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Road vehicles — Diagnostic communication over Internet Protocol (DoIP) —

Part 3: Wired vehicle interface based on IEEE 802.3

Véhicules routiers — Communication de diagnostic au travers du protocole internet (DoIP) —

Partie 3: Interface du véhicule câblé sur la base de l'IEEE 802.3

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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

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

ISO 13400-3 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 3, *Electrical and electronic equipment*.

ISO 13400 consists of the following parts, under the general title *Road vehicles — Diagnostic communication over Internet Protocol (DoIP)*:

— *Part 1: General information and use case definition*

— *Part 2: Transport protocol and network layer services*

— *Part 3: Wired vehicle interface based on IEEE 802.3*

The following parts are under preparation:

— *Part 4: Ethernet diagnostic connector*

— *Part 5: Conformance test specification*

Introduction

Vehicle diagnostic communication has been developed starting with the introduction of the first legislated emissions-related diagnostics and has evolved over the years, now covering various use cases ranging from emission-related diagnostics to vehicle-manufacturer-specific applications like calibration or electronic component software updates.

With the introduction of new in-vehicle network communication technologies, the interface between the vehicle's electronic control units and the test equipment has been adapted several times to address the specific characteristics of each new network communication technology requiring optimized data link layer definitions and transport protocol developments in order to make the new in-vehicle networks usable for diagnostic communication.

With increasing memory size of electronic control units, the demand to update this increasing amount of software and an increasing number of functions provided by these control units, technology of the connecting network and buses has been driven to a level of complexity and speed similar to computer networks. New applications (x-by-wire, infotainment) require high band-width and real-time networks (like FlexRay, MOST), which cannot be adapted to provide the direct interface to a vehicle. This requires gateways to route and convert messages between the in-vehicle networks and the vehicle interface to test equipment.

The intent of ISO 13400 (all parts) is to describe a standardized vehicle interface which

— separates in-vehicle network technology from the external test equipment vehicle interface requirements to allow for a long-term stable external vehicle communication interface,

— utilizes existing industry standards to define a long-term stable state-of-the-art communication standard usable for legislated diagnostic communication as well as for manufacturer-specific use cases, and

— can easily be adapted to new physical and data link layers, including wired and wireless connections, by using existing adaptation layers.

To achieve this, all parts of ISO 13400 are based on the Open Systems Interconnection (OSI) Basic Reference Model specified in ISO/IEC 7498-1 and ISO/IEC 10731, which structures communication systems into seven layers. When mapped on this model, the services specified by ISO 14229-1, ISO 14229-2 and ISO 14229-5 are divided into

a) unified diagnostic services (layer 7), specified in ISO 14229-1, ISO 14229-5, ISO 27145-3,

b) presentation (layer 6):

   1) for enhanced diagnostics, specified by the vehicle manufacturer,

   2) for WWH-OBD (World-Wide Harmonized On-Board Diagnostics), specified in ISO 27145-2, SAE J1930-DA, SAE J1939:2011, Appendix C (SPNs), SAE J1939-73:2010, Appendix A (FMI), SAE J1979-DA, SAE J2012-DA,

c) session layer services (layer 5), specified in ISO 14229-2,

d) transport protocol (layer 4), specified in ISO 13400-2,

e) network layer (layer 3) services, specified in ISO 13400-2, and

f) physical and data link services (layers 1 and 2), specified in this part of ISO 13400,

in accordance with Table 1.

