BS ISO 20794-4:2020

BSI Standards Publication

Road vehicles — Clock extension peripheral interface (CXPI)

Part 4: Data link layer and physical layer

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National foreword

This British Standard is the UK implementation of ISO 20794-4:2020.

The UK participation in its preparation was entrusted to Technical Committee AUE/16, Data Communication (Road Vehicles).

A list of organizations represented on this committee can be obtained on request to its secretary.

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Part 4: Data link layer and physical layer

Véhicules routiers — Interface du périphérique d'extension d'horloge (CXPI) —

Partie 4: Couches de liaison de données et physique

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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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 20794 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.

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Introduction

ISO 20794 (all parts) specifies the application (partly), application layer, transport layer, network layer, data link layer, and physical layer requirements of an in-vehicle network called "clock extension peripheral interface (CXPI)".

CXPI is an automotive low-speed single-wire network. It is an enabler for reducing vehicle weight and fuel consumption by reducing wire counts to simple devices like switches and sensors.

CXPI serves as and is designed for automotive control applications, for example door control group, light switch, and HVAC (Heating Ventilation and Air Conditioning) systems.

The CXPI services, protocols, and their key characteristics are specified in different parts according to the OSI layers.

— Application and application layer

  — application measurement and control data communication to exchange information between applications in different nodes based on message communication;

  — wake-up and sleep functionality;

  — two kinds of communication methods can be selected at system design by each node:

    i) the event-triggered method, which supports application measurement- and control-based (event-driven) slave node communication, and

    ii) the polling method, which supports slave node communication based on a periodic master schedule;

  — performs error detection and reports the result to the application;

  — application error management.

— Transport layer and network layer

  — transforms a message into a single packet;

  — adds protocol control information for diagnostic and node configuration into each packet;

  — adds packet identifier for diagnostic and node configuration into each packet;

  — performs error detection and reports the result to higher OSI layers.

— Data link layer and physical layer

  — provides long and short data frames;

  — adds a frame identifier into the frame;

  — adds frame information into the frame;

  — adds a cyclic redundancy check into the frame;

  — performs byte-wise arbitration and reports the arbitration result to higher OSI layers;

  — performs frame type detection in reception function;

  — performs error detection and reports the result to higher OSI layers.

  — performs Carrier Sense Multiple Access (CSMA);

  — performs Collision Resolution (CR);

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— generates a clock, which is transmitted with each bit to synchronise the connected nodes on the CXPI network;

— supports bit rates up to 20 kbit/s.

To achieve this, it is based on the Open Systems Interconnection (OSI) Basic Reference Model specified in ISO/IEC 7498-1 and ISO/IEC 10731[1], which structures communication systems into seven layers.

Figure 1 illustrates an overview of communication frameworks beyond the scope of this document including related standards:

— vehicle normal communication framework, which is composed of ISO 20794-2, and ISO 20794-5;

— vehicle diagnostic communication framework, which is composed of ISO 14229-1, ISO 14229-2[3], and ISO 14229-8[4];

— presentation layer standards, e.g. vehicle manufacturer specific or ISO 22901-1 ODX[6];

— lower OSI layers framework, which is composed of ISO 20794-3, ISO 20794-4, ISO 20794-6, and ISO 20794-7 conformance testing.

ISO 20794 (all parts) and ISO 14229-8[4] are based on the conventions specified in the OSI Service Conventions (ISO/IEC 10731)[1] as they apply for all layers and the diagnostic services.

