# INTERNATIONAL STANDARD

**ISO 15765-5**

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# Road vehicles — Diagnostic communication over Controller Area Network (DoCAN) —

## Part 5:
## Specification for an in-vehicle network connected to the diagnostic link connector

*Véhicules routiers — Communication de diagnostic sur gestionnaire de réseau de communication (DoCAN) —*

*Partie 5: spécification pour un réseau véhicule connecté sur la prise de diagnostic*

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# Foreword

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 31, *Data communication*.

A list of all parts in the ISO 15765 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

# Introduction

The ISO 15765 series defines common requirements for vehicle diagnostic systems using the controller area network (CAN), as specified in the ISO 11898 series.

The ISO 15765 series presumes the use of external test equipment for inspection, diagnostics, repair and other possible use cases connected to the vehicle.

This document does not specify any requirements related to the in-vehicle CAN network architecture. It defines the requirements to enable the in-vehicle CAN network to successfully establish, maintain and terminate communication with the devices externally connected to the diagnostic link connector.

This document has been structured according to the open systems interconnection (OSI) basic reference model, in accordance with ISO/IEC 7498-1 and ISO/IEC 10731, which structures communication systems into seven layers. When mapped on this model, the OSI layer 4 to OSI layer 1 framework requirements specified or referenced in the ISO 15765 series are structured according to Figure 1, which shows the related documents of OSI layer 4 to OSI layer 1.
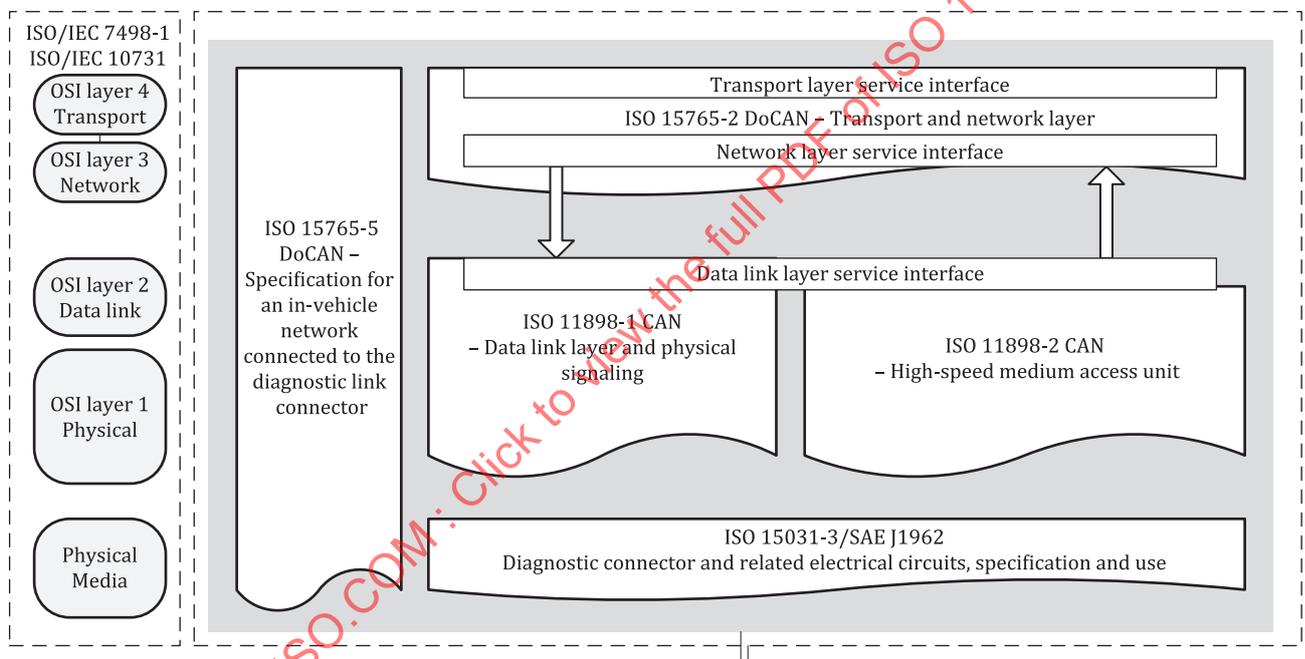


**Figure 1 — CAN documents reference according to OSI model**

The documents include the following content:

— transport layer (TL) -related requirements with reference to ISO 15765-2;

— network layer (NL) -related requirements with reference to ISO 15765-2;

— data link layer (DLL) -related requirements with reference to ISO 11898-1, which are composed of:

— DLL protocol entity requirements;

— DLL device interface requirements;

— DLL network system requirements;

— physical layer (PHY) -related requirements with reference to ISO 11898-2, which are composed of:

— physical signalling (PS) requirements, which are composed of:

— PS entity requirements;

— PS device interface requirements;

— PS network system requirements;

— physical medium attachment (PMA) requirements, which are composed of:

— PMA protocol entity requirements;

— PMA device interface requirements;

— physical medium dependent (PMD) requirements, which are composed of:

— PMD entity requirements;

— PMD device interface requirements;

— PMD network system requirements.

The PS sub-layer is implemented in the CAN protocol controller. The PMA sub-layer is implemented normally in the CAN transceiver or the system base chip (SBC). Optionally it may comprise also additional protection circuitry. The media-dependent sub-layer comprises the connectors and the cabling.