Table 1 — Enhanced and legislated WWH-OBD diagnostic specifications applicable to the OSI layers

Applicability	OSI 7 layers	Vehicle manufacturer enhanced diagnostics	WWH-OBD document reference
Seven layers according to ISO/IEC 7498-1 and ISO/IEC 10731	Application (layer 7)	ISO 14229-1/ISO 14229-5	ISO 14229-1/ISO 27145-3
	Presentation (layer 6)	Vehicle manufacturer specific	ISO 27145-2, SAE J1930-DA, SAE J1939:2011, Appendix C (SPNs), SAE J1939-73:2010, Appendix A (FMIs), SAE J1979-DA, SAE J2012-DA
	Session (layer 5)	ISO 14229-2	ISO 14229-2
	Transport (layer 4)	ISO 13400-2	ISO 13400-2
	Network (layer 3)		
	Data link (layer 2)	ISO 13400-3	ISO 13400-3
	Physical (layer 1)		

The application layer services covered by ISO 14229-5 have been defined in compliance with diagnostic services established in ISO 14229-1, but are not limited to use only with them.

The transport and network layer services covered by ISO 13400-2 have been defined to be independent of the physical layer implemented.

For other application areas, this part of ISO 13400 can be used with any Ethernet physical layer.

Road vehicles — Diagnostic communication over Internet Protocol (DoIP) —

Part 3:
Wired vehicle interface based on IEEE 802.3

1 Scope

This part of ISO 13400 specifies the vehicle communication interface and test equipment requirements for a physical and data link layer based on IEEE 802.3 100BaseTx.

This interface serves as the physical basis for IP-based communication between the vehicle and test equipment. This part of ISO 13400 specifies the following aspects:

— requirements for signal and wiring schematics in order to ensure physical layer compatibility of the vehicle interface and Ethernet networks and test equipment communication interfaces;

— activation and deactivation of the diagnostic Ethernet interface;

— mechanical and electrical diagnostic connector requirements.

2 Normative references

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

ISO 13400-1, *Road vehicles — Diagnostic communication over Internet Protocol (DoIP) — Part 1: General information and use case definition*

ISO 14229-1, *Road vehicles — Unified diagnostic services (UDS) — Part 1: Specification and requirements*

IEC 60950-1, *Information technology equipment — Safety — Part 1: General requirements*

IEEE 802.3, *IEEE Standard for Information Technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements — Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13400-1, ISO 14229-1 and the following apply.

3.1.1
Auto-MDI(X)
automatic medium-dependent interface crossover
device that allows the Ethernet hardware to decide whether a cross-linked cable or a one-to-one connected (patch) cable is used for the connection between two Ethernet ports and which configures the physical layer transceiver (PHY) according to the type of cable in order to correctly connect Tx and Rx lines

3.1.2
DoIP Edge Node
host inside the vehicle, where an Ethernet activation line in accordance with this part of ISO 13400 is terminated and where the link from the first node/host in the external network is terminated

3.1.3
link segment
twisted-pair link for connecting two physical layers (PHYs) for 100baseTx

NOTE Adapted from IEEE 802.3:2008, 1.4.355.

3.2 Abbreviated terms

Cat5 category 5 cable as specified in TIA/EIA-568-B[1]

DoIP diagnostics over Internet Protocol

DoEth diagnostics over Internet Protocol on Ethernet

FMI failure mode indicator

MAC media access control

MDI medium-dependent interface

PE protective earth conductor

PHY physical layer transceiver

Rx receive

SPN suspect parameter number

Tx transmit

4 Conventions

ISO 13400 is based on the conventions discussed in the OSI Service Conventions (ISO/IEC 10731) as they apply to diagnostic services.

5 Document overview

ISO 13400 is applicable to vehicle diagnostic systems implemented on an IP communication network.

ISO 13400 has been established in order to define common requirements for vehicle diagnostic systems implemented on an IP communication link.

Although primarily intended for diagnostic systems, ISO 13400 has been developed to also meet requirements from other IP-based systems needing a transport protocol and network layer services.

Figure 1 illustrates the most applicable application implementations utilizing DoIP.