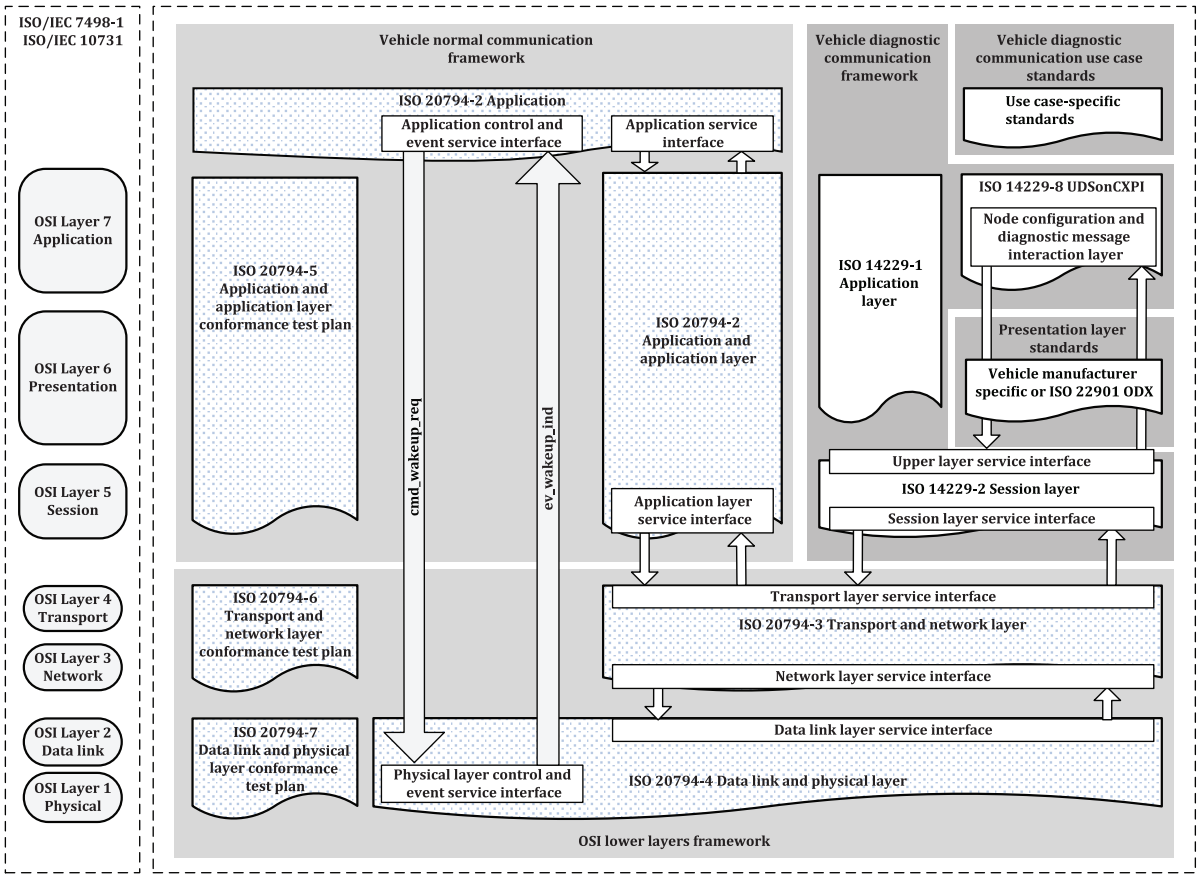

Figure 1 — ISO 20794 documents reference according to OSI model

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Road vehicles — Clock extension peripheral interface (CXPI) —

Part 4: Data link layer and physical layer

1 Scope

This document specifies the CXPI data link layer and the CXPI physical layer.

The DLL is based on:

— priority-based CXPI network access;

— non-destructive content-based arbitration;

— broadcast frame transfer and acceptance filtering; and

— node related error detection and error signalling.

The CXPI physical layer (PHY) requirements comprise of:

— physical signalling (PS) sub-layer, which specifies the requirements of the clock generation function, the encoding and decoding of CXPI frames, and bit-wise collision resolution logic;

— physical media attachment (PMA) sub-layer, which specifies the requirements of the signal shaping waveform logic;

— physical media dependent (PMD) sub-layer, which specifies the requirements of the CXPI network termination, electrostatic discharge protection, etc., and device connector requirements; and

— physical media (PM), which specifies the requirements of the CXPI network cable/wiring harness.