Figure 2 shows an implementation example of the data link and physical layers block diagram.
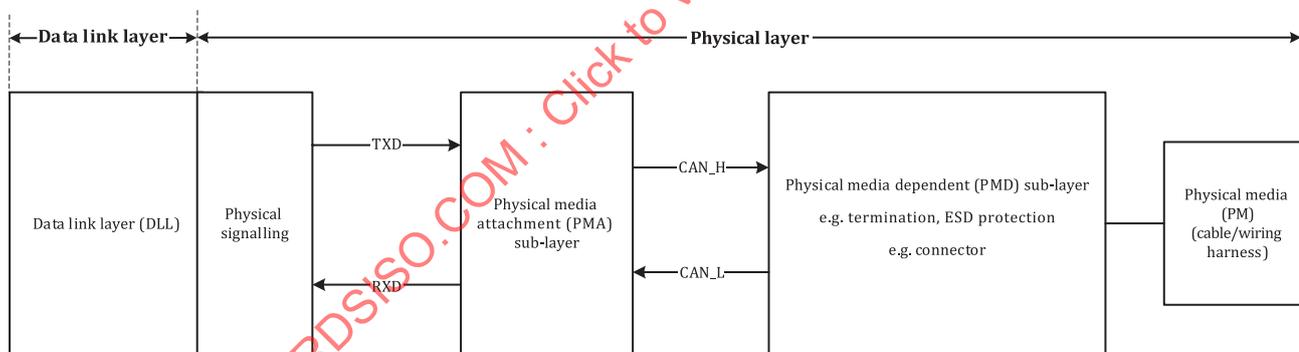


**Figure 2 — Implementation example of lower OSI layers block diagram**

The above structure is chosen to provide the following implementers with relevant requirements:

— transceiver developers;

— device (e.g. electronic control unit) developers;

— system network developers.

All requirements are numbered and headlined uniquely, so that each implementer can reference them.

Annex A provides a description of the compatibility between test equipment and in-vehicle network connected to the diagnostic link connector.

# Road vehicles — Diagnostic communication over Controller Area Network (DoCAN) —

## Part 5:
## Specification for an in-vehicle network connected to the diagnostic link connector

## 1 Scope

This document specifies the requirements related to the connection between the external test equipment externally connected to the diagnostic link connector and the in-vehicle CAN network to successfully establish, maintain and terminate communication.

## 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.

ISO 11898 (all parts), *Road vehicles — Controller area network (CAN)*

ISO 15031-3, *Road vehicles — Communication between vehicle and external equipment for emissions-related diagnostics — Part 3: Diagnostic connector and related electrical circuits: Specification and use*

ISO 15765-2, *Road vehicles — Diagnostic communication over Controller Area Network (DoCAN) — Part 2: Transport protocol and network layer services*

ISO 15765-4, *Road vehicles — Diagnostic communication over Controller Area Networks (DoCAN) — Part 4: Requirements for emissions-related systems*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in the ISO 11898 series, ISO 15765-2 and ISO 15765-4 apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

## 4 Symbols and abbreviated terms

### 4.1 Symbols

| – | empty table cell or feature undefined |
| $\Delta f$ | oscillator tolerance |
| $f_{Ba}$ | nominal data bit rate |

| $f_{Bd}$ | data bit rate |
|---|---|
| $L_{CABLE}$ | cable length between in-vehicle CAN node and diagnostic link connector |
| $t_{Ba}$ | arbitration bit time |
| $t_{Bd}$ | data bit time |
| $t_{BIT}$ | bit time |
| $t_{BIT\_RX}$ | receive bit time |
| $t_{BIT\_TX}$ | transmit bit time |
| $t_{Qa}$ | nominal arbitration bit time quantum length |
| $t_{Qd}$ | nominal data bit time quantum length |
| $t_{SJWa}$ | arbitration bit synchronisation jump width |
| $t_{SJWd}$ | data bit synchronisation jump width |
| $t_{Q}$ | time quantum |
| $t_{SPa}$ | nominal arbitration bit sample point position |
| $t_{SPd}$ | nominal data bit sample point position |
| X | table cell selected or feature defined |

## 4.2 Abbreviated terms

| AE | address extension |
|---|---|
| AL | application layer |
| CAN | controller area network |
| CAN FD | controller area network flexible data-rate |
| CBFF | classical base frame format |
| CEFF | classical extended frame format |
| DCC | diagnostic communication channel |
| DLL | data link layer |
| DoCAN | diagnostic communication over controller area network |
| Ftype | frame type |
| FBFF | FD base frame format |
| FEFF | FD extended frame format |
| L_ | data link |
| MSb | most significant bit |
| Mtype | message type |

| N_ | network |
|---|---|
| NL | network layer |
| N_PDU | network protocol data unit |
| PDU | protocol data unit |
| PHY | physical layer |
| Ptype | packet type |
| SA | source address |
| SJW | synchronisation jump width |
| SP | sample point |
| T_ | transport |
| TA | target address |
| TAtype | target address type |
| TL | transport layer |
| T_PDU | transport protocol data unit |
| DiagNormAddr | diagnostic message with normal addressing |
| DiagNormFixAddr | diagnostic message with normal fixed addressing |
| DiagExtAddr | diagnostic message with extended addressing |
| RDiagMixAddr | remote diagnostic message with mixed addressing |

## 5 Conventions

This document is based on OSI service conventions as specified in ISO/IEC 10731.