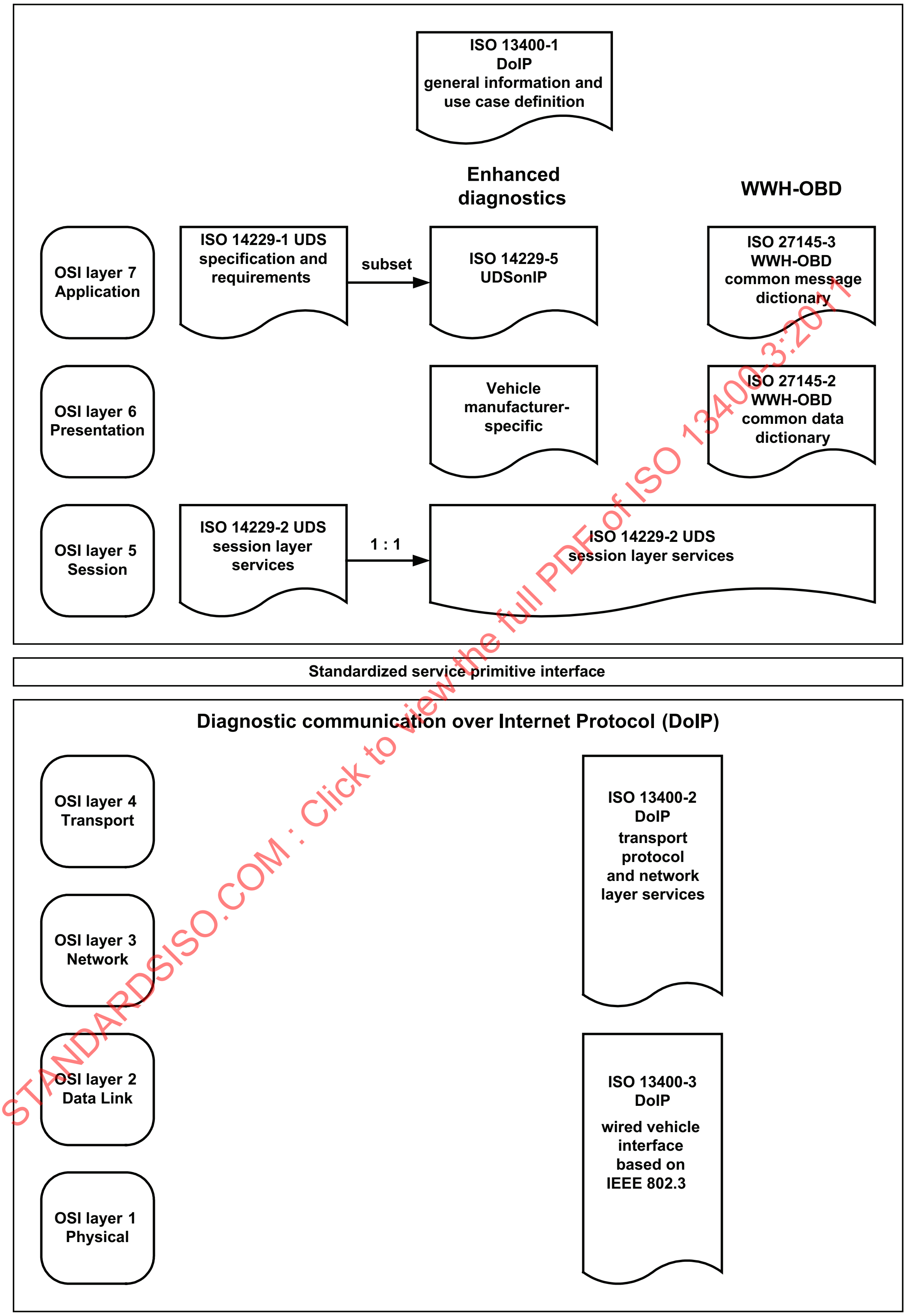


Figure 1 — DoIP document reference according to the OSI model

6 Ethernet physical and data link layer requirements

6.1 General information

Ethernet is a collection of several standards for different transmission technologies and speeds contained in IEEE 802.3 and is a frame-based networking technology for wired local area networks. Frames are defined as the format of data packets on the wire. The Internet Protocol (IPv4) theoretically allows for a maximum IP packet length of 64 Kbytes. This size is limited by the Ethernet specification, which defines a 16-bit-length field and requires a minimum packet length of 64 bytes as well as allowing for a maximum payload length of 1 500 bytes. Consequently, IP packets can have a maximum length of only 1 500 bytes on Ethernet. However, IP allows for fragmentation of IP packets over multiple Ethernet frames to work around this limitation. The rules for fragmentation of IP packets differ between IPv6 and IPv4 and are not specified in this part of ISO 13400.

The Ethernet connection of a vehicle works with four transmission lines in accordance with IEEE 802.3 100BaseTx as well as using an additional activation line. The Ethernet controller in the DoIP Edge Node can be switched on and off via the activation line when the test equipment is connected to, or disconnected from, the car.

There are two types of Ethernet patch cables available:

— One-to-one (1:1) connection, which is usually used to connect an end-node (e.g. a computer) with a network hub or switch. In this case, the pins of each RJ45 connector of the patch cable or the cable to the car connector are directly connected to each other (e.g. Rx+ on the source port is connected to Rx+ on the destination port).

— Cross-linked connection, which is usually used to connect two end nodes directly with each other (e.g. computer to computer). In this case, the Tx pins on the source port of the patch cable are connected to the Rx pins on the destination port and vice versa.

Depending on the Auto-MDI(X) capabilities of the Ethernet implementation, it is possible that cross-linked connections or 1:1 connections can be used interchangeably. This depends on the Auto-MDI(X) capabilities of the PHY. The Auto-MDI(X) feature was developed to allow for plug and play use of both types of patch cable.

