overhead lines
DE	534.4.1	In Germany, where the installation of a building is supplied by overhead lines, SPDs shall be class I tested according to Annex D.
FR	534.4.1	In France, the following does not apply: Where the structure is not equipped with an external lightning protection system and where the occurrence of direct lightning strike to the overhead lines between the last pole and the entrance of the installation is to be taken into consideration, class I tested SPDs at or near the origin of the electrical installation may be also selected according to Annex D.
GR	534.4.1	In Greece, the following does not apply: Where the structure is not equipped with an external lightning protection system and where the occurrence of direct lightning strike to the overhead lines between the last pole and the entrance of the installation is to be taken into consideration, class I tested SPDs at or near the origin of the electrical installation may be also selected according to Annex D.
HU	534.4.1	In Hungary, the following does not apply: Where the structure is not equipped with an external lightning protection system and where the occurrence of direct lightning strike to the overhead lines between the last pole and the entrance of the installation is to be taken into consideration, class I tested SPDs at or near the origin of the electrical installation may be also selected according to Annex D.

Country	Subclause	Wording
ES	534.4.1	In Spain, the origin of the installation can be the location where the supply enters the building and/or the main distribution board.  **Key** 1 Public supply; 2 Supply cable (owned by utility); 8 Individual distribution circuit; 9 Fuse (cut out);10 Meter; 11 Main Circuit Breaker; 12 Switchboard; 13 Private installation **Figure F.1 – Single user**  **Key** 1 Public supply; 2 Supply cable (owned by utility); 4 Supply cable of the private installation; 5 Main switching device; 7 Meters room; 8 Individual distribution circuit; 9 Fuse (cut out);10 Meter; 11 Main Circuit Breaker; 12 Switchboard; 13 Private installation **Figure F.2 – Several users**

<table>
<tr><th>Country</th><th>Subclause</th><th>Wording</th></tr>
<tr><td>DE</td><td>534.4.3</td><td>In Germany, the restriction to a maximum distance of 0,5m is the only requirement to be considered.</td></tr>
<tr><td>NO</td><td>534.4.4.3</td><td>In Norway, where the installation is galvanically connected to a public IT-distribution network, the minimum required U_c for a SPD located at the origin of the installations shall be at least 350 V.</td></tr>
<tr><td>DE</td><td>534.4.4.4.1</td><td>Class II tested SPDs installed at or near the origin of installations with increased safety level, where the installation effects e.g. a) care of human life, b) public services and cultural heritage, their nominal discharge current (I_n) shall not be less than given in Table 3 below:

Table 3 – I_n (kA) depending on supply system and connection type for installation with increased safety level
<table><tr><th rowspan="2">Connection</th><th colspan="4">Supply system</th></tr><tr><th colspan="2">Single phase</th><th colspan="2">3 phases</th></tr><tr><th>CT1</th><th>CT2</th><th>CT1</th><th>CT2</th></tr><tr><td>L - N</td><td></td><td>10</td><td></td><td>10</td></tr><tr><td>L - PE</td><td>10</td><td></td><td>10</td><td></td></tr><tr><td>N – PE</td><td>10</td><td>20</td><td>10</td><td>40</td></tr></table></td></tr>
<tr><td>NO</td><td>534.4.4.5</td><td>In Norway, where the installation is galvanically connected to a public IT-distribution network, and where a second SPD is installed downstream of the SPD located in the main distribution board, the maximum continuous operating voltage, U_c, for the second SPD shall be at least 440 V between line conductors and PE, and at least 275 V between line conductors.</td></tr>
<tr><td>AT</td><td>534.4.6</td><td>In Austria, the SPD assembly at or near the origin of the installation may not be installed downstream of any RCD.</td></tr>
<tr><td>DE</td><td>534.4.6</td><td>In order to avoid false tripping or welding of the RCD contacts, the flow of high impulses currents or partial lightning currents should be avoided. Therefore, SPDs tested in accordance with test class I or test class II should be installed on the line side of an RCD. If the surge is expected from the load side, e.g. due to external mounted equipment, not protected by a LPS, SPDs tested in accordance with test class I or test class II should be installed on the loud side of an RCD.</td></tr>
<tr><td>NO</td><td>534.4.6</td><td>In Norway, where the installation is galvanically connected to a public IT or TT distribution network without the provision of a distributed PE conductor (i.e. installation supplied by overhead lines), protection against fire caused by a failure of the SPD located in the main distribution board shall be ensured by:

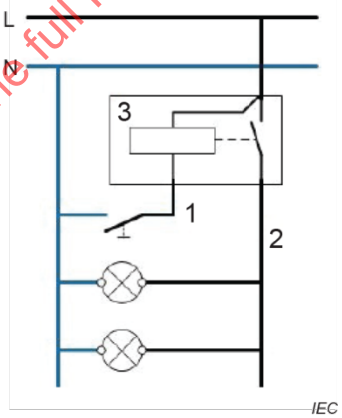
– locating the SPD in a separate enclosure of non-combustible materials; or

– protecting the SPD by a time-delayed RCD (S-type or similar) with a rated residual operating current not exceeding 300 mA; or

– using an SPD constructed so as to minimize the risk of damage and fire due to an earth failure in the high-voltage distribution network.</td></tr>
<tr><td>DE</td><td>534.4.7</td><td>It should be ensured that lightning currents or high impulse currents will not flow through the RCD. Therefore the installation of class I tested SPDs downstream the RCD is not admissible, except partial lightning currents may be expected from the load side of the RCD.

The installation of class II tested SPDs downstream of the RCD is admissible, only if already a class II tested SPD is installed upstream of the RCD or if impulse currents are expected from the load side of the RCD.

In case of surge currents higher than 3 kA 8/20, the RCD may trip causing interruption of the power supply.</td></tr>
<tr><td>AT</td><td>534.4.7</td><td>In Austria, the SPD assembly at or near the origin of the installation may not be installed downstream of any RCD.</td></tr>
<tr><td>DE</td><td>Annex D</td><td>In Germany, Annex D is normative</td></tr>
<tr><td>FR</td><td>Annex D</td><td>Annex D does not apply</td></tr>
<tr><td>GR</td><td>Annex D</td><td>Annex D does not apply</td></tr>
<tr><td>HU</td><td>Annex D</td><td>Annex D does not apply</td></tr>
</table>

Country	Subclause	Wording
DE	536.2.1.1	In Germany, the text of clause 536.2.1.1 is replaced by the following: Each electrical installation shall have provisions for isolation from each supply. Every circuit shall be capable of being isolated from all live conductors except as described in the following two paragraphs: In TN-C systems and in the TN-C part of the TN-C-S systems, the PEN conductor shall not be isolated or switched. The neutral conductor not needed to be isolated or switched in TN-S systems, in the TN-S part of TN-C-S systems or in TT-systems if: – in TN system, following 411.1 and 542.2, a protective equipotential bonding is installed, – in TT system the voltage between N and PE in no cases exceeds the conventional touch voltage. The verification of compliance with this requirement may be done in TT system by taking care of the following relationship: $50\ V \leq I_{Lmax} \cdot 0{,}5 \cdot Z_i$ I_{Lmax} = maximal current in line conductors Z_i = impedance of the grid including the impedances of line conductors and N and the impedance of the source Provisions may be made for isolation of a group of circuits by a common means, if the service conditions allow this
SE	536.3	Due to Swedish legislation concerning machinery the clause 536.3, including its sub-clauses is not applicable for electrical installations.
SE	536.4.3	Due to Swedish legislation concerning machinery the clause 536.4.3 is not applicable for electrical installations
CH	536.5.1.2	In Switzerland, a single-pole switching device in the neutral conductor is not allowed.
DE	536.5.1.2	In Germany, the following is added: An example is given in Figure F.3.  **Key** 1 connection of the control device for lighting circuits 2 circuit supplying the lamps 3 control device **Figure F.3 – Lamp control circuit with switching in the neutral conductor**
NL	536.5.1.2	In the Netherlands, single pole switching in the neutral conductor to a control device is not accepted.
NO	536.5.1.2	In Norway, a single-pole functional switching device shall not be inserted in the neutral conductor.

<table>
<tr><th>Country</th><th>Subclause</th><th>Wording</th></tr>
<tr><td>AT</td><td>537.1</td><td>In Austria, monitoring devices are in general not intended to provide protection against electric shock.
NOTE Exemptions from this general requirement may be provided within relevant parts of HD 60364 (e.g. HD 60364-5-551).</td></tr>
<tr><td>GB</td><td>537.3</td><td>In the United Kingdom, IT public distribution systems are not allowed.</td></tr>
<tr><td>GB</td><td>Table E.1</td><td>In the United Kingdom, the following applies:
<table>
<tr><th>Device</th><th>Standard</th><th>Isolation(4)</th><th>Emergency switching(2)</th><th>Functional switching(5)</th></tr>
<tr><td>Luminaire supporting coupler</td><td>BS 6972</td><td>Yes(3)</td><td>No</td><td>No</td></tr>
<tr><td>Plug and unswitched socket-outlet</td><td>BS 1336-1
BS 1336-2</td><td>Yes(3)
Yes(3)</td><td>No
No</td><td>Yes
Yes</td></tr>
<tr><td>Plug and switched socket-outlet</td><td>BS 1336-1
BS 1336-2</td><td>Yes(3)
Yes(3)</td><td>No
No</td><td>Yes
Yes</td></tr>
<tr><td>Plug and socket-outlet</td><td>BS 5733</td><td>Yes(3)</td><td>No</td><td>Yes</td></tr>
<tr><td>Switched fused connection unit</td><td>BS 1363-4</td><td>Yes(3)</td><td>Yes</td><td>Yes</td></tr>
<tr><td>Unswitched fused connection unit</td><td>BS 1363-4</td><td>Yes(3) (removal of fuse link)</td><td>No</td><td>No</td></tr>
<tr><td>Fuse</td><td>BS 1362</td><td>Yes(3)</td><td>No</td><td>No</td></tr>
<tr><td>Cooker control unit</td><td>BS 4177</td><td>Yes(3)</td><td>Yes</td><td>Yes</td></tr>
</table>
Yes = Function provided, No = Function not provided
(1) Function provided if the device is suitable and marked with the symbol for isolation (see BS EN 60617 Identity number S00288
(2) See Regulation 537.3.3.6 of BS 7671 (2018)
(3) Device is suitable for on-load isolation, i.e. disconnection whilst carrying load current</td></tr>
<tr><td>DE</td><td>Table E.1</td><td>In Germany the following applies:
– Add to row “Circuit-breakers”:
DIN VDE 0641-21 Yes – Yes d – Yes
– Add to row “Residual current protective devices (RCDs)”
DIN VDE 0664-400 Yes – Yes d – Yes
DIN VDE 0664-401 Yes – Yes d – Yes
DIN VDE 0664-101 Yes – Yes d – Yes
– Replace in row “Plugs and socket-outlets”
IEC 60884 (all parts) and IEC 60906 (all parts) with DIN VDE 0620 (all parts)</td></tr>
</table>

Annex G
(informative)

Description of the different types of residual current devices (RCDs)

G.1 Description of RCD types

Different types of RCDs exist depending on their behaviour in the presence of DC components and frequencies other than the rated frequency:

RCD Type AC:

An RCD for which tripping is ensured for residual sinusoidal alternating currents, whether suddenly applied or slowly rising.

RCD Type A:

An RCD for which tripping is ensured

- as for type AC,
- for residual pulsating direct currents, and
- for residual pulsating direct currents superimposed on a smooth direct current of 0,006 A,

with or without phase-angle control, independent of polarity, whether suddenly applied or slowly rising.

NOTE 1 According to IEC 61140, pluggable electrical equipment on a rated input ≤ 4 kVA are designed to have protective conductor current on a smooth superimposed DC current component limited to 6 mA.

RCD Type F:

An RCD for which tripping is ensured

- as for Type A,
- for composite residual currents which may result from circuits supplied between phase and neutral or phase and earthed middle conductor, as given in IEC 60755:2017, and
- for residual pulsating direct currents superimposed on smooth direct current of 0,01 A.

The above specified residual currents may be suddenly applied or slowly rising.

NOTE 2 Operation in the case of alternating current superimposed on smooth DC residual current is assumed to be covered by the test of pulsating DC superimposed on smooth DC residual current.

RCD Type B:

An RCD for which tripping is ensured as for Type F and in addition:

- for residual sinusoidal alternating currents up to 1 000 Hz;
- for residual alternating currents superimposed on a smooth direct current of 0,4 times the rated residual current ($I_{\Delta n}$);
- for residual pulsating direct currents superimposed on a smooth direct current of 0,4 times the rated residual current ($I_{\Delta n}$) or 10 mA, whichever is the highest value;
- for residual direct currents which may result from rectifying circuits, i.e.
  - two-pulse bridge connection line to line for 2-, 3- and 4-pole devices;

– three-pulse star connection or six-pulse bridge connection for 3- and 4-pole devices;

- for residual smooth direct currents.

The above specified residual currents may be suddenly applied or slowly increased independent of polarity.

G.2 Examples of use of RCD types

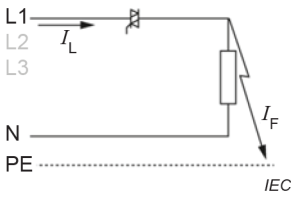
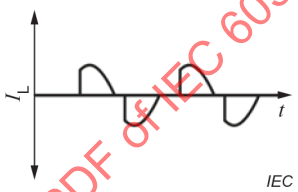
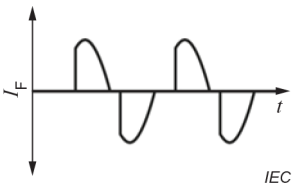
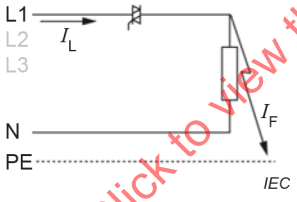
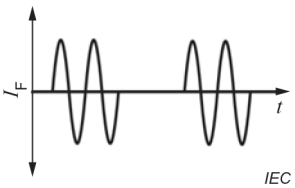
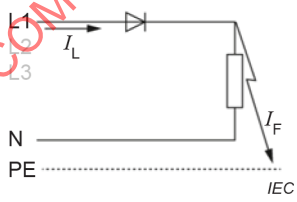
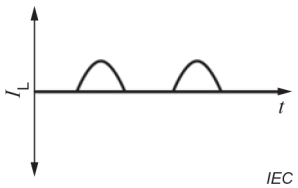
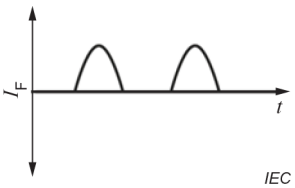
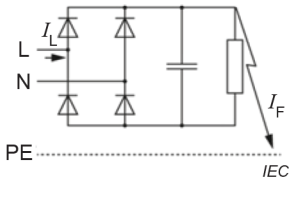
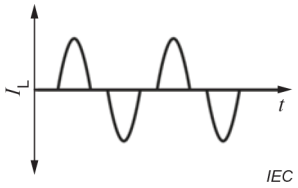
RCDs of type AC are typically used for general applications.