## 6 In-vehicle network to external test equipment connection

### 6.1 Connectivity scenarios between external test equipment and vehicle

This document specifies the requirements for the diagnostic link connector providing access to CAN FD network. A backward compatibility to classical CAN is described in Annex A.

### 6.2 Technical requirements overview

Table 1 provides an overview of the technical requirements and associated requirement numbers.

Table 1 — Technical requirements overview

| REQ # | Technical requirement title |
|---|---|
| 4 | Transport layer (TL) |
| 4.1 | TL – ISO 15765-2 T_Data interface primitive parameter mapping |
| 4.2 | TL – ISO 15765-2 TX_DL = 8 |

**Table 1** *(continued)*

| REQ # | Technical requirement title |
|---|---|
| 4.3 | TL – ISO 15765-2 TX_DL > 8 |
| 3 | Network layer (NL) |
| 3.1 | NL – ISO 15765-2 N_Data interface primitive parameter mapping |
| 3.2 | NL – ISO 15765-2 network layer services |
| 3.3 | NL – ISO 15765-2 network layer timing parameters |
| 3.4 | NL – ISO 15765-2 uniqueness of node diagnostic address |
| 3.5 | NL – ISO 15765-2 supported addressing formats |
| 3.6 | NL – ISO 15765-2 functional addressing |
| 3.7 | NL – ISO 15765-2 reception of N_PDU |
| 2 | Data link layer (DLL) |
| 2.1 | DLL – Data interface primitive parameter mapping – Mapping of upper OSI layer service interface parameters |
| 2.2 | DLL – Data interface primitive parameter mapping – ISO 11898-1 |
| 2.3 | DLL – Mapping of N_AI into the 11-bit CAN identifier |
| 2.4 | DLL – Mapping of N_AI into the 29-bit CAN identifier |
| 2.5 | DLL – Device acceptance of CAN identifier |
| 1 | Physical layer (PHY) |
| 1.1 | PHY – PS entity requirements – ISO 11898-1 conformance |
| 1.2 | PHY – PS device interface requirements – Classical CAN bit timing parameters |
| 1.3 | PHY – PS device interface requirements – CAN FD sampling method |
| 1.4 | PHY – PS device interface requirements – CAN FD bit timing parameters |
| 1.5 | PHY – PS device interface requirements – CAN FD transmitter delay compensation |
| 1.6 | PHY – PS device interface requirements – Termination resistance |
| 1.7 | PHY – PMA entity requirements – ISO 11898-2 conformance |
| 1.8 | PHY – PMA entity requirements – Qualification |
| 1.9 | PHY – PMD entity requirements – Diagnostic link connector |
| 1.10 | PHY – PMD entity requirements – DoCAN pin assignment on diagnostic link connector |
| 1.11 | PHY – PMD entity requirements – Cable characteristics between vehicle network connected to the diagnostic link connector for data bit rates > 500 kbit/s |
| 1.12 | PHY – PMD network system requirements |
| 1.13 | PHY – PMD network system requirements – Cable length between single CAN node and diagnostic link connector |

## 6.3   SI — Data.req, Data.ind and Data.conf service interface

The service interface defines the service and parameter mapping from the application layer (AL) to the session layer.

Figure 3 shows the Data.req (request), Data.ind (indication) and Data.conf (confirmation) service interface.
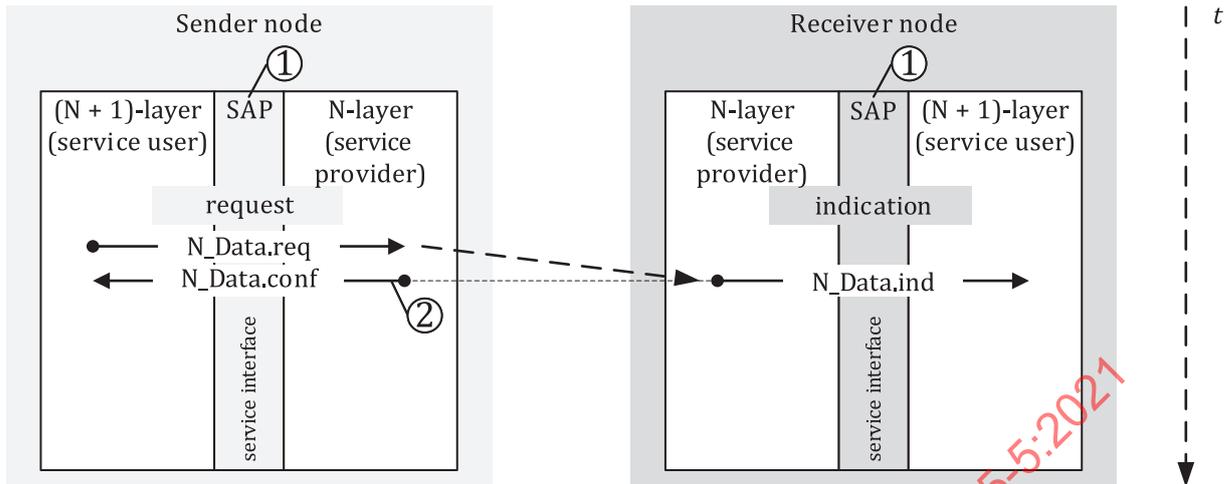
**Key**

1    service access point

2    read back from N-layer service provider

**Figure 3 — Data.req, Data.ind and Data.conf service interface**

## 6.4   SI — Parameter mapping and configuration of OSI-layers

Each OSI layer contains layer-specific information to manipulate or edit the PDU depending on whether the PDU is provided as a Data.req (sender), Data.ind (receiver) or Data.conf (receiver).