6.2 Ethernet physical layer requirements

This subclause specifies the requirements for implementation of the physical layer of Ethernet by the DoIP Edge Node, including stub length in the vehicle and maximum cable length between test equipment and the DoIP Edge Node PHY so as to allow for guaranteed operation even in noisy environments.

[DoEth-001] The DoIP Edge Node shall support the 100Base-TX (100 Mbit/s Ethernet) standard as specified in IEEE 802.3.

[DoEth-002] The DoIP Edge Node shall support the 10Base-T (10 Mbit/s Ethernet) standard as specified in IEEE 802.3.

NOTE The requirement to support 10 Mbit/s is intended as a fall-back solution in environments where a 100 Mbit/s connection cannot be established between the two Ethernet interfaces. In such cases, the connection can still be established at a reduced speed.

[DoEth-003] The DoIP Edge Node shall provide for isolation of 1 500 V for 1 min between the transformer coils, in accordance with IEC 60950-1 (TNV1 circuit) and IEEE 802.3, on the link to the outside network.

6.3 Ethernet data link layer requirements

This subclause specifies the requirements for implementation of the data link layer of Ethernet by the DoIP Edge Node so as to allow for backwards-compatible communication with older versions of Ethernet at the best achievable data rate.

[DoEth-004] The DoIP Edge Node shall support 10 Mbit/s Ethernet on the link to the external network.

[DoEth-005] The DoIP Edge Node shall support 100 Mbit/s Ethernet (100Base-Tx).

[DoEth-006] The DoIP Edge Node shall support Auto-Negotiation as specified in IEEE 802.3, which is an Ethernet procedure for automatic handshaking of two directly networked interfaces to connect with identical parameters (i.e. transmission rate and duplex mode).

[DoEth-007] The test equipment shall support the 100BaseTx standard as specified in IEEE 802.3.

[DoEth-008] For improved fault tolerance against incorrect Ethernet cabling (1:1 connection/cross-linked), the test equipment shall support the Auto-MDI(X) feature.

NOTE The DoIP Edge Node is not required to support the Auto-MDI(X)-feature.