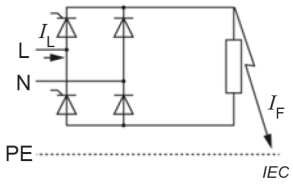
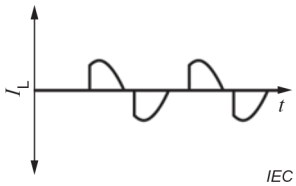
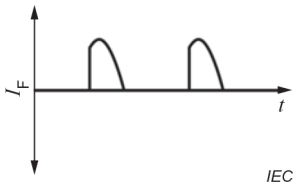
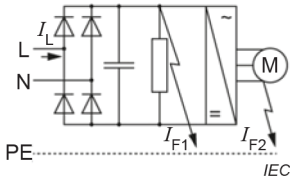
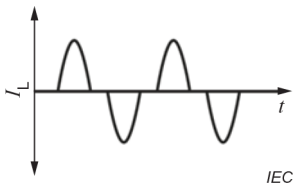
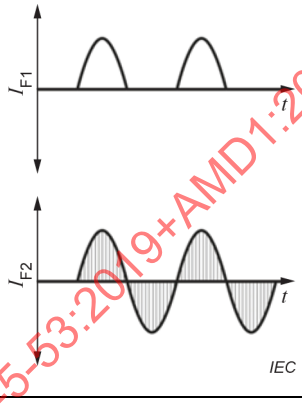
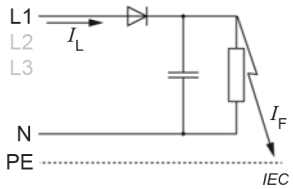
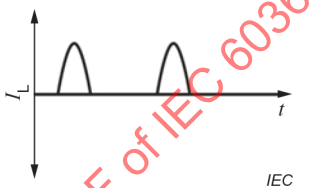
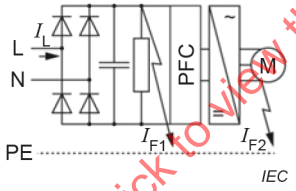
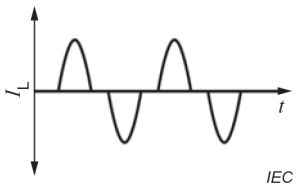
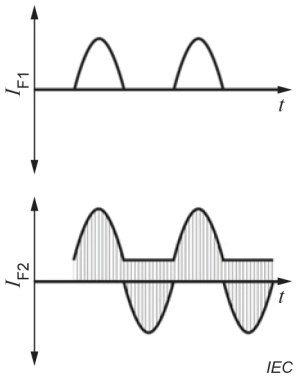
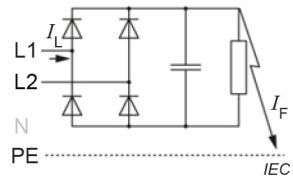
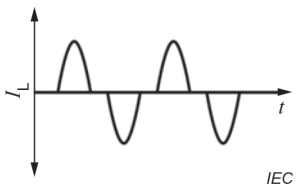
RCDs of type A are typically used for circuits where there is a risk of residual current with DC components (e.g. Class I equipment containing rectifiers).

RCDs of type F are typically used for circuits where there is a risk of residual current containing DC components and chopping frequency currents (e.g. class I equipment containing single phase frequency converters).

RCDs of type B are typically used for circuits supplying multi-phase frequency converters.

Examples are referred to in Figure G.1.

	Circuit diagram with fault location	Shape of load current I_L	Shape of earth fault current I_F	RCD type characteristic
1	Phase control 			**AC, A, F, B**
2	Burst control 			**AC, A, F, B**
3	Single-phase 			**A, F, B**
4	Two-pulse bridge 			**A, F, B**

	Circuit diagram with fault location	Shape of load current I_L	Shape of earth fault current I_F	RCD type characteristic
5	Two-pulse bridge, half controlled 			A, F, B
6	Frequency inverter with two-pulse bridge 			F, B
7	Single-phase with smoothing 			B
8	Frequency inverter with two-pulse bridge and PFC 			B
9	Two-pulse bridge between phases 			B

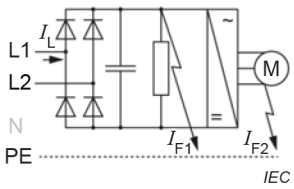
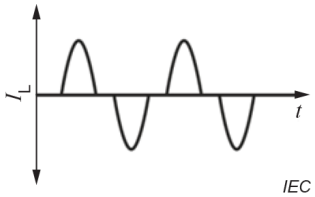
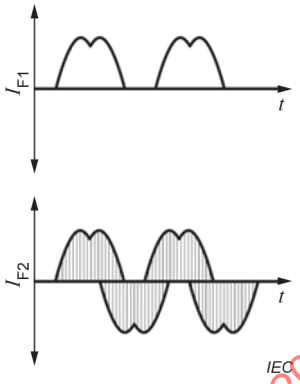
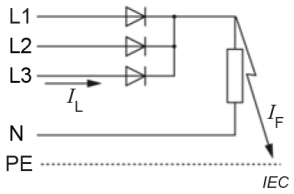
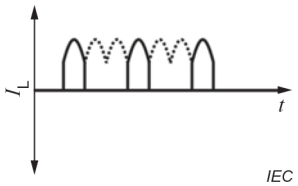
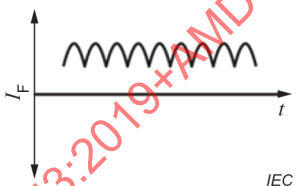
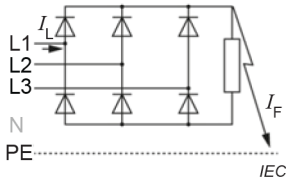
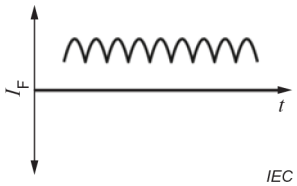
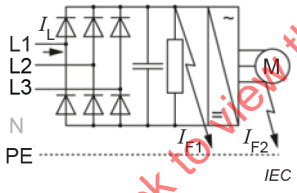
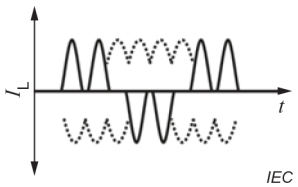
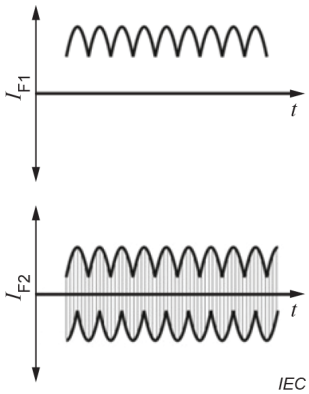
	Circuit diagram with fault location	Shape of load current I_L	Shape of earth fault current I_F	RCD type characteristic
10	Frequency inverter with two-pulse bridge between phases 			B
11	Three-phase star 			B
12	Six-pulse bridge 			B
13	Frequency inverter with six-pulse bridge 			B

Figure G.1 – Possible earth fault currents in systems with semiconductors

Annex H
(informative)

Additional information for the application of DC SPDs

H.1 General

As there is a diversity of voltages used in DC systems, other system parameters may vary over a wide range depending on the application, equipment and component used.

Owing to the varying parameters of such DC systems, only SPDs especially dedicated to DC systems should be used. The manufacturer of SPDs should give the relevant information.

IEC 60364-4-44:2024, Clause 442 is applicable only for AC systems. For DC systems, which are galvanically coupled to an AC system, it is necessary to consider how the potential temporary overvoltages (TOVs) from the AC system and as specified in IEC 60364-4-44:2024, Clause 442 are transferred to the DC system. For temporary overvoltages caused by faults within a DC system, the corresponding data based on the DC system characteristics shall be taken into consideration.

IEC 60364-4-44:2024, Clause 443 is applicable for both AC and DC applications and additional requirements for DC systems are not necessary.

NOTE The specific risk of switching overvoltages in DC applications is under consideration.

Therefore, the parameters specified in Clause H.2 are provided for the selection and installation of SPDs and the corresponding design of the installation.

H.2 Parameters for the selection of SPDs in DC applications

The following parameters should be considered:

– maximum operating voltage of the DC application;
– nominal DC voltage of the DC application;
– minimum and maximum prospective short circuit currents at the point where the SPD is installed;
– type of source (linear or non-linear) and characteristics of non-linear source;
– nominal DC current of the supply(ies) of the DC application;
– expected temporary overvoltages which can occur in the DC application, either from an AC application which is galvanically coupled to the DC application, or caused by a fault within a DC application;
– expected amplitude and energy content of switching surges due to supply or load switching;
– transfer effects due to supply or load switching;
– configuration of the DC application as related to its connection to an AC application and its earthing;
– expected AC/DC stress voltage between live conductor and earth, under normal and fault conditions;
– expected wave shape of the fault current during fault conditions;
– applicable overvoltage category (OVC).

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IEC 60364-1:2005, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60364-5-51:2005, *Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules*

IEC 60364-5-52:2009, *Low-voltage electrical installations – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

IEC 60670 (all parts), *Boxes and enclosures for electrical accessories for household and similar fixed electrical installations*

IEC 60755:2017, *General safety requirements for residual current operated protective devices*

IEC 61084 (all parts), *Cable trunking systems and cable ducting systems for electrical installations*

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61439 (all parts), *Low-voltage switchgear and controlgear assemblies*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and similar products for supply voltages up to 1 100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

IEC 61643-41[1], *Low-voltage surge protective devices – Part 41: Surge protective devices connected to DC low-voltage power systems – Requirements and test methods*

IEC 62640, *Residual current devices with or without overcurrent protection for socket-outlets for household and similar uses*

IEC TS 63053, *General requirements for residual current operated protective devices for DC system*

[1] First edition under preparation. Stage at the time of publication: IEC CDV 61643-41:2023.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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LOW-VOLTAGE ELECTRICAL INSTALLATIONS –

Part 5-53: Selection and erection of electrical equipment – Devices for protection for safety, isolation, switching, control and monitoring

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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This consolidated version of the official IEC Standard and its amendments has been prepared for user convenience.

IEC 60364-5-53 edition 4.2 contains the fourth edition (2019-02) [documents 64/2352/FDIS and 64/2359/RVD], its amendment 1 (2020-12) [documents 64/2457/FDIS and 64/2465/RVD] and its amendment 2 (2024-12) [documents 64/2648/FDIS and 64/2738/RVD].

This Final version does not show where the technical content is modified by amendments 1 and 2. A separate Redline version with all changes highlighted is available in this publication.

International Standard IEC 60364 has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This fourth edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) revision of all clauses except 531 and 534;
b) introduction of a new Clause 537 Monitoring;
c) Clause 530 contains all normative references and all terms and definitions.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The reader's attention is drawn to the fact that Annex F lists all of the "in-some-country" clauses on differing practices relating to the subject of this standard.

A list of all parts in the IEC 60364 series, published under the general title *Low-voltage electrical installations*, can be found on the IEC website.

The committee has decided that the contents of this document and its amendments will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

IMPORTANT – The *'colour inside'* logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

LOW-VOLTAGE ELECTRICAL INSTALLATIONS –

Part 5-53: Selection and erection of electrical equipment – Devices for protection for safety, isolation, switching, control and monitoring

530.1 Scope

This document provides requirements for:

a) isolation, switching, control and monitoring, and

b) selection and erection of:

   1) devices for isolation, switching, control and monitoring, and

   2) devices to achieve compliance with measures of protection for safety.

530.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60204-1, *Safety of machinery – Electrical equipment of machines – Part 1: General requirements*

IEC 60269-2, *Low-voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to K*

IEC 60269-3, *Low-voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications) – Examples of standardized systems of fuses A to F*

IEC 60269-4, *Low-voltage fuses – Part 4: Supplementary requirements for use-links for the protection of semiconductor devices*

IEC 60309 (all parts), *Plugs, socket-outlets and couplers for industrial purposes*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*
IEC 60364-4-41:2005/AMD1:2017

IEC 60364-4-42:2010, *Low-voltage electrical installations – Part 4-42: Protection for safety – Protection against thermal effects*
IEC 60364-4-42:2010/AMD1:2014

IEC 60364-4-43:2008, *Low-voltage electrical installations – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-4-44:2007, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*
IEC 60364-4-44:2007/AMD1:2015

IEC 60364-5-55, *Electrical installations of buildings – Part 5-55: Selection and erection of electrical equipment – Other equipment*

IEC 60364-6:2016, *Low voltage electrical installations– Part 6: Verification*

IEC 60417 (all parts), *Graphical symbols for use on equipment*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60669-1, *Switches for household and similar fixed-electrical installations – Part 1: General requirements*

IEC 60669-2-1, *Switches for household and similar fixed electrical installations – Part 2-1: Particular requirements – Electronic switches*

IEC 60669-2-2, *Switches for household and similar fixed electrical installations – Part 2-2: Particular requirements – Electromagnetic remote-control switches (RCS)*

IEC 60669-2-3, *Switches for household and similar fixed electrical installations – Part 2-3: Particular requirements – Time-delay switches (TDS)*

IEC 60669-2-4, *Switches for household and similar fixed electrical installations – Part 2-4: Particular requirements – Isolating switches*

IEC 60669-2-5, *Switches for household and similar fixed electrical installations – Part 2-5: Particular requirements – Switches and related accessories for use in home and building electronic systems (HBES)*

IEC 60669-2-6, *Switches for household and similar fixed electrical installations – Part 2-6: Particular requirements – Fireman's switches for exterior and interior signs and luminaires*

IEC 60670-24, *Boxes and enclosures for electrical accessories for household and similar fixed electrical installations – Part 24: Particular requirements for enclosures for housing protective devices and other power dissipating electrical equipment*

IEC 60884 (all parts), *Plugs and socket-outlets for household and similar purposes*

IEC 60898 (all parts), *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations*

IEC 60906 (all parts), *IEC system of plugs and socket-outlets for household and similar purposes*

IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

IEC 60947-3, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-4-1, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

IEC 60947-4-2, *Low-voltage switchgear and controlgear – Part 4-2: Contactors and motor-starters – AC semiconductor motor controllers and starters*

IEC 60947-4-3, *Low-voltage switchgear and controlgear – Part 4-3: Contactors and motor-starters – AC semiconductor controllers and contactors for non-motor loads*

IEC 60947-5-1, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 60947-6-1, *Low-voltage switchgear and controlgear – Part 6-1: Multiple function equipment – Transfer switching equipment*

IEC 60947-6-2, *Low-voltage switchgear and controlgear – Part 6-2: Multiple function equipment – Control and protective switching devices (or equipment) (CPS)*

IEC 61008 (all parts), *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs)*

IEC 61009 (all parts), *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)*

IEC 61095, *Electromechanical contactors for household and similar purposes*

IEC 61439-2, *Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies*

IEC 61439-3, *Low-voltage switchgear and controlgear assemblies – Part 3: Distribution boards intended to be operated by ordinary persons (DBO)*

IEC 61439-6, *Low-voltage switchgear and controlgear assemblies – Part 6: Busbar trunking systems (busways)*

IEC 61534 (all parts), *Powertrack systems*

IEC 61557-8, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 8: Insulation monitoring devices for IT systems*

IEC 61557-9, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 9: Equipment for insulation fault location in IT systems*

IEC 61643-11, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*

IEC 61643-12, *Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles*

IEC 61984:2008, *Connectors – Safety requirements and tests*

IEC 61995 (all parts), *Devices for the connection of luminaires for household and similar purposes*

IEC 62020, *Electrical accessories – Residual current monitors for household and similar uses (RCMs)*

IEC 62208, *Empty enclosures for low-voltage switchgear and controlgear assemblies – General requirements*

IEC 62305 (all parts), *Protection against lightning*

IEC 62423, *Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses*

IEC 62606, *General requirements for arc fault detection devices*

IEC 62626-1, *Low-voltage switchgear and controlgear enclosed equipment – Part 1: Enclosed switch-disconnectors outside the scope of IEC 60947-3 to provide isolation during repair and maintenance work*

530.3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp.