A PDU, which is sent by an application (service user), is assembled by each applicable OSI-layer based on PDU identification information. A PDU, which is received by the OSI-layers (service provider), has PDU identification information used by each applicable OSI layer to disassemble the PDU before it is transferred to the application (service user).

A specific implementation of the service primitive interface parameter management for each OSI-layer is not specified in this document.

## 6.5   Transport layer (TL)

### 6.5.1   TL – Data interface primitive parameter mapping

This requirement specifies the A_Data to T_Data interface primitive parameter mapping between the AL and the TL.

| **REQ 4.1 TL – ISO 15765-2 T_Data interface primitive parameter mapping** |
|---|
| The T_Data service primitive shall use the service primitive parameters as specified in Table 2. |

**Table 2 — T_Data service primitive parameter mapping**

| TL | .req | .ind | .conf | Description |
|---|---|---|---|---|
| T_TAtype | X | X | X | target address type: the configurable TX_DL value is an upper bound for the valid CAN frame data length (CAN_DL) for the transmitting node. <br><br> AddrType: (DiagNormAddr, DiagNormFixAddr, DiagExtAddr, RDiagMixAddr) |
| T_Length | X | X | X | length of PDU |
| T_Data | X | X | – | transport layer data |
| T_Result | – | – | X | result |
| X  Supported. | | | | |
| –  Not supported. | | | | |

### 6.5.2    TL – Message segmentation

The TL performs message segmentation into packets of 8 byte. The support of the ISO 15765-2 transport protocol is determined by the application.

| REQ | **4.2 TL – ISO 15765-2 TX_DL = 8** |
|---|---|
| The CAN node(s) shall support the transport protocol feature TX_DL = 8 as specified in ISO 15765-2: <br><br> — single segment transmission with TX_DL = 8 byte; <br><br> — multiple-segments transmission with TX_DL = 8 up to $2^{12} - 1$ byte for first packet escape sequence. | |

The TL performs message segmentation into packets greater than 8 byte. The support of the ISO 15765-2 transport protocol is determined by the application.

| REQ | **4.3 TL – ISO 15765-2 TX_DL > 8** |
|---|---|
| The CAN node(s) shall support the transport protocol feature TX_DL > 8 as specified in ISO 15765-2: <br><br> — single segment transmission with TX_DL > 8 byte; <br><br> — multiple segments transmission with TX_DL > 8 up to $2^{32} - 1$ data byte for first packet escape sequence. | |

### 6.5.3    TL ISO 15765-2 packet flow control

The TL controls the packet flow by means of the FlowControl packet.

| REQ | **4.4 TL – ISO 15765-2 definition of Flow Control parameter values** |
|---|---|
| The CAN node(s) shall be capable of adapting to any valid parameter in a FlowControl packet as specified in ISO 15765-2. | |

## 6.6    Network layer (NL)

### 6.6.1    NL – Data interface primitive parameter mapping

The requirements specified in this subclause are applicable to NL implementations.

| REQ | **3.1 NL – ISO 15765-2 N_Data interface primitive parameter mapping** |
|---|---|
| The N_Data service primitive shall use the service primitive parameters as specified in Table 3. | |

**Table 3 — N_Data service primitive parameter mapping**

| NL | .req | .ind | .conf | Description |
|---|---|---|---|---|
| N_AI[N_TAtype] | X | X | – | [AddrType: (DiagNormAddr, DiagNormFixAddr, DiagExtAddr, RDiagMixAddr), |
| | | | | N_TAtype #1: physical addressing, CBFF, 11-bit CAN identifier, |
| | | | | N_TAtype #2: functional addressing, CBFF, 11-bit CAN identifier, |
| | | | | N_TAtype #3: physical addressing, FBFF, 11-bit CAN identifier, |
| | | | | N_TAtype #4: functional addressing, FBFF, 11-bit CAN identifier, |
| | | | | N_TAtype #5: physical addressing, CEFF, 29-bit CAN identifier, |
| | | | | N_TAtype #6: functional addressing, CEFF, 29-bit CAN identifier, |
| | | | | N_TAtype #7: physical addressing, FEFF, 29-bit CAN identifier, |
| | | | | N_TAtype #8: functional addressing, FEFF, 29-bit CAN identifier] |
| N_AI[TA] | X | X | – | target address to be added to PDU if N_TAtype = DiagExtAddr. |
| N_AI[AE] | X | X | – | address extension to be added to PDU if N_TAtype = RDiagMixAddr. |
| N_Length | X | X | X | length of PDU |
| N_Data | X | X | – | network layer data |
| N_Result | – | – | X | result |
| X  Supported. | | | | |
| –  Not supported. | | | | |