6.4 Ethernet PHY and MAC requirements

[DoEth-009] The DoIP Edge Node shall use an Ethernet device that allows for detection of physical connects and disconnects (link detection) and notification of upper communication layers about these occurrences.

NOTE A DoIP Edge Node Ethernet Controller is not required to support Wake on LAN (WoL) as activation of the Ethernet hardware is ensured using the separate activation line described in 6.5.

6.5 Ethernet activation line requirements

6.5.1 Vehicle activation line requirements

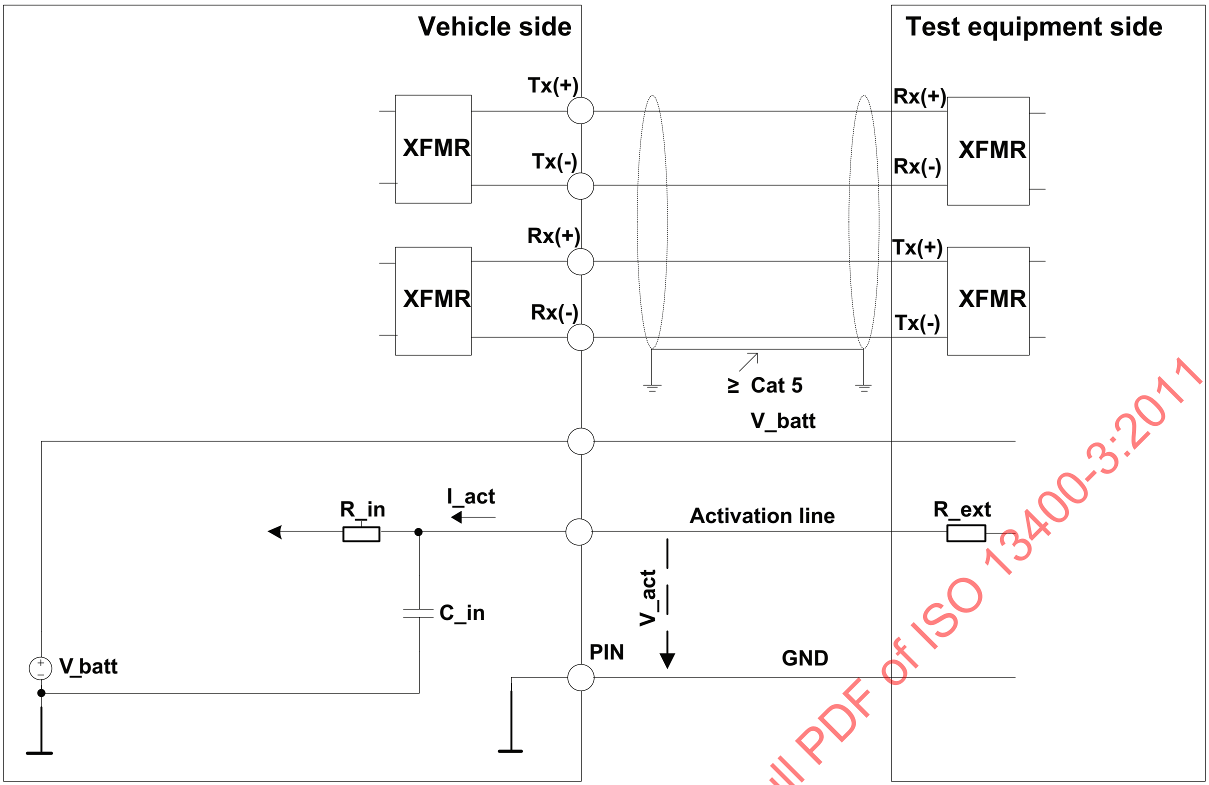
Reasons for activating and deactivating the Ethernet Controller are

— reduction of electromagnetic interference, and

— reduction of power consumption of the DoIP Edge Node.