530.3.1
disconnector
mechanical switching device which in the open position complies with the requirements specified for the isolating function

Note 1 to entry: A disconnector is capable of opening and closing a circuit when either negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the poles of the disconnector occurs. It is also capable of carrying currents under normal circuit conditions and carrying for a specified time currents under abnormal conditions such as those of short-circuit.

[SOURCE: IEC 60050-441:2000, 441-14-05, modified – Referring to isolating function instead of isolating distance.]

530.3.2
switch disconnector
switch which, in the open position, satisfies the isolating requirements specified for a disconnector

[SOURCE: IEC 60050-441:1984, 441-14-12]

530.3.3
mechanical switch
device capable of making, carrying and breaking currents through contacts controlled by mechanical operation under normal circuit conditions which may include specified operating overload conditions and also carrying for specified time currents under specified abnormal circuit conditions such as those of short-circuit

Note 1 to entry: A switch can be capable of making but not breaking short-circuit currents.

[SOURCE: IEC 60050-441:2000, 441-14-10, modified – "through contacts controlled by mechanical operation" has been added.]

530.3.4
switching-off for mechanical maintenance
opening operation of a switching device intended to inactivate an item or items of electrically powered equipment for the purpose of preventing a hazard, other than due to electric shock or to arcing, during non-electrical work on the equipment

[SOURCE: IEC 60050-826:2004, 826-17-02]

530.3.5
emergency switching-off
opening operation of a switching device intended to remove electric power from an electrical installation to avert or alleviate a hazardous situation

[SOURCE: IEC 60050-826:2004, 826-17-03]

530.3.6
emergency stopping
operation intended to stop as quickly as possible a movement which has become dangerous

[SOURCE: IEC 60050-826:2004, 826-17-04]

530.3.7
functional switching
operation intended to switch on or off or vary the supply of electric energy to an electrical installation or parts of it for normal operating purposes

[SOURCE: IEC 60050-826:2004, 826-17-05]

530.3.8
SPD assembly
one SPD or a set of SPDs, in both cases including all SPD disconnectors required by the SPD manufacturer, providing the required overvoltage protection for a type of system earthing

530.3.9
SPD disconnector
disconnector
device for disconnecting an SPD, or part of an SPD, from the power system

Note 1 to entry: This disconnecting device is not required to have isolating capability for safety purposes. It is to prevent a persistent fault on the system and is used to give an indication of an SPD's failure. Disconnectors can be internal (built in) or external (required by the manufacturer). There may be more than one disconnector function, for example an overcurrent protection function and a thermal protection function. These functions may be in separate units.

[SOURCE: IEC 61643-11:2011, 3.1.28]

530.3.10
mode of protection of an SPD
intended current path, between terminals that contains protective components, e.g. line-to-line, line-to-earth, line-to-neutral, neutral-to-earth

[SOURCE: IEC 61643-11:2011, 3.1.8]

530.3.11
follow current interrupt rating
I_{fi}
prospective short-circuit current that an SPD is able to interrupt without operation of a disconnector

[SOURCE: IEC 61643-11:2011, 3.1.39]

530.3.12
short-circuit current rating
I_{SCCR}
maximum prospective short-circuit current from the power system for which the SPD, in conjunction with the disconnector specified, is rated

[SOURCE: IEC 61643-11:2011, 3.1.27]

530.3.13
voltage protection level
U_P
maximum voltage to be expected at the SPD terminals due to an impulse stress with defined voltage steepness and an impulse stress with a discharge current with given amplitude and waveshape

Note 1 to entry: The voltage protection level is given by the manufacturer and may not be exceeded by:

- the measured limiting voltage determined for front-of-wave sparkover (if applicable) and the measured limiting voltage determined from the residual voltage measurements at amplitudes corresponding to I_n and/or I_{imp} respectively for test classes II and/or I;
- the measured limiting voltage at the open circuit voltage of the combination wave generator (U_{OC}), determined for the combination wave for test class III.

[SOURCE: IEC 61643-11:2011, 3.1.14]

530.3.14
rated impulse voltage
U_W
impulse withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against transient overvoltages

[SOURCE: IEC 60664-1:2007, 3.9.2]

530.3.15
maximum continuous operating voltage
U_C
maximum RMS voltage, which may be continuously applied to the SPD's mode of protection

Note 1 to entry: The U_C value covered by this document may exceed 1 000 V.

[SOURCE: IEC 61643-11:2011, 3.1.11]

530.3.16
nominal discharge current for class II test
I_n
crest value of the current through the SPD having a current waveshape of 8/20 µs

[SOURCE: IEC 61643-11:2011, 3.1.9]

530.3.17
impulse discharge current for class I test
I_{imp}
crest value of a discharge current through the SPD with specified charge transfer Q and specified energy W/R in the specified time

[SOURCE: IEC 61643-11:2011, 3.1.10]

530.3.18
two-port SPD
SPD having specific series impedance connected between separate input and output connections

[SOURCE: IEC 61643-11:2011, 3.1.3]

530.4 General and common requirements

530.4.1

Equipment for protection, isolation, switching, control and monitoring shall be selected and erected to provide for the safety and proper functioning for the intended use of the installation.

Such equipment shall be selected and erected so as to allow compliance with the requirements stated in this document and the relevant requirements in other parts of IEC 60364.

530.4.2

Except as provided in 536.2.2.7 and 536.5.1.2, an independently operated single-pole protective or switching device shall not be inserted in the neutral conductor.

530.4.3

Devices providing more than one function shall comply with all the requirements of this document appropriate to each separate function.

530.5 Erection of equipment

530.5.1

Equipment shall be erected in such a way that connections between wiring and equipment shall not be subject to undue stress or strain resulting from the foreseen use of the equipment.

530.5.2

Unenclosed type equipment shall be mounted in a suitable mounting box or enclosure in compliance with a relevant standard.

NOTE Examples of relevant standards are IEC 60670 (all parts), IEC 62208, IEC 61439 (all parts), and IEC 61084 (all parts).

531 Equipment for protection against electric shock

531.1 General

Clause 531 deals with requirements for the selection and erection of equipment for the following protective measures in accordance with IEC 60364-4-41:

- automatic disconnection of supply,
- double or reinforced insulation,
- electrical separation,
- extra-low-voltage provided by SELV and PELV systems.

It also deals with requirements for the selection and erection of equipment for additional protection.

531.2 Devices for automatic disconnection of supply

531.2.1 General

Devices used for automatic disconnection of supply shall be placed at the origin or upstream of the circuit which is intended to be protected.

These devices shall be suitable for isolation in accordance with 536.

NOTE 1 Protective devices which require manual operation in order to achieve isolation are not excluded.

The following protective devices may be used:

– overcurrent protective devices in accordance with 531.2.2;
– residual current protective devices (RCDs) in accordance with 531.2.3.

Devices according to IEC 60947-2 identified with voltage value(s) followed by the symbol  (IEC 60417-6363:2016-07-16) or by the symbol shall not be used in IT systems for such voltage(s) or above.

Devices according to IEC 60947-2 identified with the symbol  (IEC 60417-6363:2016-07-16) or by the symbol with no associated voltage value, shall not be used in IT systems.

NOTE 2 The symbol  previously required will be progressively superseded by the preferred new symbol above.

531.2.2 Overcurrent protective devices

531.2.2.1 TN system

An overcurrent protective device shall be so selected that its operating characteristics meet the following requirement:

$$I_a \leq \frac{U_o}{Z_s}$$

where

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.3.

Z_s is the impedance in ohms (Ω) of the fault loop comprising
  – the source,
  – the line conductor up to the point of the fault, and
  – the protective conductor between the point of the fault and the source;

U_o is the nominal AC or DC line-to-earth voltage in volts (V).

531.2.2.2 TT system

According to IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD 1:2017, 411.5.2, RCDs shall generally be used for protection against electric shock in TT systems.

Overcurrent protective devices may alternatively be used for this purpose, provided a suitably low value of earth fault loop impedance is permanently and reliably ensured.

Where, exceptionally, an overcurrent protective device is used for this purpose, it shall be so selected that its operating characteristics meet the following requirement.

$$I_a \leq \frac{U_o}{Z_s}$$

where

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.4;

Z_s is the impedance in ohms (Ω) of the fault loop comprising

- the source,
- the line conductor up to the point of the fault,
- the protective conductor of the exposed-conductive-parts,
- the earthing conductor,
- the earth electrode of the installation, and
- the earth electrode of the source;

U_o is the nominal AC or DC line-to-earth voltage in volts (V).

531.2.2.3 IT system

Devices shall be suitable for IT systems in accordance with the manufacturer instructions.

The overcurrent protective devices shall be so selected that their operating characteristics comply with the following requirement:

a) Where exposed-conductive-parts are interconnected by a protective conductor collectively earthed to the same earthing arrangement, the following conditions shall be fulfilled:

- where the neutral or mid-point conductor is not distributed:

$$I_a \leq \frac{U}{2Z_s}$$

- or where the neutral or mid-point conductor is distributed:

$$I_a \leq \frac{U_o}{2Z'_s}$$

where

U is the nominal AC or DC voltage in volts (V) between line conductors;

U_o is the nominal AC or DC voltage in volts (V) between line conductor and neutral or mid-point conductor, as appropriate;

Z_s is the impedance in ohms (Ω) of the fault loop comprising the line conductor and the protective conductor of the circuit;

Z'_s is the impedance in ohms (Ω) of the fault loop comprising the neutral or mid-point conductor and the protective conductor of the circuit;

I_a is the current in amperes (A) causing operation of the protective device within the time required for TN systems in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.3.

NOTE The factor 2 in both formulas takes into account that in the event of the simultaneous occurrence of two faults, the faults may exist in different circuits.

b) Where the exposed-conductive-parts are earthed in groups or individually, the following condition applies:

- In alternating current

$$I_a \leq \frac{50}{R_A}$$

where

R_A is the sum of the resistances in ohms (Ω) of the earth electrode and the protective conductor to the exposed-conductive-parts;

I_a is the current in amperes (A) causing automatic disconnection of the protective device in a time complying to that for TT systems in IEC 60364-4-41:2005 and IEC 60364-4-41: 2005/AMD1:2017, 411.3.2.2 or 411.3.2.4.

In direct current, in accordance with IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.6.2, no requirement is needed.

531.2.3 Residual current protective devices

531.2.3.1 General conditions of installation

An RCD shall disconnect all live conductors in the circuit protected, except as permitted in 531.2.3.5.1.

For a multiphase supplied installation, where there is subdivision into single phase final circuits, protection by individual RCDs is recommended. Where time delayed RCDs (CBRs (circuit breaker incorporating residual current protection), and MRCD (modular residual current device) in conjunction with circuit-breakers, according to IEC 60947-2) are used, the setting of the time delay shall be in accordance with IEC 60364-4-41:2005 and IEC 60364-4-41:2005/
AMD1:2017, 411.3.2.

Where a modular RCD is used, an MRCD according to IEC 60947-2:2016, Annex M shall be selected and used in conjunction with a circuit breaker in accordance with IEC 60947-2.

A protective conductor shall not pass through the sensor of an MRCD. However, where such passing is unavoidable, for example in case of armoured cables, the protective conductor alone shall be passed again through the sensor but in the reverse direction. The protective conductor shall be insulated and shall not be earthed between the first and the second passing.

531.2.3.2 Unwanted tripping

To reduce the risk of unwanted tripping, the following shall be considered:

- subdivision of electrical circuits with individual associated RCDs so that the accumulated protective conductor currents and/or leakage currents likely to occur during normal operation downstream of an RCD is less than 0,3 times the value of the rated residual operating current ($I_{\Delta n}$) of the RCD. See also IEC 60364-1:2005, Clause 314 and IEC 60364-5-51:2005, Clause 516,
- coordination of general type RCDs, selective type RCDs (i.e. type S according to IEC 61008-1, IEC 61009-1 or IEC 62423) and time delayed RCDs (i.e. CBRs, MRCDs according to IEC 60947-2), and
- coordination of RCDs with surge protective devices (SPDs).

531.2.3.3 Types of RCDs

531.2.3.3.1 Selection of type of RCD

The type of RCD shall be selected according to the waveform of the expected AC and DC components of the residual current to be interrupted.

531.2.3.3.2 Selection of the types of RCDs connected in series

Wherever an RCD type A, F or B is installed downstream of another RCD, the upstream RCD

- shall comply at least with the requirements of the type of the downstream RCD, or
- shall be coordinated with the downstream RCD, in accordance with the manufacturer's instructions.

NOTE See Annex G for the different types of RCDs and their behaviour with fault currents.

531.2.3.4 Selection according to the accessibility to the installation

531.2.3.4.1

In AC installations where RCDs are accessible to ordinary persons (BA1), children (BA2) or handicapped persons (BA3), residual current protective devices shall comply with

- IEC 61008-2-1 for RCCBs, or
- IEC 61009-2-1 for RCBOs, or
- IEC 62423 for RCCBs and RCBOs.

531.2.3.4.2

In AC installations where RCDs are accessible only to instructed persons (BA4) or skilled persons (BA5), residual current protective devices shall comply with

- IEC 61008 (all parts) for RCCBs, or
- IEC 61009 (all parts) for RCBOs, or
- IEC 62423 for RCCBs and RCBOs, or
- IEC 60947-2 for CBRs and MRCDs.

NOTE

RCCB is a residual current operated circuit breaker without integral overcurrent protection.

RCBO is a residual current operated circuit breaker with integral overcurrent protection.

CBR is a circuit breaker incorporating residual current protection.

MRCD is a modular residual current device, in conjunction with a circuit-breaker.

531.2.3.4.3

In DC installations, IEC TS 63053 may be used as a reference for DC-RCDs.

531.2.3.5 Selection of RCD according to the type of system earthing

531.2.3.5.1 TN systems

A PEN conductor shall not be used on the load side of an RCD.

In a TN-S system and in the part of a TN-C-S system, where the neutral and protective functions are provided by separate conductors, the neutral conductor need not be disconnected if the neutral conductor is considered to be reliably at earth potential.

In TN-C systems RCDs shall not be used.

The characteristics of the RCD, except those selected according to IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.3, shall be such that:

$$I_a \leq \frac{U_o}{Z_s}$$

where

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.3;

Z_s is the impedance in ohms (Ω) of the fault loop comprising

- the source,
- the line conductor up to the point of the fault, and
- the protective conductor between the point of the fault and the source;

U_o is the nominal AC or DC line-to-earth voltage in volts (V).

531.2.3.5.2 TT systems

In AC installations the characteristics of the RCD, except those selected according to IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.3, shall be such that:

$$I_a \leq \frac{50}{R_A}$$

where

R_A is the sum of the resistance in ohms (Ω) of the earth electrode and the protective conductor to the exposed conductive-parts;

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.4.

NOTE The disconnecting times according to IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, Table 41.1 relate to prospective residual currents significantly higher than the rated residual operating current of the RCD (typically 5 $I_{\Delta n}$).

Where the value of R_A is not known, it shall be replaced by Z_s (see 531.2.2.2).

531.2.3.5.3 IT systems

531.2.3.5.3.1 Disconnection at first fault condition for IT public distribution systems

Where the disconnection at the first fault is to be achieved by an RCD, the rated residual operating current of the RCD shall be selected to be less or equal to the current which circulates on the first fault to earth.

NOTE Where the current circulating during the first fault is not known or cannot be calculated, the current in mA can, for IT installations connected to a network, be estimated to 0,5 times the value of the rated power of the transformer given in kVA.

531.2.3.5.3.2 Disconnection at second fault condition

Where the automatic disconnection of supply at a second fault is to be achieved by an RCD, that RCD shall be installed in the final circuit to be protected. The rated residual current of the RCD shall be greater than 2 times the current which circulates on the first fault to earth of negligible impedance affecting a line conductor.