### 6.6.2    NL – ISO 15765-2 network layer services

A detailed specification of the NL services is given in ISO 15765-2.

| REQ | 3.2 NL – ISO 15765-2 network layer services |
|---|---|
| The NL services of the vehicle's ECU(s) shall be in accordance with ISO 15765-2. | |

### 6.6.3    NL – ISO 15765-2 network layer timing parameters

A detailed specification of the NL timing parameter values is given in ISO 15765-2.

| REQ | 3.3 NL – ISO 15765-2 network layer timing parameters |
|---|---|
| The NL timing parameters of the vehicle's ECU(s) shall be in accordance with ISO 15765-2. | |

### 6.6.4    NL – ISO 15765-2 uniqueness of node diagnostic address

The node diagnostic address in a CAN network is used to indicate to all nodes on the network that the node with this diagnostic address is the targeted.

| REQ | 3.4 NL – ISO 15765-2 uniqueness of node diagnostic address |
|---|---|
| The node diagnostic address ('XX$_{16}$') shall be unique for a node in a given vehicle. | |

### 6.6.5    NL – ISO 15765-2 supported addressing formats

ISO 15765-2 specifies several addressing formats. The addressing information is contained in the N_Ptype N_Data interface parameter.

| REQ | 3.5 NL – ISO 15765-2 supported addressing formats |
|---|---|
| The CAN node(s) shall use one of the following addressing formats as specified in ISO 15765-2: — N_Ptype = DiagNormAddr: no address information N_AI[N_SA, N_TA] mapped in the N_PDU; — N_Ptype = DiagNormFixAddr: no address information N_AI[N_SA, N_TA] mapped in the N_PDU; — N_Ptype = DiagExtAddr: address information N_AI[N_TA] mapped in the N_PDU; — N_Ptype = RDiagMixAddr: address information N_AI[N_AE] mapped into the N_PDU. | |

Functional addressing is used to reach more than one CAN node connected to the network.

| REQ | 3.6 NL – ISO 15765-2 functional addressing |
|---|---|
| Functional addressed N_PDU shall not exceed the packet limitation as specified in ISO 15765-2. | |

Physical addressing is used to reach only one CAN node connected to the network.

| REQ | 3.7 NL – ISO 15765-2 reception of N_PDU |
|---|---|
| The NL shall extract the N_AI or N_AE from the N_PDU depending on the addressing format as specified in REQ 3.5. | |

## 6.7 Data link layer (DLL)

### 6.7.1 DLL – Data interface primitive parameter mapping

The DLL protocol entity transfers data frames between network nodes on the CAN network. The following requirements are applicable to DLL implementations.

| REQ | 2.1 DLL – Data interface primitive parameter mapping – Mapping of upper OSI layer service interface parameters |
|---|---|
| The L_Data service primitive shall use the service primitive parameters as specified in Table 4. | |

**Table 4 — L_Data service primitive parameter mapping**

| DLL | .req | .ind | .conf | Description |
|---|---|---|---|---|
| Format | X | X | X | N_TAtype #1: physical address, CBFF, 11-bit CAN identifier; |
| | | | | N_TAtype #2: functional address, CBFF, 11-bit CAN identifier; |
| | | | | N_TAtype #3: physical addressing, FBFF, 11-bit CAN identifier; |
| | | | | N_TAtype #4: functional addressing, FBFF, 11-bit CAN identifier; |
| | | | | N_TAtype #5: physical addressing, CEFF, 29-bit CAN identifier; |
| | | | | N_TAtype #6: functional addressing, CEFF, 29-bit CAN identifier; |
| | | | | N_TAtype #7: physical addressing, FEFF, 29-bit CAN identifier; |
| | | | | N_TAtype #8: functional addressing, FEFF, 29-bit CAN identifier. |
| Identifier | X | X | – | If 11-bit CAN identifier: target and source address are mapped to a PDU-specific CAN identifier value. |
| Identifier | – | – | X | If 29-bit CAN identifier: target and source address are mapped into the CAN identifier TA and SA fields of the PDU-specific CAN identifier value. |
| DLC | X | X | X | Data Length Code |
| X  Supported. | | | | |
| –  Not supported. | | | | |

**Table 4** *(continued)*

| DLL | .req | .ind | .conf | Description |
|---|---|---|---|---|
| Data | X | X | – | (CAN) data field |
| Transfer_Status | – | – | X | Result information |
| X  Supported. | | | | |
| –  Not supported. | | | | |

The DLL is specified in ISO 11898-1.

| REQ | 2.2 DLL – Data interface primitive parameter mapping – ISO 11898-1 conformance |
|---|---|
| The DLL shall be conform with ISO 11898-1 and support the optional data frame formats (FBFF and FEFF). | |

### 6.7.2   DLL – Service interface parameter requirements

The DLL uses the value of the L_Ftype service interface parameter to identify the address information N_AI[N_TA, N_SA] mapping into the CAN identifier.