The Wake on LAN (WoL) feature cannot be used for this purpose as it requires knowledge of the MAC address of the controller in order to wake it up and this is typically not known when a vehicle drives into a repair workshop. Another disadvantage of the standard WoL feature is that the Magic Packet requires the Ethernet controller to process the complete frame, which results in increased current consumption.

Figure 2 shows a schematic configuration of Ethernet and the activation line with the electrical parameters listed in Table 2.



Key

C_{in}	internal capacitance
I_{act}	activation current
R_{ext}	external resistance
R_{in}	internal resistance
V_{act}	activation voltage
V_{batt}	battery voltage
GND	ground
XFMR	Ethernet transformer

Figure 2 — Equivalent circuit diagram

Table 2 gives an overview of the electrical parameters.

Table 2 — Overview of electrical parameters

Electrical parameter	Minimum	Typical	Maximum
R_{in}	9 kΩ – 1 %	—	10 kΩ + 1 %
I_{act}	0 mA[a]	1,3 mA[b]	2 mA
R_{ext}	510 Ω (–5 %)	—	1 kΩ (+5 %)
V_{act}[c]	0 V	—	16 V
V_{act} ($t \le 60$ s)[c]	–14 V	—	28 V

[a] If Ethernet is deactivated with $V_{act} = 0$ V.

[b] With $V_{act} = 12$ V and $R_{in} = 9\,500\ \Omega$ (Ethernet activated) as an example.

[c] Limiting values.

[DoEth-010] The input resistance (R_{in}) in the activation circuit shall be at least 9 kOhms (–1 %). This is to guarantee that the input current will not exceed 2 mA in this circuit.

[DoEth-011] The deactivation voltage threshold ($V_{inactive}$) shall be 2 V (see Table 3), implying that a voltage value below 2 V shall not activate the Ethernet controller of the DoIP Edge Node if Ethernet is already deactivated. This is to avoid random activation caused by ground shift or electromagnetic interference (see Figure 3).

[DoEth-012] The guaranteed activation voltage threshold (V_{active}) shall be 5 V, implying that Ethernet will not be activated until the voltage value on the activation line rises above this threshold.

[DoEth-013] The activation signal V_{act} shall remain between V_{active} and V_{max} for at least 200 ms to activate the Ethernet hardware.

[DoEth-014] For Ethernet deactivation V_{act} shall drop below $V_{inactive}$ for at least 200 ms.

NOTE 1 The aforementioned requirements imply that, depending on the electrical design, a DoIP Edge Node can activate the Ethernet connection starting with any value above $V_{inactive}$. However, there is no guarantee that Ethernet is really active until the voltage levels rise above V_{active}. Once activated, the Ethernet connection can remain active until all conditions to deactivate the Ethernet connection are met (e.g. some manufacturers might decide to keep the Ethernet connection active, even with V_{act} below $V_{inactive}$, if the physical Ethernet connection is still present, while other manufacturers might deactivate the Ethernet connection if V_{act} falls below $V_{inactive}$).

[DoEth-021] When the activation line is in the “guaranteed active” state, communication shall be allowed, although it will only be possible after a link has been detected.

[DoEth-022] When a link is detected, but the activation line is in the “deactivation criteria fulfilled” state, communication cannot be guaranteed.

[DoEth-015] The shield of the connecting cable shall be connected to the protective earth conductor (PE) on the test equipment side.

[DoEth-016] The shield of the connecting cable shall not be connected to the vehicle ground, either in the vehicle or in the test equipment.

Figure 3 depicts the Ethernet activation and deactivation voltage thresholds and timings.