After the occurrence of a first fault, conditions for automatic disconnection of supply in the event of a second fault occurring on a different live conductor shall be as follows:

a) Where exposed-conductive-parts are interconnected by a protective conductor collectively earthed to the same earthing arrangement, the following condition shall be fulfilled:

- where the neutral or mid-point conductor is not distributed:

$$I_a \leq \frac{U}{2Z_s}$$

- or where the neutral or mid-point conductor is distributed:

$$I_a \leq \frac{U_o}{2Z'_s}$$

where

U_o is the nominal AC or DC voltage, in volts (V) between line conductor and neutral conductor or mid-point conductor, as appropriate;

U is the nominal AC or DC voltage in volts (V) between line conductors;

Z_s is the impedance in ohms (Ω) of the fault loop comprising the line conductor and the protective conductor of the circuit;

Z'_s is the impedance in ohms (Ω) of the fault loop comprising the neutral conductor and the protective conductor of the circuit;

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.4.

The times stated in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, Table 41.1 for the TN system apply to IT systems with a distributed or non-distributed neutral conductor or mid-point conductor.

NOTE 1 The factor 2 in both formulas takes into account that in the event of the simultaneous occurrence of two faults, the faults can exist in different circuits.

b) In AC installations where the exposed-conductive-parts are earthed in groups or individually, the following condition applies:

$$I_a \leq \frac{50}{R_A}$$

where

R_A is the sum of the resistances in ohms (Ω) of the earth electrode and the protective conductor to the exposed-conductive-parts;

I_a is the current in amperes (A) causing the automatic operation of the disconnecting device within the time specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.3.2.2 or 411.3.2.4.

NOTE 2 The disconnecting times according to IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, Table 41.1 relate to prospective residual fault currents significantly higher than the rated residual operating current of the RCD (typically 5 $I_{\Delta n}$)

531.3 Equipment for protection by double or reinforced insulation

531.3.1 General

For compliance with IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD 1:2017, Clause 412, electrical equipment shall be selected as follows:

a) electrical equipment marked with the symbol ⧈ (IEC 60417-5172:2003-02-18); or

b) electrical equipment declared in the relevant product standard or by the manufacturer as equivalent to Class II; or

c) electrical equipment with basic insulation only: supplementary insulation shall be provided by an enclosure of at least IPXXB or IP2X, or by a process of installation providing the equivalent level of safety; or

d) electrical equipment having uninsulated live parts shall have reinforced insulation provided by an enclosure of at least IPXXB or IP2X, or by a process of installation providing the equivalent level of safety.

In the case of equipment covered by c) or d) above, 531.3.2 to 531.3.6 apply.

531.3.2

The following requirements apply as specified:

– the insulating enclosure shall not be traversed by conductive parts likely to transmit a potential; and

– the insulating enclosure shall not contain any screws or other fixing means of insulating material which might need to be removed, or are likely to be removed, during installation and maintenance and whose replacement by metallic screws or other fixing means could impair the enclosure's insulation.

Where the insulating enclosure has to be traversed by mechanical joints or connections (e.g. for operating handles of built-in apparatus), these should be arranged in such a way that protection against shock in case of a fault is not impaired.

531.3.3

Where lids or doors in the insulating enclosure can be opened without the use of a tool or key, all conductive parts which are accessible if the lid or door is open shall be behind an insulating barrier (providing a degree of protection not less than IPXXB or IP2X) preventing persons from coming unintentionally into contact with those conductive parts. This insulating barrier shall be removable only by use of a tool or key.

531.3.4

Conductive parts enclosed in the insulating enclosure shall not be connected to a protective conductor. However, provision may be made for connecting protective conductors which necessarily run through the enclosure in order to serve other items of electrical equipment whose supply circuit also runs through the enclosure. Inside the enclosure, any such conductors and their terminals shall be insulated as though they were live parts, and their terminals shall be marked as PE terminals.

531.3.5

Accessible-conductive-parts and intermediate parts shall not be connected to a protective conductor unless specific provision for this is made in the specifications for the equipment concerned.

531.3.6

The enclosure shall not adversely affect the operation of the equipment protected in this way.

531.3.7

The installation of equipment mentioned in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 412.2.1 (fixing, connection of conductors, etc.) shall be effected in such a way as not to impair the protection afforded in compliance with the equipment specification.

531.4 Equipment for protection by electrical separation

The equipment selected for electrical separation, for example safety isolating transformer in accordance with IEC 61558-2-6, shall provide at least simple separation between incoming and outgoing terminals and the separated side shall be installed so that it is isolated from other circuits and earth.

531.5 Equipment for protection by extra-low-voltage provided by SELV and PELV systems

531.5.1 Sources for SELV or PELV systems

The following sources may be used for SELV or PELV systems:

- A safety isolating transformer in accordance with IEC 61558-2-6.
- A source of current providing a degree of safety equivalent to that of the safety isolating transformer specified above (e.g. motor generator with windings providing equivalent isolation).
- An electrochemical source (e.g. a battery) or another source independent of a higher voltage circuit (e.g. a diesel-driven generator).
- Certain electronic devices complying with appropriate standards where provisions have been taken in order to ensure that, even in the case of an internal fault, the voltage at the outgoing terminals cannot exceed the values specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 414.1.1. Higher voltages at the outgoing terminals are, however, permitted if it is ensured that, in case of contact with a live part or in the event of a fault between a live part and an exposed-conductive-part, the voltage at the output terminals is immediately reduced to those values or less.

  NOTE 1 Examples of such devices include insulation testing equipment and monitoring devices.

  NOTE 2 Where higher voltages exist at the outgoing terminals, compliance with 531.5 can be assumed if the voltage at the outgoing terminals is within the limits specified in IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 414.1.1 when measured with a voltmeter having an internal resistance of at least 3 000 Ω.
- Mobile sources supplied at low voltage, for example safety isolating transformers or motor generators, shall be selected or erected in accordance with the requirements for protection by the use of double or reinforced insulation (see IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, Clause 412).

531.5.2 Selection of plugs and socket-outlets

Plugs and socket-outlets in SELV or PELV systems shall comply with the following requirements:

– plugs shall not be able to enter socket-outlets of other voltage systems;
– socket-outlets shall not admit plugs of other voltage systems;
– plugs and socket-outlets in SELV systems shall not have a protective contact.

NOTE For socket-outlets according to IEC 60884-1 the protective contact is referred to as earthing contact.

531.6 Devices for additional protection

A PEN conductor shall not be used on the load side of an RCD.

In AC installations, an RCD used for additional protection shall have a rated residual operating current not exceeding 30 mA and shall be selected according to the requirements of 531.2.3.1 to 531.2.3.4.

In AC installations, when installed at the origin of a final circuit, an RCD with a rated residual current not exceeding 30 mA may ensure simultaneously fault protection and additional protection. In this case, not all final circuits supplied by a common distribution circuit shall be disconnected by this RCD.

NOTE Correct assignment of the final circuits to the common RCD will contribute to continuity of the supply (see 531.3.2).

In AC installations, an RCD for protection of socket-outlets shall be installed at the origin of the final circuit except where this additional protection is provided by RCDs integral with all the socket-outlets of the circuit or associated with all fixed socket-outlets within the same mounting box or in the immediate vicinity, see for example IEC 62640.

RCDs for protection of luminaires shall be installed at the origin of the final circuit.

In DC installations, an RCD used for additional protection shall have a rated residual operating current not exceeding 80 mA, and shall be selected according to the requirements of 531.2.3.1 to 531.2.3.4.

531.7 Monitoring devices

In IT-systems the following monitoring devices may be used to detect insulation fault conditions:

– Insulation monitoring devices (IMDs) selected and erected in accordance with 537.1.2;
– residual current monitors (RCMs) selected and erected in accordance with 537.1.3;
– equipment for insulation fault location selected and erected in accordance with 537.2.1.

532 Devices and precautions for protection against thermal effects

532.1 General

Devices shall be mounted so as to allow, under all operating conditions to be expected at the point of installation, safe dissipation of heat or arcs/sparks which could cause harmful thermal effects.

Protective devices shall be installed as close as practically possible to the origin of the circuit to be protected.

532.2 Locations with a particular risk of fire

532.2.1 General

NOTE Locations with a particular risk of fire are defined in IEC 60364-4-42.

Devices in the fixed installation or in equipment incorporated in the fixed installation and used for protection against thermal effects shall not be provided with automatic re-closure.

532.2.2 Locations with external influences BD2, BD3 or BD4

With the exception of devices to facilitate evacuation, switchgear and controlgear devices in locations with external influences BD2, BD3 or BD4 shall be accessible only to authorized persons. Where installed in passages, switchgear and controlgear devices shall be placed within enclosures complying with IEC 60670-24, IEC 61439-2, IEC 61439-3 or IEC 62208.

532.2.3 Locations with external influences BE2

532.2.3.1 General

Switchgear for protection, control or isolation shall be placed outside locations presenting external condition BE2, unless it is in an enclosure providing a degree of protection appropriate for such a location of at least:

- IP4X, or
- IP5X in the presence of dust, or
- IP6X in the presence of conductive dust.

Unless specifically designed to be inherently heat-limiting, in all operational modes, motors shall be protected against excessive temperature by a motor protective device with manual reset.

532.2.3.2 Selection of residual current protective devices (RCD)

Where an RCD for protection against thermal effects is required, the rated residual operating current shall be in compliance with IEC 60364-4-42:2010 and IEC 60364-4-42:2010/AMD1:2014, 422.3.9.

RCDs shall comply with IEC 61008 (all parts), IEC 61009 (all parts), IEC 62423 or IEC 60947-2 and shall comply with the requirements of 531.2.2.

An RCD shall ensure the disconnection of all live conductors of the circuit protected.

532.2.3.3 Selection of residual current monitoring device (RCM) in IT systems

Where an RCM is selected preventing the risk of fire in compliance with IEC 60364-4-42:2010 and IEC 60364-4-42:2010/AMD1:2014, 422.3.9 b), the rated residual warning level shall not exceed 300 mA and shall be less than or equal to the expected first fault current.

It is recommended to set the response value to a reasonable lower value to indicate a fault as early as possible.

RCMs shall comply with IEC 62020.

532.2.3.4 Selection of insulation monitoring devices (IMDs) in IT systems

Where an IMD is selected preventing the risk of fire in compliance with IEC 60364-4-42:2010 and IEC 60364-4-42:2010/AMD1:2014, 422.3.9 b), the response value shall not be lower than:

- 100 Ω/V except in a public distribution system with a galvanic supply, the value shall not be lower than 40 Ω/V; or
- 50 % of the insulation resistance without insulation failure and full load.

It is recommended to set the response value to a reasonable higher value to indicate a fault as early as possible.

IMDs shall comply with IEC 61557-8.

532.3 Selection of arc fault detection devices (AFDD)

Where an AFDD is specified for the protection against arc faults in accordance with IEC 60364-4-42:2010 and IEC 60364-4-42:2010/AMD1:2014, 421.7, the following applies:

- the AFDD shall comply with IEC 62606;

- the AFDD shall be placed at the origin of the final circuit to be protected;
- the AFDD shall be erected and coordinated in accordance with the manufacturer's instructions.

NOTE AFDDs according to IEC 62606 can include other protective capabilities, i.e. overcurrent protection and/or residual current protection.

533 Devices for protection against overcurrent

533.1 General requirements

533.1.1 General

Clause 533 provides requirements for the selection and erection of overcurrent protective devices where required by IEC 60364-4-43.

A protective device that may be operated by persons other than instructed persons (BA4) and skilled persons (BA5) shall be so selected or installed that access to its overcurrent characteristic settings, if any, is only possible with a deliberate act involving the use of a key, padlock, tool, password or similar, and resulting in a visible indication of its setting.

533.1.2 Compliance with standards

533.1.2.1 General

Devices for protection against overcurrent shall comply with at least one of the following standards:

- IEC 60269-2;
- IEC 60269-3;
- IEC 60269-4;
- IEC 60898 (all parts);
- IEC 60947-2;
- IEC 60947-3;
- IEC 60947-6-2;
- IEC 61009 (all parts);
- IEC 62423.

533.1.2.2 Applicability of devices

Circuit-breakers according to IEC 60947-2 identified with voltage value(s) followed by the symbol (IEC 60417-6363:2016-07-16) or by the symbol shall not be used in IT systems for such voltage(s) or above.

Circuit-breakers according to IEC 60947-2 identified with the symbol  (IEC 60417-6363:2016-07-16) or by the symbol  with no associated voltage value, shall not be used in IT systems.

IEC 62423 is only applicable for residual current operated circuit-breakers with integral overcurrent protection (RCBOs).

IEC 60947-3 is only applicable for devices in combination with fuses, i.e. switch-fuses, fuse-switch, disconnector-fuse, fuse-disconnector, switch-disconnector-fuse and fuse-switch-disconnector.

The following devices provide protection against short-circuit current only and therefore shall not be used for overload protection:

- instantaneous trip circuit-breakers (ICB) complying with IEC 60947-2:2016, Annex O;
- aM and aR type fuses complying with IEC 60269-2 or IEC 60269-3.

533.1.3 Fuses

533.1.3.1 A fuse base using screw-in fuses shall be connected so that the centre contact is connected to the conductor from the supply and the shell contact is connected to the conductor to the load.

Fuse bases shall be arranged so as to exclude the possibility of the fuse carrier making contact between conductive parts belonging to adjacent fuse bases.

Fuse bases in accordance with IEC 60269-3 shall be used together with gauge pieces preventing the use of fuse-links of higher rated current. The gauge piece is superfluous in cases where the fuse-link with the highest rated current within the fuse system is acceptable for the purpose of protection.

For protection of DC circuits or DC applications, only fuse systems (e.g. fuse-holder, fuse base) that are marked by the manufacturer as suitable for direct current shall be used.

533.1.3.2 Fuses having fuse-links intended to be removed or replaced by persons other than instructed persons (BA4) or skilled persons (BA5), shall comply with IEC 60269-3.

Fuses or combination units having fuse-links intended to be removed and replaced only by instructed persons (BA4) or skilled persons (BA5), shall be installed in such a manner that it is ensured that the fuse-links can be removed or replaced without unintentional contact with live parts. These devices shall be erected in such a manner that they are not accessible to ordinary persons.

533.2 Selection of devices for protection against overload current

533.2.1 General

Protective devices shall be selected to fulfil the following requirements:

a) the rated current or the current setting of the protective device, I_n, is greater than or equal to the design current of the circuit, I_B; and

b) the rated current or the current setting of the protective device, I_n, is less than or equal to the current carrying capacity of the cable, I_z; and

c) the current ensuring effective operation within the conventional time of the protective device I_2, is less than or equal to the current carrying capacity of the cable, I_z, multiplied by the factor 1,45.

Compliance with a), b) and c) may not ensure protection in certain cases, for example where sustained overcurrents less than I_2 occur. In such cases, consideration should be given to selecting a cable with a larger cross-sectional area or to selecting a device having a value of I_2 equal to or less than I_z.

NOTE 1 By applying b), requirement c) is automatically fulfilled where protective devices are in compliance with IEC 60898 (all parts), IEC 60947-2, IEC 61009 (all parts) or RCBOs complying with IEC 62423.

The current I_2 ensuring effective operation of the protective device is provided by the manufacturer.

The current ensuring effective operation in the conventional time of protective devices may also be named I_r, I_t or I_f according to the product standards. Both I_t and I_f are multiples of I_n and attention should be given to the correct representation of values and indexes.

Where the copper equivalent cross-sectional area of the neutral conductor is less than that of the line conductors, overload protection for the neutral conductor shall be provided in accordance with IEC 60364-4-43. For the purposes of this requirement, the current carrying capacity for the neutral conductor shall be ascertained, for example by obtaining it from the manufacturer.