For 11-bit CAN identifiers the DLL uses the value included in the L_Ftype service interface parameter to set the applicable 11-bit CAN identifier.

| REQ | 2.3 DLL – Mapping of N_AI into the 11-bit CAN identifier |
|---|---|
| The CAN node(s) shall support the mapping of N_AI into the 11-bit CAN identifier based on the L_Ftype service interface parameter value as specified in Table 5. | |

**Table 5 — Mapping of N_AI into the 11-bit CAN identifier**

| L_Ftype | N_AI | 11-bit CAN ID | Description |
|---|---|---|---|
| DiagNormAddr<br>(diagnostics with normal addressing) | N_TA, N_SA | XXX XXXX XXXX$_2$ | The SA and TA values are mapped to a predefined CAN identifier. |
| DiagExtAddr<br>(diagnostics with extended addressing) | N_SA | XXX XXXX XXXX$_2$ | The SA value is mapped to a predefined CAN identifier. |
| RDiagMixAddr<br>(remote diagnostics with mixed addressing) | N_TA, N_SA | XXX XXXX XXXX$_2$ | The SA value is mapped to a predefined CAN identifier. |

| REQ | 2.4 DLL – Mapping of N_AI into the 29-bit CAN identifier |
|---|---|
| The CAN node(s) shall support the mapping of N_AI into the 29-bit CAN identifier L_PDU based on the L_Ftype service interface parameter value as specified in Table 6. | |

**Table 6 — Mapping of N_AI into the 29-bit CAN identifier**

| L_Ftype | N_AI | 29-bit CAN ID | Description |
|---|---|---|---|
| DiagNormAddr<br>(diagnostics with normal addressing) | N_TA, N_SA | $18_{16}$ $DB_{16}$ N_TA N_SA | The N_SA and N_TA (functional request address) values are mapped to predefined byte locations in the CAN identifier as specified in ISO 15765-2. |
| DiagNormFixAddr<br>(diagnostics with normal fixed addressing) | N_TA, N_SA | $18_{16}$ $DA_{16}$ N_TA N_SA | The N_SA and N_TA (physical request address) values are mapped to predefined byte locations in the CAN identifier as specified in ISO 15765-2. |
| DiagExtAddr<br>(diagnostics with extended addressing) | N_TA, N_SA | $18_{16}$ $DA_{16}$ N_TA N_SA | The N_SA and N_TA (physical response address) values are mapped to predefined byte locations in the CAN identifier as specified in ISO 15765-2. |

**Table 6** *(continued)*

| L_Ftype | N_AI | 29-bit CAN ID | Description |
|---------|------|---------------|-------------|
| RDiagMixAddr<br><br>(remote diagnostics with mixed addressing) | N _ T A , N_SA | $18_{16}$ $CD_{16}$ N_TA N_SA | The N_SA and N_TA functional request address values are mapped to predefined byte locations in the CAN identifier as specified in ISO 15765-2. |
| | | $18_{16}$ $CE_{16}$ N_TA N_SA | The N_SA and N_TA physical request address values are mapped to predefined byte locations in the CAN identifier as specified in ISO 15765-2. |
| | | $18_{16}$ $CE_{16}$ N_TA N_SA | The N_SA and N_TA physical response values are mapped to predefined byte locations in the CAN identifier as specified in ISO 15765-2. |

### 6.7.3   DLL – Device acceptance of CAN identifier

A CAN node accepts a CAN identifier if the value matches with its internally stored supported set of CAN identifiers.

| REQ | 2.5 DLL – Device acceptance of CAN identifier |
|-----|-----------------------------------------------|
| A CAN node shall accept a CAN identifier of its supported CAN identifier set (11-bit and/or 29-bit). | |

## 6.8   Physical layer (PHY)

### 6.8.1   PHY – Physical signalling (PS) requirements

#### 6.8.1.1   PHY – PS entity requirements

The PS sub-layer is specified in ISO 11898-1.

| REQ | 1.1 PHY – PS entity requirements – ISO 11898-1 conformance |
|-----|-----------------------------------------------------------|
| The PS sub-layer shall conform with ISO 11898-1. | |

#### 6.8.1.2   PHY – PS device interface requirements

The following requirements are related to the PS device to provide detailed specification about bit timing and bit sampling of the arbitration phase and the data phase.

| REQ | 1.2 PHY – PS device interface requirements – Classical CAN bit timing parameters |
|-----|---------------------------------------------------------------------------------|
| The PS device classical CAN interface shall only support one-bit timing parameter set as specified in Table 7 and Table 8 or Table 9 and Table 10. | |

The CAN bit timing parameter values used in this document is based on equivalent terms in ISO 11898-1:

— $t_{SYNCSEG}$    = SyncSeg                     = $1 \times t_Q$

— $t_{SEG1}$       = PropSeg + PhaseSeg1          = $t_{BIT} - t_{SYNCSEG} - t_{SEG2}$

— $t_{SEG2}$       = PhaseSeg2

— $t_{SJW}$        = synchronisation jump width

— $t_{BIT}$        = $t_B$ (nominal bit time)

— $t_Q$ = time quantum

— $t_{SP}$ = nominal sample point position = $(1 - t_{SEG2}/t_{BIT}) \times 100\%$

Conformity with the nominal bit time tolerance requirement given in this document is directly dependent on the classical CAN system clock tolerance of the external test equipment and the programmed nominal bit time value. In a classical CAN controller, the nominal bit time value shall be an integer multiple of its system clock periods. When the programmable nominal bit time value is set exactly to the required nominal bit time value, accuracy is only affected by the system clock tolerance. Otherwise, the accuracy is dependent upon both the deviation of the programmed bit time value from the nominal bit time value and the system clock tolerance. The contributions from drift or ageing of the system clock source and from the inability to achieve the desired nominal bit time value are additive. The bit time tolerance specification shall be met after consideration of both.