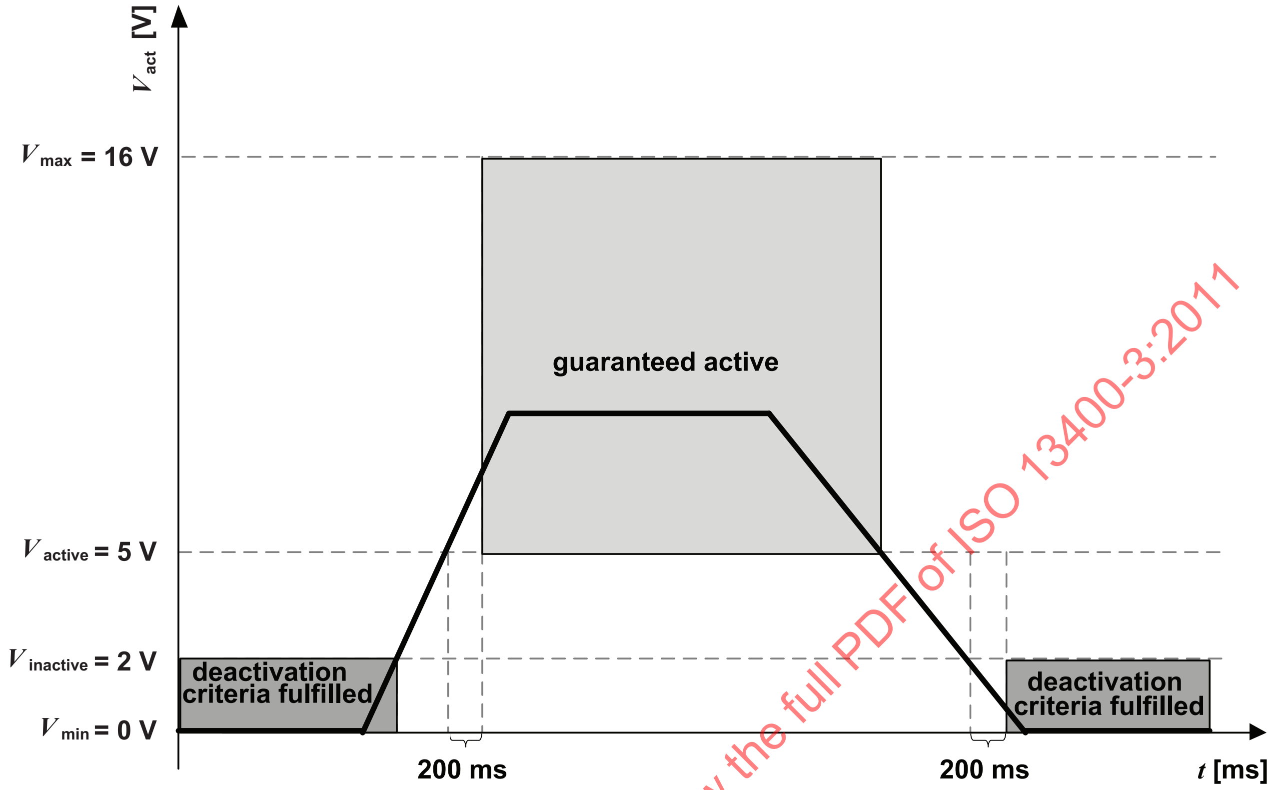


Figure 3 — Ethernet activation and deactivation voltage thresholds and timings

Table 3 defines the activation and deactivation voltage thresholds.

Table 3 — Activation and deactivation voltage thresholds

Parameter	Threshold
V_{active}	5 V
$V_{inactive}$	2 V
V_{min}	0 V
V_{max}	16 V

Figure 4 shows an example application of the requirements above, which results in a switching voltage (activation, deactivation) threshold on the activation line of 3,4 V.