NOTE 2 The current-carrying capacity of the neutral conductor can be considered to be that of a circuit with conductors having the same cross-sectional area, construction and installation conditions (e.g. ambient temperature and grouping) as the neutral conductor, determined in accordance with IEC 60364-5-52:2009, Clause 523.

533.2.2 Presence of harmonic currents

Overload protective devices shall be selected in order to operate correctly in the presence of harmonic currents.

533.2.3 Unequal current sharing between parallel conductors

Where the currents in parallel conductors are unequal, each conductor shall be individually protected by an overload protective device according to 533.2.1.

533.3 Selection of devices for protection against short-circuit current

533.3.1 Thermal stresses

533.3.1.1 Cables and insulated conductors

In order to comply with the requirements of IEC 60364-4-43:2008, 434.5, for all currents caused by a short-circuit occurring at any point of the circuit, the operating times of the protective devices shall be equal to or lower than that which brings the insulation of the conductors to the highest permissible temperature, calculated using the formula:

$$t \leq (k \cdot S/I)^2$$

where

t is the operating time, in s, of the protective device;

I is the effective short-circuit current, in A, expressed as an RMS value;

S is the cross-sectional area of the conductor, in mm^2;

k is a factor taking account of the resistivity, temperature coefficient and heat capacity of the conductor material, and the appropriate initial and final temperatures.

NOTE 1 Refer to IEC 60364-4-43 for the description and values of the factor k used in the above formula.

For operating times of protective devices < 0,1 s (e.g. current-limiting devices) the application of the above requirement is achieved where the let-through energy (I^2t) of the protective device is less than or equal to the maximum withstand energy of the conductor (k^2S^2).

$$I^2t \leq k^2S^2$$

NOTE 2 The let-through energy of the protective device is given by the manufacturer.

533.3.1.2 Busbar trunking systems and powertracks

In order to comply with the requirements of IEC 60364-4-43:2008, 434.5.3, where busbar trunking systems complying with IEC 61439-6 or powertrack complying with IEC 61534 (all

parts) are used, the short-circuit protective device shall be selected according to one of the following conditions:

- the maximum operating time of the protective device shall not exceed the maximum time for which the I_{CW} (rated short-time withstand current) is defined for such busbar trunking or powertrack system, or
- the rated conditional short-circuit current, I_{CC}, of the busbar trunking or powertrack system associated with a protective device, selected according to the manufacturer of the busbar trunking or the powertrack system, is equal to or higher than the prospective short-circuit current at the point of installation.

533.3.2 Breaking capacity

The short-circuit breaking capacity (I_{CU} or I_{cn}) of the protective device shall be equal to or higher than the maximum prospective short-circuit current at the point where it is installed. However, a lower short-circuit capacity may be selected where permitted by IEC 60364-4-43:2008, 434.5.1.

In certain circumstances (e.g. where the protective device is intended to be fit for service after breaking a short-circuit current) it may be desirable to select the protective device on the service short-circuit breaking capacity (I_{CS}).

NOTE Breaking capacities are defined as follows:

in IEC 60947-2:

– service short-circuit breaking capacity (I_{CS}): a breaking capacity for which the conditions according to a specified test sequence include the capability of the circuit-breaker to carry its rated current continuously;

– ultimate short-circuit breaking capacity (I_{CU}): a breaking capacity for which the conditions according to a specified test sequence do not include the capability of the circuit-breaker to carry its rated current continuously.

in IEC 60898-1 and IEC 61009-1:

– service short-circuit breaking capacity (I_{cs}): the breaking capacity for which the conditions according to a specified test sequence include the capability of the circuit-breaker to carry 0,85 times its non-tripping current for the conventional time;

– rated short-circuit capacity (I_{cn}): the breaking capacity for which the conditions according to a specified test sequence do not include the capability of the circuit-breaker to carry 0,85 times its non-tripping current for the conventional time.

533.4 Positioning of overcurrent protection devices

533.4.1 General

Devices required by IEC 60364-4-43 for overload and/or short-circuit protection shall be installed at the origin of each circuit, unless the exceptions of 533.4.2 and/or 533.4.3 are applied, see Annex A.

533.4.2 Positioning of devices for overload protection

533.4.2.1 A device for protection against overload shall be placed at each point where there is a reduction in the value of current-carrying capacity of the conductors except where IEC 60364-4-43:2008, 533.4.2.2, 533.4.2.3, 533.4.2.4 or 433.3 apply.

The requirements in 533.4.2.2 to 533.4.2.4 shall not be applied to installations situated in locations presenting a fire risk or risk of explosion.

NOTE A reduction in the current-carrying capacity of the conductors could be due to a change in, for example:

- conductor cross-sectional area,
- conductor material,
- conductor insulation material,
- method of installation,

- external influences,
- grouping of conductors.

533.4.2.2 The device protecting the conductor against overload may be connected within the run of that conductor if:

a) the part of the run between the point where a reduction in the value of current-carrying capacity occurs (see note in 533.4.2.1) and the position of the protective device has neither a branch circuit nor a socket-outlet, and

b) it fulfils at least one of the following two conditions:

1) it is protected against short-circuit current in accordance with the requirements stated in IEC 60364-4-43:2008, Clause 434;

2) its length does not exceed 3 m, it is carried out in such a manner as to reduce the risk of short-circuit to a minimum, and it is installed in such a manner as to reduce to a minimum the risk of fire or danger to persons (see also 533.4.3.2).

NOTE For installations according to 1), see Figure A.1. For installation according to 2) see Figure A.2.

533.4.2.3 Devices for protection against overload need not be provided:

a) for a conductor situated on the load side of a reduction in the value of current-carrying capacity of the conductors, that is effectively protected against overload by a protective device placed on the supply side; or

b) at the origin of an installation where the distributor provides an overload device and agrees that it affords protection to the part of the installation between the origin and the main distribution point of the installation where further overload protection is provided.

533.4.2.4 In IT systems without a neutral conductor, the overload protective device may be omitted in one of the line conductors if a residual current protective device is installed in each circuit.

533.4.3 Positioning of devices for short-circuit protection

533.4.3.1 A device for protection against short-circuit shall be placed at the point where there is a reduction of the let through energy withstand capability (k^2S^2) of the conductor, except where IEC 60364-4-43:2008, 533.4.3.2, 533.4.3.3 or 434.3 applies.

NOTE The let through energy withstand capability (k^2S^2) of the conductor is determined in accordance with IEC 60364-4-43:2008, 434.5.

The requirements in 533.4.3.2 and 533.4.3.3 shall not be applied to installations situated in locations presenting a fire risk or risk of explosion.

533.4.3.2 Where permitted by IEC 60364-4-43:2008, 434.2.1, the device for protection against short-circuit may be placed other than as specified in 533.4.3, provided

a) the part of the run between the point where there is a reduction of the let through energy withstand capability (k^2S^2) and the position of the protective device has neither a branch circuit nor a socket-outlet, and

b) that part of the conductor

1) does not exceed 3 m in length, and

2) is installed in such a manner as to reduce the risk of a short-circuit to a minimum, and

NOTE 1 This condition can be obtained for example by reinforcing the protection of the wiring against external influences.

NOTE 2 See Figure B.1.

3) is not placed close to combustible material.

533.4.3.3 A protective device may be placed on the supply side of the point where there is a reduction of the let through energy withstand capability (k^2S^2), provided that it possesses an operating characteristic such that it protects the wiring situated on the load side of that point against short-circuit, in accordance with IEC 60364-4-43:2008, 434.5.2.

NOTE The requirements of 533.4.3.3 can be met by the method given in Annex B.

533.4.3.4 Devices for protection against short-circuit need not be provided at the origin of an installation where the distributor installs one or more devices providing protection against short-circuit and agrees that such a device affords protection to the part of the installation between the origin and the main distribution point of the installation where further short-circuit protection is provided.

533.5 Co-ordination of overload and short-circuit protective functions

533.5.1 Protective functions provided by one device

A protective device providing protection against overload and short-circuit currents shall fulfil the applicable requirements of 533.1 to 533.4.

533.5.2 Protective functions provided by separate devices

The requirements of 533.1 to 533.4 apply, respectively, to overload protective devices and short-circuit protective devices. In addition, those devices shall be coordinated according to manufacturer's instructions, if any, regarding the suitability of devices to be used in combination with each other.

534 Devices for protection against transient overvoltages

534.1 General

This clause contains provisions for the application of voltage limitation to obtain an insulation coordination in the cases described in IEC 60364-4-44, IEC 60664-1, IEC 62305-1, IEC 62305-4 and IEC 61643-12. See also Annex C.

This clause focuses mainly on the requirements for the selection and erection of SPDs for protection against transient overvoltages where required by Clause 443 of IEC 60364-4-44:2007, the IEC 62305 series, or as otherwise specified.

This *clause* does *not take* into account:

– surge protective components which may be incorporated in the appliances connected to the installation;

– portable SPDs.

NOTE Further information can be found in IEC 61643-12.

Annex H provides additional information for the application of DC SPDs.

534.2 Void

534.3 Void

534.4 Selection and erection of SPDs

534.4.1 SPD location and SPD test class

SPDs shall at least be installed as close as possible to the origin of the installation. For protection against effects of lightning and against switching overvoltages, class II tested SPDs shall be used.

Where the structure is equipped with an external lightning protection system or protection against effects of direct lightning is otherwise specified, class I tested SPDs shall be used.

Where the structure is not equipped with an external lightning protection system and where the occurrence of direct lightning strike to the overhead lines between the last pole and the entrance of the installation is to be taken into consideration, class I tested SPDs at or near the origin of the electrical installation may be also selected according to Annex D.

NOTE 1 The origin of the installation could be the location where the supply enters the building or the main distribution board.

NOTE 2 Following the product standard, the marking of the product is as follows:

– for test class I: "test class I" and/or "T1" (T1 in a square);

– for test class II: "test class II" and/or "T2" (T2 in a square);

– for test class III: "test class III" and/or "T3" (T3 in a square).

Additional class II tested or class III tested SPDs may be needed to sufficiently protect the installation according to 534.4.4.2 and shall be located downstream in the fixed electrical installation, for example in the sub-distribution boards or at the socket outlets. These SPDs shall not be used without SPDs being installed at the origin of the installation and shall be coordinated with SPDs located upstream (see 534.4.4.5).

If a class I tested SPD is not able to provide protection according to 534.4.4.2, it shall be accompanied by a coordinated class II tested or class III tested SPD to ensure the required voltage protection level.

Additional class II tested SPDs or class III tested SPDs may be needed close to sensitive equipment to sufficiently protect the equipment according to IEC 60364-4-44:2024, Table 3 and shall be coordinated with SPDs located upstream.

NOTE 3 Such additional SPDs may be part of the fixed electrical installation or may be portable SPDs.

Additional SPDs may be necessary to provide transient overvoltage protection regarding threats coming from other sources such as:

– switching overvoltages produced by current using equipment located within the installation;
– overvoltages on other incoming services such as telephone lines, internet connections;
– overvoltages on other services feeding other structures such as secondary buildings, external installations/lighting, power lines feeding external sensors;

in which case one should consider installing SPDs located as close as possible to the origin of such threats. More information may be found in IEC 61643-12.

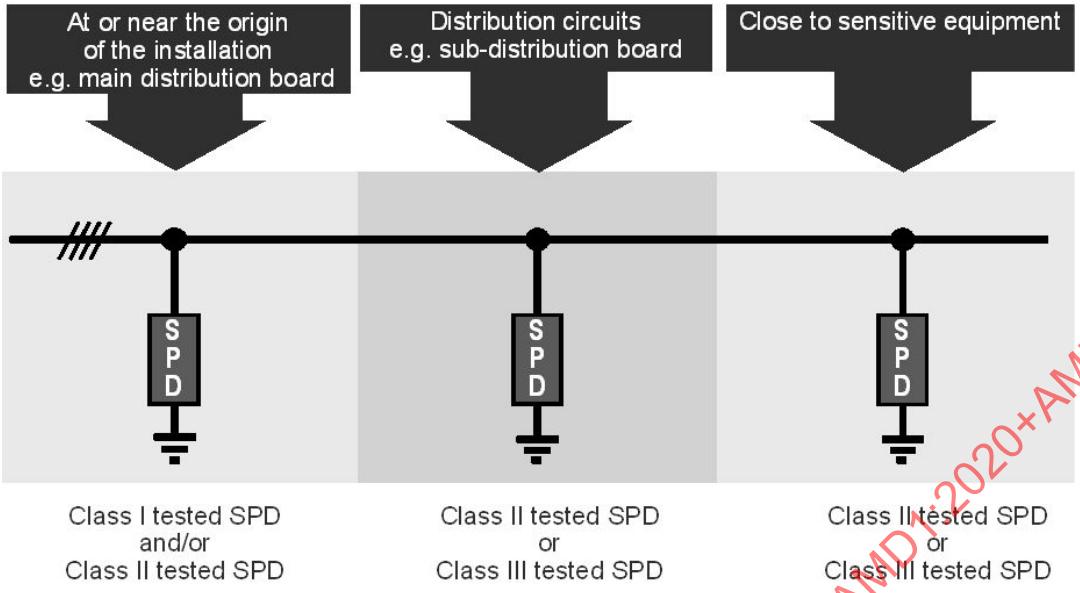


Figure 1 – Example of installation of class I, class II and class III tested SPDs

The presence of SPDs installed downstream of a distribution board (e.g. in a socket-outlet) shall be permanently indicated (e.g. by a label) in this distribution board.

534.4.2 Transient overvoltage protection requirements

Protection against transient overvoltages may be provided:

– between live conductors and PE (common mode protection);

– between live conductors (differential mode protection).

NOTE 1 Connection type CT1 provides primarily common mode protection. If differential mode protection is also necessary, this will in most cases require additional SPDs between live conductors.

NOTE 2 Connection type CT2 provides a combination of common mode protection and differential mode protection.

Protection between live conductors and PE (including neutral to PE if there is a neutral conductor) is compulsory.

Protection between line conductors and neutral (if there is a neutral conductor) is recommended to ensure equipment protection.

Protection between line conductors (in the case of multiple phases) is optional.

Some equipment may require both common mode protection (for impulse withstand) and differential mode protection (for impulse immunity).

NOTE 3 For example, electronic class I equipment or class II equipment with FE-connection requires common mode as well as differential mode protection to ensure overall protection against transient overvoltages due to switching or from atmospheric origin.

534.4.3 Connection types

Connection type CT1 (e.g. 3+0 or 4+0-configuration): SPD assembly providing a mode of protection between each live conductor (line and neutral conductors, if available) and PE or between each line conductor and PEN.

Two examples of connection type CT1 for application in a three-phase system are represented in Figure 2 and in Figure 3.

Connection type CT2 (e.g. 3+1-configuration): SPD assembly providing a mode of protection between each line conductor and the neutral conductor, and between the neutral conductor and PE.

An example of connection type CT2 for application in a three-phase system is represented in Figure 4.