Figure 4 illustrates the partitioning of the classical CAN bit time.
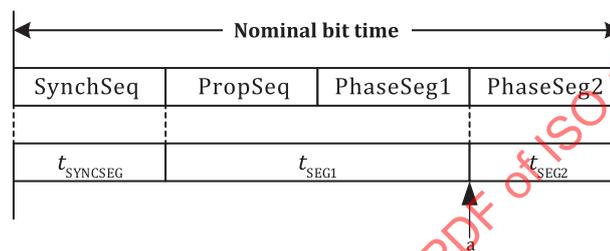


a Nominal sample point position (SP) in single data sampling mode.

**Figure 4 — Partitioning of classical CAN bit time**

Table 7 specifies the allowed CAN bit timing parameter values for a bit rate of 250 kbit/s. The external test equipment shall operate in single data sampling mode.

**Table 7 — 250 kbit/s classical CAN bit timing parameter values — Single data sampling mode**

| Parameter/function | Symbol | Minimum | Nominal | Maximum | Unit | Conditions/Comment |
|---|---|---|---|---|---|---|
| Nominal data bit time RX | $t_{BIT\_RX}$[a] | 3 980 | 4 000 | 4 020 | ns | ±0,5 % |
| Nominal data bit time TX | $t_{BIT\_TX}$[b] | 3 994 | 4 000 | 4 006 | ns | ±0,15 % |
| Time quantum | $t_Q$ | — | — | 250 | ns | — |
| Oscillator tolerance | $\Delta f$ | — | — | 0,15 | % | — |

a The minimum and maximum value of the nominal bit time $t_{BIT\_RX}$ are worst-case values for the reception of bits from the CAN bus based on a nominal bit rate tolerance of ± 0,5 %.

b The minimum and maximum value of the nominal bit time $t_{BIT\_TX}$ are worst-case values for the transmission of bits onto the CAN bus based on the specified external test equipment nominal bit rate tolerance of ± 0,15 %.

Table 8 presents the only allowed CAN bit timing parameter values for the external test equipment based on standard time quanta ($t_Q$).

**Table 8 — 250 kbit/s classical CAN bit timing parameter values for standard time quanta**

| $t_Q$ ns | $t_{SJW}$ ns | $t_{SEG1}$ ns | $t_{SEG2}$ ns | Nominal sample point position[a] % |
|---|---|---|---|---|
| 200 | 600 | 3 000 | 800 | 80 |
| 250 | 750 | 3 000 | 750 | 81,25 |

a The nominal sample point position is specified relative to one-bit time.

Table 9 specifies the allowed classical CAN bit timing parameter values for a bit rate of 500 kbit/s. The external test equipment shall operate in single data-sampling mode. The tolerance of the external test equipment nominal bit rate 500 kbit/s shall be ± 0,15 %.

**Table 9 — 500 kbit/s classical CAN bit timing parameter values — Single data sampling mode**

| Parameter/function | Symbol | Minimum | Nominal | Maximum | Unit | Conditions/comment |
|---|---|---|---|---|---|---|
| Nominal data bit time RX | $t_{BIT\_RX}$[a] | 1 990 | 2 000 | 2 010 | ns | ±0,5 % |
| Nominal data bit time TX | $t_{BIT\_TX}$[b] | 1 997 | 2 000 | 2 003 | ns | ±0,15 % |
| Time quantum | $t_Q$ | — | — | 125 | ns | — |
| Oscillator tolerance | $\Delta f$ | — | — | 0,15 | % | — |

[a]    The minimum and maximum value of the nominal bit time $t_{BIT\_RX}$ are worst-case values for the reception of bits from the CAN bus based on a nominal bit rate tolerance of ± 0,5 %.

[b]    The minimum and maximum value of the nominal bit time $t_{BIT\_TX}$ are worst-case values for the transmission of bits onto the CAN bus based on the specified external test equipment nominal bit rate tolerance of ± 0,15 %.

Table 10 presents the only allowed classical CAN bit timing parameter values for the external test equipment based on standard time quanta ($t_Q$).

**Table 10 — 500 kbit/s classical CAN bit timing parameter values for standard time quanta**

| $t_Q$ ns | $t_{SJW}$ ns | $t_{SEG1}$ ns | $t_{SEG2}$ ns | Nominal sample point position[a] % |
|---|---|---|---|---|
| 100 | 300 | 1 500 | 400 | 80 |
| 125 | 375 | 1 500 | 375 | 81,25 |

[a]    The nominal sample point position is specified relative to one-bit time.

| REQ | 1.3 PHY – PS device interface requirements – CAN FD sampling method |
|---|---|
| The PS device shall be configured to use the single-sampling method. | |

| REQ | 1.4 PHY – PS device interface requirements – CAN FD bit timing parameters |
|---|---|
| The PS device CAN FD interface shall only support one-bit timing parameter set as specified in Table 11, Table 12 or Table 13. | |