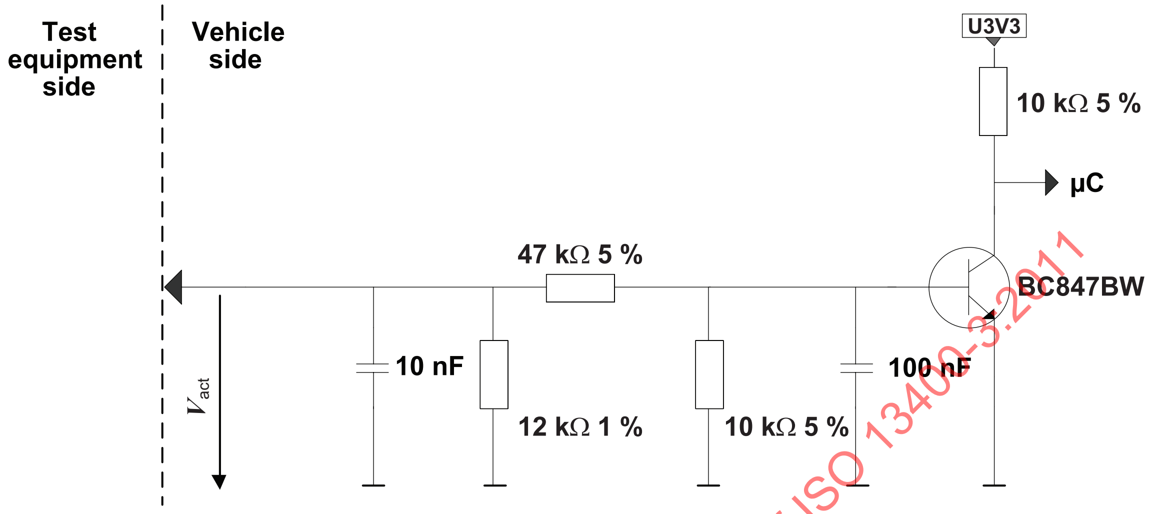


Figure 4 — Activation line circuit example

Table 4 defines the electrical parameters of the circuit example in Figure 4.

Table 4 — Electrical parameters of circuit example in Figure 4

Electrical parameter	Minimum	Typical	Maximum
R_{in}	9 300 Ω	9 560 Ω	9 800 Ω
C_{in}	—	10 nF	—

NOTE 2 The base-emitter resistance of a transistor needs to be taken into account when calculating R_{in}.

6.5.2 Test equipment activation line requirements

[DoEth-017] In order to establish communication with the DoIP Edge Node over Ethernet, the test equipment needs to provide a voltage signal (V_{act}) on the Ethernet activation line in accordance with the requirements in Table 3. Thus, only for the "guaranteed activation" range as depicted in Figure 3 can communication with the vehicle be performed reliably. Outside this range it depends on the vehicle manufacturer's design whether communication can still be performed.

NOTE 1 Additional pre-conditions may be necessary in order to perform communication with the vehicle (e.g. ignition key in "Run" position). Depending on the vehicle manufacturer's power network architecture, this implies that only providing the activation voltage signal does not necessarily "wake up" the vehicle.

[DoEth-018] When a connection is no longer required by the external test equipment (e.g. tester application is not used for a certain amount of time) the vehicle's Ethernet hardware shall be deactivated according to [DoEth-014]. This applies even if the external test equipment is still physically connected to the vehicle.

NOTE 2 Physically disconnecting the external test equipment from the vehicle automatically results in the deactivation voltage thresholds specified in 6.5.1.

6.6 Cable definitions

This subclause specifies the requirements regarding cable characteristics and cable length to ensure Ethernet communication at the intended speed of 100 Mbit/s.

[DoEth-019] The cable from the vehicle to the test equipment shall be at least Cat5.

[DoEth-020] While IEEE 802.3 (100BaseTx) defines a Cat5 link segment length of 100 m (unshielded twisted pair), for successful transmission the link segment length between the diagnostic connector of the vehicle and the next PHY (e.g. Ethernet port of test equipment or Ethernet switch) shall not exceed 50 m.

NOTE A detailed specification of cables that are needed for test equipment power supply or for the activation line circuit is outside the scope of this part of ISO 13400; this will be left to the discretion of the vehicle manufacture or test equipment manufacturer.