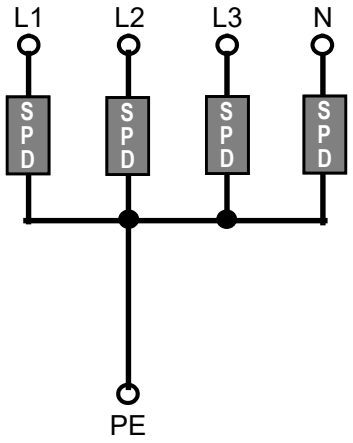


Figure 2 – Connection type CT1 (4+0-configuration) for a three-phase system with neutral

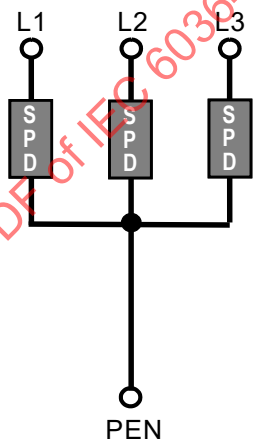


Figure 3 – Connection type CT1 (3+0-configuration) for a three-phase system

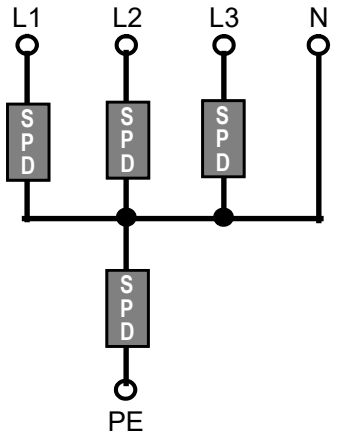


Figure 4 – Connection type CT2 (e.g. 3+1-configuration) for a three-phase system with neutral

When assembling SPDs, attention should be drawn to the selection of parameters for SPDs connected between N and PE, depending on the connection type.

In TN-S or TN-C-S systems, the SPD between neutral and PE may be omitted if the distance between the separation point of PE to N and the location of the installed SPDs is less than 0,5 m or if the separation point and the SPDs are located in the same distribution board.

If a line conductor is earthed, it is considered to be technically equivalent to a neutral conductor for the application of this subclause. However correct choice of the SPD parameters requires special considerations in such case.

534.4.4 Selection of SPDs

534.4.4.1 General

The selection of SPDs shall be based on the following parameters:

– voltage protection level (U_p) and rated impulse voltage (**U_W**) of equipment to be protected (see 534.4.4.2);
– continuous operating voltage (U_c), i.e. supply system (TT, TN, IT) (see 534.4.4.3);
– nominal discharge current (I_n) and impulse discharge current (I_{imp}) (see 534.4.4.4);
– SPD coordination (see 534.4.4.5);
– expected short-circuit current (see 534.4.4.6);
– follow current interrupting rating (see 534.4.4.7).

SPDs for use in AC circuits shall comply with the requirements of IEC 61643-11.

NOTE 1 Additional information regarding selection and application is given in IEC 61643-12.

NOTE 2 IEC 61643-41 Low-voltage surge protective devices – Part 41: Surge protective devices connected to DC low-voltage power systems – Requirements and test methods, is under development.

534.4.4.2 Selection of voltage protection level (U_p) as a function of equipment rated impulse voltage (U_W)

The voltage protection level U_p of SPDs between live conductors and protective earthing conductors shall be selected in accordance with the required rated impulse voltage of the equipment and not exceed the value specified for overvoltage category II in accordance with IEC 60364-4-44:2024, Table 4.

Where protection between line conductors and PE is provided by a series connection of SPD protection modes (e.g. single mode SPDs, line-to-neutral + neutral-to-PE, according CT2), this series connection shall fulfill the above voltage protection level requirement.

Where such combined voltage protection level between line conductor and PE is not provided in the data sheet of the manufacturer, it shall be calculated by addition of the voltage protection levels given for the individual SPDs modes of protection, which are connected in series.

The voltage protection level provided by SPDs should not exceed 80 % of the required rated impulse voltage of the equipment and the value specified for overvoltage category II in accordance with IEC 60364-4-44:2024, Table 4.

This safety margin is not necessary where one of the following cases applies:

– where the equipment is connected directly to the SPD terminals;
– where a protection scheme according Figure 9 is already applied;
– where the voltage drop across the overcurrent protection in the SPD branch circuit is already taken into account for the voltage protection level U_p;
– where protection according to overvoltage category II is provided but only overvoltage category III or IV equipment is installed at this location.

NOTE IEC 61643-12 gives additional information about the rated impulse voltage of equipment and the given U_p for the SPD.

Additional SPDs between live conductors may be needed to avoid equipment malfunctions. An appropriate voltage protection level needs to be evaluated based on equipment immunity and availability requirements (see IEC 61643-12).

Where the required voltage protection level cannot be met with a single SPD assembly, additional coordinated SPDs shall be applied to ensure the required voltage protection level.

534.4.4.3 Selection of SPDs with regard to continuous operating voltage (U_c)

In AC, the maximum continuous operating voltage U_c of SPDs shall be equal to or higher than required in Table 2.

Table 2 – U_c of the SPD dependent on supply system configuration

SPD connected between (as applicable)	System configuration of distribution network		
	TN system	TT system	IT system
Line conductor and neutral conductor	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)
Line conductor and PE conductor	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)	1,1 × U
Line conductor and PEN conductor	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)	N/A	N/A
Neutral conductor and PE conductor	$\frac{U}{\sqrt{3}}$ [a]	$\frac{U}{\sqrt{3}}$ [a]	$\frac{1{,}1\ U}{\sqrt{3}}$ or (0,64 × U)
Line conductors	1,1 × U	1,1 × U	1,1 × U

NOTE 1 N/A: not applicable.

NOTE 2 U is the line-to-line voltage of the low-voltage system.

[a] These values are related to worst-case fault conditions, therefore the tolerance of 10 % is not taken into account.

534.4.4.4 Selection of SPDs with regard to nominal discharge current (I_n) and impulse discharge current (I_{imp})

At or near the origin of the installation, SPDs shall comply with one of the following cases, as applicable:

– where the building is protected against direct lightning strike, SPDs at the origin of the installation shall be selected according to 534.4.4.4.2 and Table 4;

– in other cases, SPDs shall be selected according to 534.4.4.4.1.

Further SPDs installed downstream of the SPDs at or near the origin of the installation shall also comply with the coordination requirements in 534.4.4.5.

Overvoltages due to switching can be longer in duration and can contain more energy than the transient overvoltages of atmospheric origin. This has to be considered for the selection of SPDs with regard to nominal discharge current and impulse discharge current.

534.4.4.4.1 Class II tested SPDs

Where class II tested SPD are required at or near the origin of installation, their nominal discharge current shall be not less than that given in Table 3.

Table 3 – Nominal discharge current (I_n) in kA depending on supply system and connection type

Connection	Supply system			
	Single-phase		Three-phase	
	CT1	CT2	CT1	CT2
L – N		5		5
L – PE	5		5	
N – PE	5	10	5	20

534.4.4.4.2 Class I tested SPDs

Where class I tested SPDs are required at or near the origin of the installation, one of the following cases applies:

a) Where no risk analysis according to IEC 62305-2 has been carried out, the impulse discharge current (I_{imp}) shall be not less than as given in Table 4:

Table 4 – Selection of impulse discharge current (I_{imp}) where the building is protected against direct lightning strike

Connection	I_{imp} in kA			
	Supply system			
	Single phase		Three phase	
	CT1	CT2	CT1	CT2
L – N		12,5		12,5
L – PE	12,5		12,5	
N – PE	12,5	25	12,5	50
NOTE This table refers to lightning protection levels (LPL) III and IV.				

b) Where the risk analysis according to IEC 62305-2 has been carried out, the impulse discharge current (I_{imp}) shall be determined according to the IEC 62305 series.

534.4.4.5 Coordination of two or several SPDs

Coordination of SPDs in the installation needs to be ensured. The manufacturer's instructions on how to achieve coordination between SPDs shall be followed with reference IEC 61643-12.

534.4.4.6 Selection of SPDs with regard to the short-circuit current rating I_{SCCR}

In general, the short-circuit current rating I_{SCCR} of the SPD, as stated by the manufacturer, shall be not lower than the maximum prospective short-circuit current at the connection points of the SPD assembly. See Figure 5.

This requirement does not apply to SPDs connected between neutral conductor and PE in TN or TT systems, for which this is already covered by the product standard IEC 61643-11.

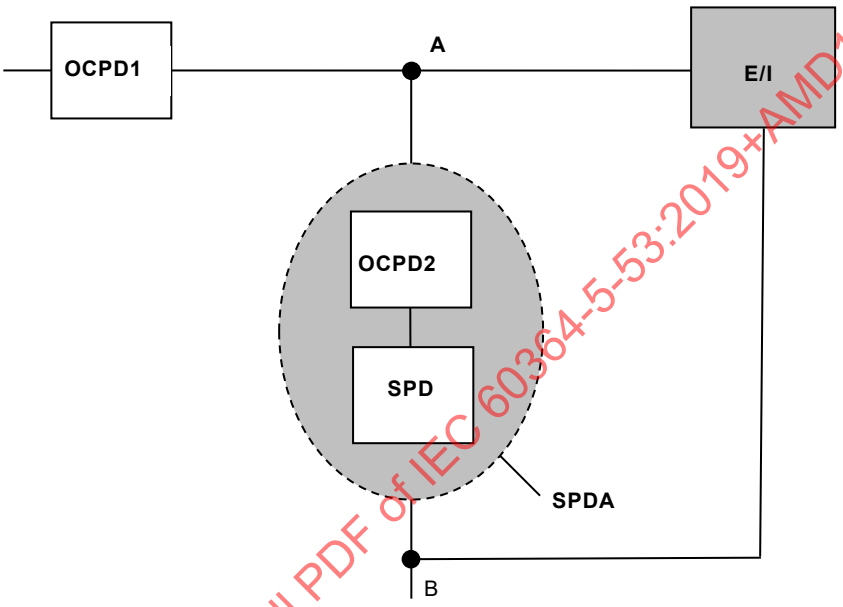
For SPDs connected between the neutral conductor and PE in IT systems, the short-circuit current rating I_{SCCR} of the SPD shall not be lower than the maximum prospective short-circuit current at the connection points of this SPD in case of a double earth fault under worst case conditions.

534.4.4.7 Selection of SPDs with regard to the follow current interrupting rating

In general, the follow current interrupting rating I_{fi} of the SPD, if declared by the manufacturer, shall not be lower than the maximum prospective short-circuit current at the connection points of the SPD assembly. See Figure 5.

This requirement does not apply to SPDs connected between neutral conductor and PE conductor in TN or TT systems, for which this is already covered by the product standard IEC 61643-11.

For SPDs connected between the neutral conductor and PE in IT systems, the follow current interrupting rating I_{fi} of the SPD if declared by the manufacturer shall not be lower than the maximum prospective short-circuit current at the connection points of this SPD in case of a double earth fault under worst case conditions.



Key

OCPD1	overcurrent protective device in the installation
OCPD2	overcurrent protective device (SPD disconnector) required by the SPD manufacturer
SPD	surge protective device
SPDA	SPD assembly
A & B	connection points of SPD assembly
E/I	equipment or installation to be protected

Figure 5 – Connection points of an SPD assembly

534.4.5 Protection of the SPD against overcurrent

534.4.5.1 General

SPD installations shall be protected against overcurrent with respect to short-circuit currents. This protection may be internal and/or external to the SPD according to the manufacturer's instructions.

The ratings and characteristics of external overcurrent protective device(s) (OCPD) for protecting the SPD assembly shall be selected:

– according to Clause 434; and

– as high as possible, to ensure a high surge current capability for the complete assembly

but not exceeding the ratings and characteristics as required in the SPD manufacturer's installation instructions for the maximum overcurrent protection.

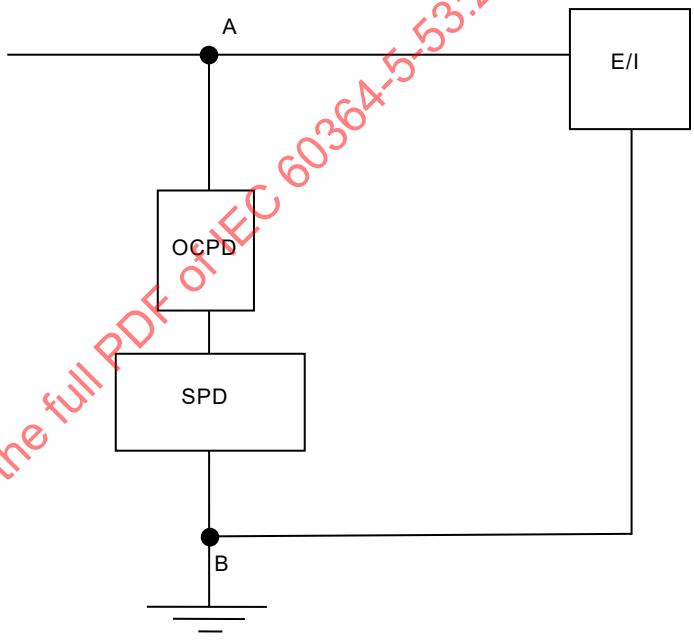
534.4.5.2 Arrangement of SPDs with relation to overcurrent protection

The location of overcurrent protective devices used to protect the SPDs may have an influence on the continuity of supply of the installation and the effective voltage protection level within the installation.

NOTE 1 National committees may decide which of the following arrangement is to be preferred, depending on the type of installation.

a) If the overcurrent protective device for the SPD is located in the SPD branch circuit, the continuity of the supply is unaffected in case of SPD failure, but neither the installation nor the equipment is protected against possible further overvoltages (see Figure 6) after tripping of such protective devices. In such an arrangement, the effective voltage protection level within the installation is increased due to the voltage drop at the external overcurrent protective device connected in series with the SPD.

NOTE 2 If the protection against overcurrent is internal to the SPD the voltage drop of the overcurrent protective device is already included in the SPD's voltage protection level U_p.



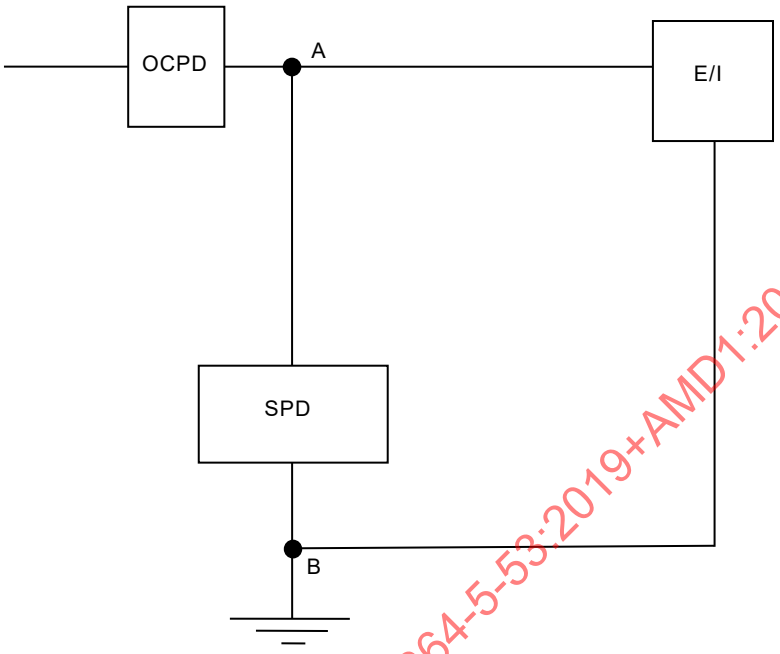
Key

OCPD	overcurrent protective device (SPD disconnector) required by the SPD manufacturer
SPD	surge protective device
A and B	connection points of SPD assembly
E/I	equipment or installation to be protected

Figure 6 – Example of overcurrent protection in the SPD branch by using a dedicated external overcurrent protective device

b) If the overcurrent protective device for the SPD is installed upstream of the SPD branch circuit, continuity of the supply is not likely to be provided in the event of SPD failure (see Figure 7). Nevertheless, in such an arrangement, the effective voltage protection level within the installation is kept to a minimum.