**Table 11 — CAN FD bit timing parameter for 5 Mbit/s**

| Parameter/function | Symbol | Minimum | Nominal | Maximum | Unit | Conditions/comment |
|---|---|---|---|---|---|---|
| Nominal data bit rate | $f_{Ba}$ | – | 500 | – | kbit/s | – |
| Data bit rate | $f_{Bd}$ | – | 5 000 | – | kbit/s | – |
| Arbitration bit time | $t_{Ba}$ | 1 992 | 2 000 | 2 008 | ns | ±0,4 % (including aging) |
| Data bit time | $t_{Bd}$ | 199,2 | 200,0 | 200,8 | ns | ±0,4 % (including aging) |
| Nominal arbitration bit time quantum length | $t_{Qa}$ | 25 | 25 | 25 | ns | 80 $t_q$/bit |
| Nominal data bit time quantum length | $t_{Qd}$ | 25 | 25 | 25 | ns | 8 $t_q$/bit |
| Nominal arbitration bit sample point position[a] | $t_{SPa}$ | 0,80 | 0,80 | 0,80 | $t_B$ | 80 % of bit time |
| Nominal data bit sample point position[a] | $t_{SPd}$ | 0,75 | 0,75 | 0,75 | $t_B$ | 75 % of bit time |

[a]    The nominal sample point position shall be located at the specified time after the start of a bit.

**Table 11** *(continued)*

| Parameter/function | Symbol | Minimum | Nominal | Maximum | Unit | Conditions/comment |
|---|---|---|---|---|---|---|
| Arbitration bit synchronisation jump width | $t_{SJWa}$ | 16 | 16 | 16 | $t_Q$ | typically corresponds to SJW = $1111_2$ |
| Data bit synchronisation jump width | $t_{SJWd}$ | 2 | 2 | 2 | $t_Q$ | typically corresponds to SJW = $0001_2$ |
| [a] The nominal sample point position shall be located at the specified time after the start of a bit. | | | | | | |

**Table 12 — CAN FD bit timing parameter for 4 Mbit/s**

| Parameter/function | Symbol | Minimum | Nominal | Maximum | Unit | Conditions/Comment |
|---|---|---|---|---|---|---|
| Nominal data bit rate | $f_{Ba}$ | – | 500 | – | kbit/s | – |
| Data bit rate | $f_{Bd}$ | – | 4 000 | – | kbit/s | – |
| Arbitration bit time | $t_{Ba}$ | 1 992 | 2 000 | 2 008 | ns | ±0,4 % (including aging) |
| Data bit time | $t_{Bd}$ | 249,0 | 250,0 | 251,0 | ns | ±0,4 % (including aging) |
| Nominal arbitration bit time quantum length | $t_{Qa}$ | 25 | 25 | 25 | ns | 80 $t_q$/bit |
| Nominal data bit time quantum length | $t_{Qd}$ | 25 | 25 | 25 | ns | 10 $t_q$/bit |
| Nominal arbitration bit sample point position[a] | $t_{SPa}$ | 0,80 | 0,80 | 0,80 | $t_B$ | – |
| Nominal data bit sample point position[a] | $t_{SPd}$ | 0,70 | 0,70 | 0,70 | $t_B$ | – |
| Arbitration bit synchronisation jump width | $t_{SJWa}$ | 16 | 16 | 16 | $t_Q$ | typically corresponds to SJW = $1111_2$ |
| Data bit synchronisation jump width | $t_{SJWd}$ | 3 | 3 | 3 | $t_Q$ | typically corresponds to SJW = $0010_2$ |
| [a] The nominal sample point position shall be located at the specified time after the start of a bit. | | | | | | |

**Table 13 — CAN FD bit timing parameter for 2 Mbit/s**

| Parameter/function | Symbol | Minimum | Nominal | Maximum | Unit | Conditions/comment |
|---|---|---|---|---|---|---|
| Nominal data bit rate | $f_{Ba}$ | – | 500 | – | kbit/s | – |
| Data bit rate | $f_{Bd}$ | – | 2 000 | – | kbit/s | – |
| Arbitration bit time | $t_{Ba}$ | 1 992 | 2 000 | 2 008 | ns | ±0,4 % (including aging) |
| Data bit time | $t_{Bd}$ | 498,0 | 500,0 | 502,0 | ns | ±0,4 % (including aging) |
| Nominal arbitration bit time quantum length | $t_{Qa}$ | 25 | 25 | 25 | ns | 80 $t_q$/bit |
| Nominal data bit time quantum length | $t_{Qd}$ | 25 | 25 | 25 | ns | 20 $t_q$/bit |
| Nominal arbitration bit sample point position[a] | $t_{SPa}$ | 0,80 | 0,80 | 0,80 | $t_B$ | – |
| Nominal data bit sample point position[a] | $t_{SPd}$ | 0,70 | 0,70 | 0,70 | $t_B$ | – |
| Arbitration bit synchronisation jump width | $t_{SJWa}$ | 16 | 16 | 16 | $t_Q$ | typically corresponds to SJW = $1111_2$ |
| Data bit synchronisation jump width | $t_{SJWd}$ | 6 | 6 | 6 | $t_Q$ | typically corresponds to SJW = $0101_2$ |
| [a] The nominal sample point position shall be located at the specified time after the start of a bit. | | | | | | |