However, protection according to Figure 6 shall also be applied whenever the rating of the upstream overcurrent protective device (OCPD) is higher than the maximum overcurrent protection recommended by the SPD manufacturer.



Key

OCPD	overcurrent protective device of the installation used to protect the SPD
SPD	surge protective device
A and B	connection points of SPD assembly
E/I	equipment or installation to be protected

Figure 7 – Protective device, which is a part of the installation, also used to protect the SPD

534.4.5.3 Selectivity between overcurrent protective devices

Where required, the need for selectivity between overcurrent protective devices shall be considered according to the installation conditions at the point of installation of the SPD and the information provided by the manufacturer (see Clause 535 of IEC 60364-5-53:2002).

534.4.5.4 Surge current withstand capability of upstream devices

For most installation devices (e.g. meters, terminals, protective devices, switches, etc.) which are installed upstream of the SPD, there is no dedicated surge current withstand capability required by the relevant product standards.

The installation of SPDs as close as possible to the origin of the installation, according to 534.4.1, reduces surge currents flowing through downstream installation devices.

For further information, see IEC 61643-12 as well as the manufacturer's information.

534.4.6 Fault protection

Fault protection, as defined in IEC 60364-4-41, shall remain effective in the protected installation even in the event of SPD failures.

In case of automatic disconnection of supply:

– in TN systems, this may generally be fulfilled by the overcurrent device on the supply side of the SPD;
– in TT systems, this may be fulfilled by:
  a) the installation of SPDs downstream of an RCD; or
  b) the installation of SPDs upstream of the main RCD. Because of the possibility of a failure of an SPD connected between neutral conductor and PE, the conditions of 411.4.1 of IEC 60364-4-41:2005 shall be met and the SPDs shall be installed in accordance with connection type CT2.
– in IT systems, no additional measure is needed.

Surge protective devices at or near the origin of installation shall be connected according to Table 5.

Table 5 – Connection of the SPD dependent on supply system

Supply system at the connection point of the SPD assembly	Connection type	
	CT1	CT2
TN system	X	X
TT system	SPD only downstream of RCD	X
IT system with neutral	X	X
IT system without neutral	X	N/A
NOTE 1 X = applicable. NOTE 2 N/A = not applicable.		

NOTE Additional requirements might apply for SPDs installed in the area of influence of applications such as railway systems, HV power systems, mobile units, etc.

534.4.7 SPDs installation in conjunction with RCDs

If SPDs are installed in accordance with 534.4.1 and are located on the load side of a residual current device, RCD(s) may be with or without a time delay but shall have an immunity to surge currents of at least 3 kA 8/20.

NOTE 1 S-type RCDs in accordance with IEC 61008-1 and IEC 61009-1 satisfy this requirement.

NOTE 2 In the case of surge current higher than 3 kA 8/20, the RCD may trip causing interruption of the power supply.

NOTE 3 This may not be applicable for RCDs installed upstream of additional SPDs provided to protect sensitive equipment.

Installation of class I tested SPDs downstream of an RCD is not recommended.

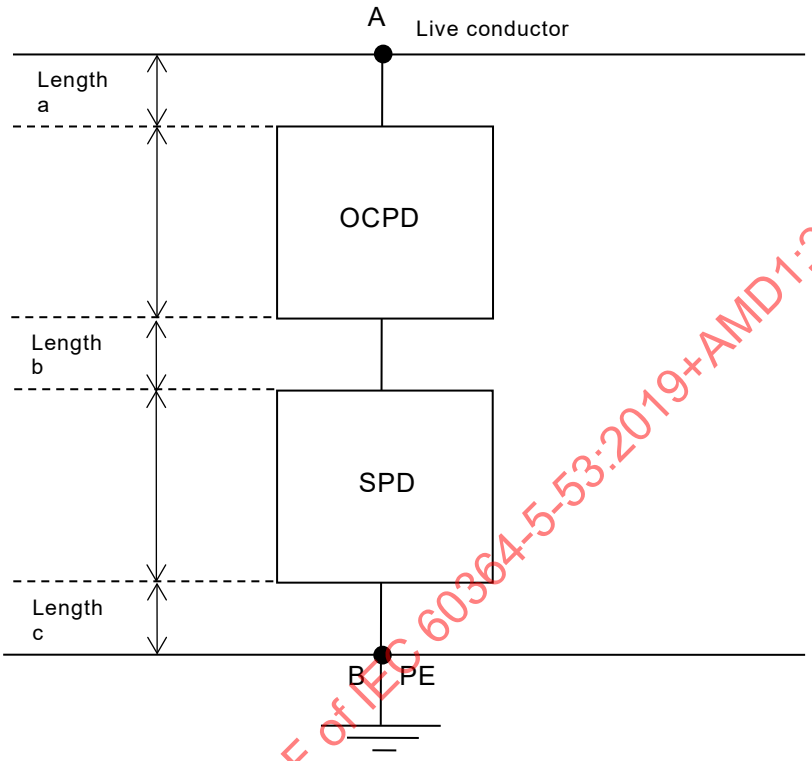
534.4.8 Connections of the SPD

The effective voltage protection level within the installation depends significantly on the connection and the wiring length and arrangement of the SPD itself and the required SPD disconnectors.

All conductors and interconnections to the relevant line to be protected as well the connections between the SPD and any external SPD disconnector shall be kept as short and as straight as possible and any unnecessary cable loop shall be avoided.

The length of the connecting conductors is defined by the sum of the path length of conductors used from the live conductor to the PE in between connection points A and B as defined in Figure 8.

Consideration shall be given to limit the total wiring length of conductors between connection points of the SPD assembly (see Figure 8 below) to a value not greater than 0,5 m.



Key

OCPD	overcurrent protective device
SPD	surge protective device
PE conductor	protective earthing conductor
A and B	connection points of SPD assembly

NOTE When OCPD is not present, length b is equal to 0.

Figure 8 – Connection of the SPD

To meet these requirements, the main protective conductor shall be connected to the earthing terminal located as near as possible to the SPD by adding, if necessary, an intermediate earthing terminal (see diagrams in Figure 9).

To determine the total length of the connecting conductors according to Figure 9, the following cable lengths:

– from the main earthing terminal to the intermediate earthing terminal;
– from the intermediate earthing terminal to the PE-conductor;

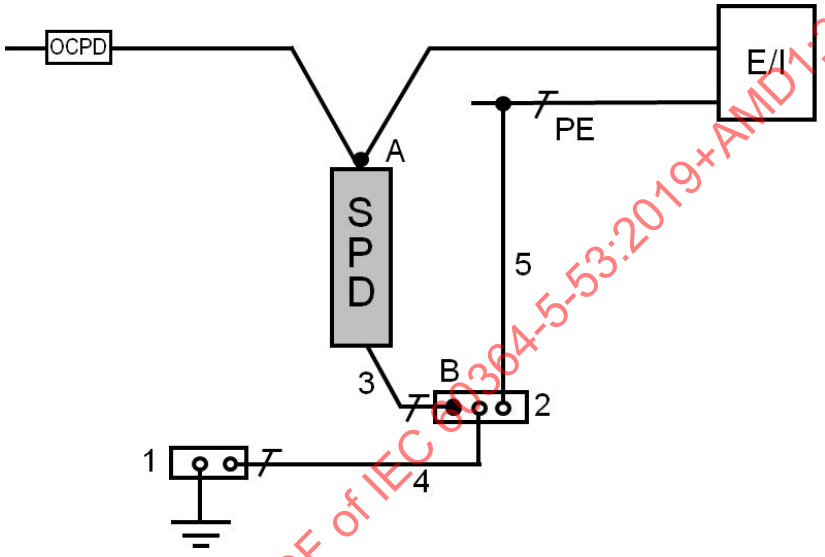
shall not be taken into account.

The length (and therefore inductance) of the cables between the SPDs and the main earthing terminal shall be kept to a minimum. SPDs may be connected to the main earthing terminal or to the protective conductor via metallic parts, e.g. the metallic enclosures of the assembly (see 543.4.2), provided it is connected to PE and meets the requirements for a protective

conductor in accordance with IEC 60364-5-54. Connection of the relevant SPD(s) to the main earthing terminal, and in addition to the main protective conductor, may improve the voltage protection level.

If the total wiring length (a + b + c) as defined in Figure 8 exceeds 0,5 m, at least one of the following options shall be chosen:

- select an SPD with a lower voltage protection level U_p (a 1 m length of rectilinear cable carrying a discharge current of 10 kA (8/20) adds a voltage drop of about 1 000 V);
- install a second coordinated SPD close to the equipment to be protected so as to adapt the voltage protection level U_p to the rated impulse voltage of the equipment to be protected;
- use the installation described in Figure 9.



Key

OCPD	overcurrent protective device
SPD	surge protective device
PE	protective earthing
E/I	equipment/installation
1	main earthing terminal
2	intermediate earthing terminal
3	length c (to be considered)
4	cable lengths need not be considered
5	cable lengths need not be considered
A and B	connection points of the SPD assembly

Figure 9 – Example of installation of an SPD in order to decrease lead length of SPD supply conductors

534.4.9 Effective protective distance of SPDs

Where the distance between the SPD and the equipment to be protected is greater than 10 m, additional protective measures should be provided such as:

– an additional SPD installed as close as possible to the equipment to be protected; its voltage protection level U_P shall in no case exceed the required rated impulse voltage U_W of the equipment; or

– the use of one-port SPDs at or near the origin of the installation; their voltage protection level U_P shall in no case exceed 50 % of the required rated impulse voltage U_W of the

equipment to be protected; This measure should be implemented together with other measures such as the use of shielded wiring in the whole protected circuit(s); or

– the use of two-port SPDs at or near the origin of the installation; their voltage protection level U_P shall in no case exceed the required rated impulse voltage U_W of the equipment to be protected. This measure should be implemented together with other measures such as the use of shielded wiring in the whole protected circuit(s).

534.4.10 Connecting conductors of SPDs

Conductors between the SPD and the main earthing terminal or the protective conductor shall have a cross-sectional area not less than:

– 6 mm^2 copper or equivalent for class II tested SPDs installed at or near the origin of the installation;

– 16 mm^2 copper or equivalent for class I tested SPDs installed at or near the origin of the installation.

Referring to 433.3.1 b) of IEC 60364-4-43:2008, conductors connecting SPDs and the overcurrent protective devices to live conductors shall be rated to withstand the prospective short-circuit current to be expected and shall have a cross-sectional area not less than:

– 2,5 mm^2 copper or equivalent for class II tested SPDs installed at or near the origin of the installation;

– 6 mm^2 copper or equivalent for class I tested SPDs installed at or near the origin of the installation.

535 Co-ordination of protective devices

535.1 Selectivity between overcurrent protective devices

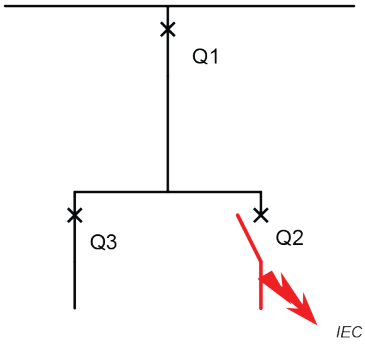
535.1.1 General

Selectivity between several overcurrent protective devices (OCPDs) in series is provided if, in case of an overload, short-circuit, or earth fault, only the OCPD (Q2) directly on the supply side of the fault or overload operates without affecting the supply to parallel circuits (Q3) (see Figure 10).

The OCPD on the load side (Q2) provides protection up to the level of overcurrent selectivity limit I_s, without causing the upstream OCPD (Q1) to operate (see Figure 10).

To determine the selectivity limit current I_s, reference shall be made to the instructions of the manufacturer of the downstream and upstream OCPDs. Where no information about this combination is available from the manufacturer, the selectivity limit current I_s may be defined by comparison of operating time-current curves of the OCPDs.

The selectivity limit current I_s shall be evaluated taking into account energy values, such as let-through energy for circuit-breakers and melting energy for fuses. See also relevant product standards.



Key

Q1, Q3 no trip

Q2 trips

Figure 10 – Example of selectivity

535.1.2 Partial selectivity

The selectivity limit current I_s is lower than the maximum prospective short-circuit current I_{sc_max} at the installation point of the OCPD on the load side (see Figure 11).

$$I_s < I_{sc\_max}$$

535.1.3 Full selectivity

The selectivity limit current I_s is equal to or higher than the maximum prospective short-circuit current I_{sc_max} at the installation point of the OCPD on the load side and lower than its breaking capacity I_{cu} according to IEC 60947-2 or I_{cn} according to IEC 60898 (all parts) or IEC 61009-1 (see Figure 11).

$$I_{sc\_max} \leq I_s < I_{cu} \text{ or } I_{cn}$$

535.1.4 Total selectivity

The selectivity limit current I_s is equal to or higher than the maximum prospective short-circuit current I_{sc_max} at the installation point of the OCPD on the load side and equal to its breaking capacity I_{cu} according to IEC 60947-2 or I_{cn} according to IEC 60898 (all parts) or IEC 61009-1 (see Figure 11).

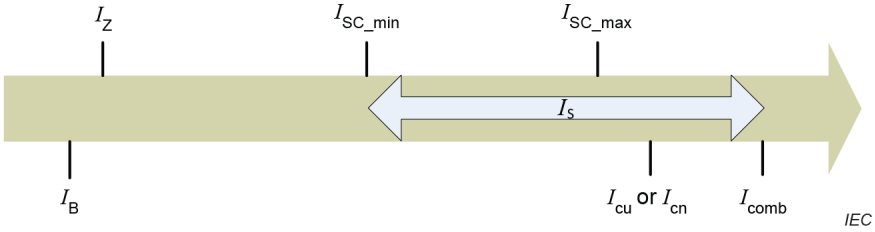
$$I_{sc\_max} \leq I_s = I_{cu} \text{ or } I_{cn}$$

535.1.5 Enhanced selectivity

The selectivity limit current I_s is equal to or higher than the maximum prospective short-circuit current at the installation point of the OCPD on the load side (Q2) and lower than or equal to the combined current I_{comb} of this combination. The breaking capacity I_{cu} according to IEC 60947-2 or I_{cn} according to IEC 60898 (all parts) or IEC 61009-1 of the OCPD on the load side (Q2) is lower than the maximum prospective short-circuit current at its installation point.

$$I_{cu} \text{ or } I_{cn} < I_{sc\_max} \leq I_s \leq I_{comb}$$

Enhanced selectivity can only be designed with respective information from the manufacturer of the devices.



Key

I_Z	continuous current-carrying capacity of the cable
I_{SC_min}	minimum prospective short-circuit current (at load side of circuit)
I_{SC_max}	maximum prospective short-circuit current (at supply side of circuit)
I_B	design current of the circuit
I_s	selectivity limit current
I_{cu}	ultimate short-circuit breaking capacity
I_{cn}	rated short-circuit capacity
I_{comb}	combined current of the combination

Figure 11 – Example of currents and their correlation to selectivity

535.2 Co-ordination between residual current protective devices and OCPDs

A residual current protective device without integral overcurrent protection requires overcurrent protection. This overcurrent protection shall be selected according to the residual current protective device manufacturer's instructions.

535.3 Selectivity between residual current protective devices

Selectivity between residual current protective devices installed in series may be required for service reasons, particularly when safety is involved, to provide continuity of supply to the parts of the installation not involved in the fault, if any.

This selectivity can be achieved by selecting and erecting residual current protective devices such that, in the event of a fault, only the RCD closest to the fault on its supply side operates.

To ensure selectivity between two residual current protective devices in series, these devices shall satisfy both the following conditions:

a) the residual current protective device located on the supply side (upstream) shall be selected according to IEC 61008 (all parts), IEC 61009 (all parts), or IEC 62423 as type S or according to IEC 60947-2 as time delay type;

b) the rated residual operating current of the device located on the supply side shall be at least three times greater than that of the residual current protective device located on the load side.

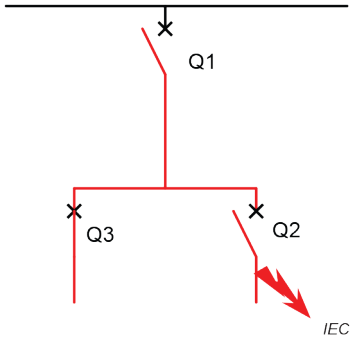
535.4 Selectivity of RCD and OCPD

Under consideration.

535.5 Combined short-circuit protection of OCPDs

Where an OCPD (Q2) has to break a prospective short-circuit current higher than its own breaking capacity I_{cu} according to IEC 60947-2 or I_{cn} according to IEC 60898 (all parts) or IEC 61009-1, it shall be assisted through the additional limiting of the short-circuit current and short-circuit energy of an upstream OCPD (Q1) (see Figure 12).

The upstream OCPD (Q1) may also trip, so that the supply to the other circuits (Q3) would be interrupted.



Key

Q1 and Q2 trip: I_{CN} or I_{CU} Q2 ≤ I_{SC_max}

Q3 no trip

Figure 12 – Example of combined short-circuit protection of OCPDs

When selecting two OCPDs for combined short-circuit protection of OCPDs, reference shall be made to the instructions of the manufacturer of the downstream OCPD. Where no information is available from the manufacturer, this combined short-circuit protection shall not be used, and each OCPD shall have the required short-circuit capability at the point of installation.

If declared by the manufacturer of both devices, the short-circuit capability of the combination of two OCPDs in series may be higher than the breaking capacity of either OCPD. In such cases, the conductors between the two OCPDs shall

- be made in such a way as to reduce the risk of a short-circuit to a minimum (see IEC 60364-4-43:2008, 434.2.1 b)), and
- not be placed close to combustible material.

If declared by the manufacturer of both devices, the combined short-circuit capability of the combination of two OCPDs in series may be higher than the breaking capacity of either OCPD. In this case, the conductors between the two OCPDs shall

- be protected by the combination of OCPDs according to IEC 60364-4-43:2008, 434.5.2,
- not exceed 3 m in length,
- be installed in such a manner as to reduce the risk of a short-circuit to a minimum, and

  NOTE This condition can be obtained for example by reinforcing the protection of the wiring against external influences.

- not be placed close to combustible material.

Co-ordination of an OCPD with a separate current limiter to increase the short-circuit breaking capacity of an OCPD may be used according to the manufacturer's instructions.

536 Isolation and switching

536.2 Isolation

536.2.1 General

536.2.1.1 Every circuit shall be capable of being isolated from all live conductors.

Provisions may be made for isolation of a group of circuits by a common means, if the service conditions allow this.

Each supply shall have a means of isolation.

536.2.1.2 Suitable means shall be provided to prevent any equipment from being unintentionally energized.

Such precaution may include one or more of the following measures:

- selection of device suitable for padlocking in the off position;
- location of the suitable means within a lockable space or lockable enclosure.

NOTE Earthing can be used as a supplementary measure.

536.2.1.3 Where an item of equipment or enclosure contains live parts connected to more than one supply, a warning notice shall be placed in such a position that any person gaining access to live parts will be warned of the need to isolate those parts from the various supplies unless an interlocking arrangement is provided to ensure that all the circuits concerned are isolated from all supplies.

The interlocking mechanism shall be both

- capable of being reliably secured in the off position so that none of the circuits can be independently energized, and
- simultaneously provide isolation for all of the circuits so that one or more circuits will not remain energized longer than any of the other protected circuits.

536.2.1.4 Where necessary, suitable means shall be provided for the discharge of stored electrical energy (see details in IEC 60364-5-55).

536.2.2 Devices for isolation

536.2.2.1 Some devices suitable for isolation are identified with the symbol  (IEC 60417-6169-1:2012-08). This symbol may be combined with symbols for other functions.

Devices shall be selected according to overvoltage category III or IV only, whichever is applicable for the point of installation.

Devices used for isolation shall be selected from Table E.1, Annex E, and in accordance with 536.2.2.2 to 536.2.2.7.

536.2.2.2 Devices for isolation shall be so selected and erected that the position of the contacts is clearly and reliably indicated.

EXAMPLE "Off", "off" or "OFF" marking or symbol "O" to indicate the open position; "On", "on", or "ON" marking or symbol "I" to indicate the closed position.

536.2.2.3 Semiconductor devices shall not be used as isolating devices.

536.2.2.4 Devices for isolation shall be designed and/or installed so as to prevent unintentional closure.

This may be achieved by locating the device in a lockable space or lockable enclosure or by padlocking.

NOTE Such closure can be caused for example by shocks and vibrations.

536.2.2.5 Provision shall be made to prevent the inadvertent and/or unauthorized opening of a disconnector, unless the device for isolation is capable of making and breaking currents under normal conditions.

This may be achieved by locating the device in a lockable space or lockable enclosure or by padlocking. Alternatively, a disconnector may be interlocked with a switch or a protective device.

536.2.2.6 Where a link is inserted in the neutral conductor, the following shall apply:

- it is accessible to skilled persons only;
- it is designed to prevent the inadvertent and/or unauthorized removal;
- it cannot be removed without the use of a tool.

536.2.2.7 Means of isolation shall be provided preferably by a multipole switching device which disconnects all poles of the relevant supply; however, single-pole devices, situated adjacent to each other for multi-phase circuits, are not excluded.

Single-pole protective devices (e.g. circuit-breakers or fuses) shall not be used in the neutral conductor only.

536.2.2.8 All devices used for isolation shall be clearly identified, for example by marking, to indicate the circuit which they isolate.

536.2.2.9 Subclauses 536.2.2.1 to 536.2.2.8 do not apply to plugs and socket-outlets, connectors and devices for connection of luminaires.

536.3 Switching-off for mechanical maintenance

536.3.1 General

536.3.1.1 Means of switching-off shall be provided where mechanical maintenance may involve a risk of physical injury other than due to electric shock or to arcing.

Where electrically powered mechanical equipment is within the scope of IEC 60204-1, the requirements for switching-off for mechanical maintenance of IEC 60204-1 apply.

Systems powered by non-electrical means, e.g. pneumatic, hydraulic or steam, are not covered by 536.3.1. In such cases, switching-off any associated supply of electricity may not be a sufficient measure.

536.3.1.2 Suitable means shall be provided to prevent electrically powered equipment from becoming unintentionally reactivated during mechanical maintenance, unless the means of switching-off is continuously under the control of any person performing such maintenance.

EXAMPLE

- selection of device suitable for padlocking in the off position;
- location within a lockable space or lockable enclosure.

The switching-off shall cause the disconnection of all line conductors by a device suitable for isolation.

536.3.2 Devices for switching-off for mechanical maintenance

536.3.2.1 Devices for switching-off for mechanical maintenance shall comply with 536.2.2 and shall fulfil all the other requirements of 536.3.2.

A device for switching-off for mechanical maintenance shall be inserted preferably in the supply circuit of the current using equipment to be maintained.

Where for this purpose switches are provided, they shall be capable of cutting off the full-load current of the relevant part of the installation. They shall not necessarily interrupt all line conductors.

Interruption of a control circuit where the device is not inserted in the supply circuit of the current using equipment to be maintained shall be used only where:

- supplementary safeguards, such as mechanical restrainers, are provided; or
- requirements for the control devices used provide a condition equivalent to the direct interruption of the main supply.

EXAMPLE Switching-off for mechanical maintenance can be achieved, by means of:

- multipole switches;
- circuit-breakers;
- control switches operating contactors;
- plugs and socket outlets.

536.3.2.2 Devices for switching-off for mechanical maintenance shall be placed and marked so as to be readily identifiable and convenient for their intended use.

536.4 Emergency switching

536.4.1 General

536.4.1.1 Where electrically powered equipment is within the scope of IEC 60204-1, the requirements for emergency switching of IEC 60204-1 apply.

Emergency switching is either emergency switching-on or emergency switching-off.

536.4.1.2 Means shall be provided for emergency switching of any part of an installation where it may be necessary to control the supply to remove an unexpected danger.

536.4.1.3 Means for emergency switching shall act as directly as possible as one single action on all relevant supply conductors.

536.4.1.4 The arrangement of the emergency switching shall be such that its operation does not introduce a further danger or interfere with the complete operation necessary to remove the danger.

536.4.2 Devices for emergency switching-off

536.4.2.1 Devices used for emergency switching shall be selected from Table E.1 and in accordance with 536.4.2.1 to 536.4.2.6.

The emergency switching-off device shall interrupt all live conductors.

The devices for emergency switching-off shall be capable of breaking the full-load current of the relevant parts of the installation taking account of stalled motor currents where appropriate.

536.4.2.2 Means for emergency switching-off shall consist of:

- one switching device suitable for isolation, capable of directly interrupting the appropriate supply, or
- a combination of equipment suitable for isolation activated by a single action for the purpose of interrupting the appropriate supply.

Hand-operated switching devices for direct interruption of the main circuit shall be selected where practicable.

A switching device suitable for isolation operated by remote control shall open on de-energization of coils, or other equivalent failure-to-safety techniques shall be employed.

EXAMPLE Failure-to-safety techniques are pneumatic actuators, or a shunt trip relay provided that the continuity of the actuating circuit is indicated (e.g. by a lamp).

536.4.2.3 The means of operating (handles, push-buttons, etc.) devices for emergency switching-off shall be clearly identified, preferably coloured red, with a contrasting background, preferably yellow.

Text shall not be used as the sole identification of such devices.

536.4.2.4 The means of operating shall be readily accessible at places where a danger might occur and, where appropriate, at any additional remote position from which that danger can be removed.

536.4.2.5 The release of an emergency switching-off device shall not result in re-energizing the relevant electrically powered equipment and/or relevant part of the installation.

536.4.2.6 Devices for emergency switching-off shall be so placed and marked as to be readily identifiable and convenient for their intended use.

536.4.3 Devices for emergency stopping

NOTE IEC 60204-1 provides requirements for the selection and erection of devices for emergency stopping.

Retention of the supply may be necessary, for example, for braking of moving parts.

536.5 Functional switching (control)

536.5.1 General

536.5.1.1 A functional switching device shall be provided for each part of a circuit which may require to be controlled independently of other parts of the installation.

536.5.1.2 Functional switching devices need not necessarily control all live conductors of a circuit.

A single-pole switching device shall not be placed in the neutral conductor, except where it is essential for the operation of a control device (e.g. sensor, luminaire control device, dimmer, remote control switch (RCS)) that the line conductor is not switched.

536.5.1.3 Current-using equipment requiring control shall be controlled by an appropriate functional switching device.

A single functional switching device may control several items of equipment intended to operate simultaneously.

536.5.2 Devices for functional switching

536.5.2.1 Devices used for functional switching shall be selected from Table E.1 and in accordance with 536.5.2.2 to 536.5.2.3

536.5.2.2 Functional switching devices shall be selected and erected for the most onerous duty they may be called upon to perform.

536.5.2.3 Functional switching devices may control the current without necessarily opening the corresponding poles.

NOTE Semiconductor switching devices are examples of devices capable of interrupting the current in the circuit but not opening the corresponding poles.

536.5.2.4 Links shall not be used for functional switching.

536.5.2.5 Plugs and socket-outlets rated at not more than 16 A may be used for functional switching.

537 Monitoring

537.1 General

537.1.1 Monitoring devices

Monitoring devices are not intended to provide protection against electric shock.

537.1.2 Selection of insulation monitoring devices (IMDs)

IMDs shall be in accordance with IEC 61557-8.

IMDs shall be installed at or near the origin of the part of the installation to be monitored, as practicable.

537.1.3 Selection of residual current monitoring devices (RCMs)

RCMs shall comply with IEC 62020.

RCMs shall be installed at or near the origin of the part of the installation to be monitored, as practicable.

Where a residual current protective device (RCD) is installed upstream of the RCM, it is recommended to set the RCM to a residual actuating current not higher than a third of the rated residual operating current $I_{\Delta n}$ of the RCD.

537.2 IT systems for continuity of supply

537.2.1 General

An IMD is intended to permanently monitor the insulation resistance of an IT system and provides an alarm where the insulation resistance R_F is below the response value R_a.

An IMD shall be installed in IT systems in accordance with the requirement of IEC 60364-4-41:2005 and IEC 60364-4-41:2005/AMD1:2017, 411.6.3.1.

Instructions shall be provided indicating that when the IMD detects an insulation fault to earth, the insulation fault shall be located and eliminated in order to restore normal operating conditions with the shortest practicable delay.

Where IT systems are used for continuity of service, the alarm indicating detection of the first insulation fault shall be located so it is audible and/or visible by instructed (BA4) or skilled (BA5) persons.

It is recommended to use an IMD that signals an interruption of the measurement connections to the system conductors and earth.

Where IT systems are used for continuity of service, it is recommended to combine the IMD with devices enabling the fault location on-load, and equipment for insulation fault location shall be selected in accordance with IEC 61557-9.

537.2.2 Insulation monitoring devices (IMDs)

In multiphase systems, IMDs shall be selected to withstand at least line to line voltage.

Where the system to be monitored contains DC components (due to electronic equipment, e.g. rectifiers or converters), IMDs shall be selected accordingly.

537.2.3 Installation of IMDs

Where an IMD is connected to the neutral conductor, no OCPD shall be inserted in the connection between the IMD and the neutral conductor.

The setting of the IMD shall only be adjusted by instructed (BA4) or skilled (BA5) persons. Access to the setting means may be achieved through use of a key, a tool or a password.

NOTE A value of 100 Ω/V (300 Ω/V for pre-warning) of the rated system voltage is an example of typical setting values.

Where the installation is supplied from more than one power supply, one IMD per supply shall be used.

For power supplies temporarily connected in parallel, the associated IMDs shall be interlocked in such a way that only one IMD remains connected to the IT system.

If the IMD is also intended to monitor the disconnected part of an installation, the IMD shall be supplied by an auxiliary source

537.3 IT public distribution system

For installations connected to an IT public distribution network and where more than one installation is intended to be connected to the same distribution network, the following apply:

Where interruption of the supply in case of a first insulation fault to earth is not required or not permitted, a monitoring device shall be selected and erected to indicate the occurrence of a first insulation fault from a live part to exposed-conductive-parts or to earth in accordance with 411.6.3.1 of IEC 60364-4-41:2005/AMD1:2017.

Such monitoring devices may be:

- IMDs, or,
- where the residual fault current is sufficiently high, residual current monitoring devices (RCMs).

It is recommended to use directionally discriminating RCMs in order to avoid unwanted signalling of leakage current when high leakage capacitances are liable to exist downstream from the point of installation of the RCM.

NOTE In IT systems the measuring principle of an RCM is not able to detect double or symmetrical insulation faults on different live conductors downstream of the RCM.

537.4 Off-line systems in TN, TT and IT systems

Where insulation monitoring of off-line systems is needed, it may be achieved by using insulation monitoring devices (IMDs).

IMDs used for off-line system monitoring shall automatically be deactivated whenever the system is switched on.

NOTE As an example, this can be applicable for systems which are normally de-energized, such as a fire pump or a fire ventilation.

The reduction of the insulation level shall be indicated locally by either a visual or an audible signal with the option of remote indication. The alarm indicating detection of the first insulation fault shall be located so it is audible and/or visible by instructed (BA4) or skilled (BA5) persons.

The alarm threshold should be above 300 kΩ, as the insulation levels measured are generally very high.