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/IEC 7498-1, *Information technology — Open Systems Interconnection — Basic Reference Model: The Basic Model*

ISO 20794-2, *Road vehicles — Clock extension peripheral interface (CXPI) — Part 2: Application layer*

ISO 20794-3, *Road vehicles — Clock extension peripheral interface (CXPI) — Part 3: Transport and network layer*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20794-2, ISO 20794-3, and ISO/IEC 7498-1 and the following apply.

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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/

3.1
bit rate
transmission speed (bit/s) of the protocol within the specification range of transmit frames

3.3
higher OSI layer
OSI layer 3 or more than higher number of layers

3.4
idle state
state of the CXPI network when no frames are exchanged (idle state) and only the clock exists to synchronise the nodes

3.5
inter frame space
IFS
time interval between frames on the CXPI network

4 Symbols and abbreviated terms

4.1 Symbols

C_{BUS}	total bus capacitance
C_{LINE}	capacity of CXPI network
C_{MASTER}	capacity of master node
C_{SLAVE}	capacity of slave node
kbit/s	kilobit per second
LEN_{BUS}	length of CXPI bus wire
R_{BUS}	total bus-resistor including all slave nodes resistors and master node resistor
R_{MASTER}	master node resistor
R_{SLAVE}	slave node resistor
t_{bit}	bit time
t_{bit_ref}	bit time of reference bit rate
$t_{rx_dif_cont}$	difference of the dominant time between logical value '1' and logical value '0'
$t_{rx_wakeup_clk}$	time that the receiving clock master detects the width of dominant level as the wake-up pulse.
t_{rx_wakeup}	time that the receiving node detects each width of dominant level in the wake-up pulse.
$t_{rx_wakeup_space}$	limitation time of acceptance second dominant pulse in the wake-up pulse from first dominant pulse.

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t_{tx_wakeup}	time that the transceiver node transmits the dominant voltage of the wake-up pulse
$t_{tx_wakeup_space}$	interval time between two of dominant level of transmitting wake-up pulse
$t_{tx_0_lo}$	dominant time of logical value '0'
$t_{tx_0_lo_dom}$	dominant time of logical value '0' (TH_{tx_dom} = 30 % of V_{SUP})
$t_{tx_0_pd}$	at the time of logical value '0' outputs, time from the LO level detection of the CXPI network until falling the voltage TH_{tx_dom} = 30 % of V_{SUP}
$t_{tx_1_lo}$	dominant time of logical value '1'
$t_{tx_1_lo_dom}$	dominant time of logical value '1' (TH_{tx_dom} = 30 % of V_{SUP})
$t_{tx_1_lo_rec}$	dominant time of logical value '1' (TH_{tx_rec} = 70 % of V_{SUP})
TH_{tx_dom}	dominant threshold voltage of the driver node
TH_{tx_rec}	recessive threshold voltage of the driver node
TH_{rx_dom}	dominant threshold voltage of the received node
TH_{rx_rec}	recessive threshold voltage of the received node
V_{BUS}	voltage of CXPI network
V_{BUS_CNT}	centre recessive threshold voltage of the received node
V_{BUSdom}	dominant voltage of the received node
V_{BUSrec}	recessive voltage of the received node
V_{HYS}	hysteresis voltage between the recessive threshold voltage and the dominant threshold voltage of the received node
V_{rec_master}	maximum recessive level of logical value “1”
V_{th_dom}	measured value of the dominant threshold voltage of the received node
V_{th_rec}	measured value of the recessive threshold voltage of the received node

4.2 Abbreviated terms

AC	alternating current
CRC	cyclic redundancy check
CT	count
DLC	data length code
DLL	data link layer
ECU	electronic control unit
FI	frame information
Ftype	frame type
HI	high

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IBS	inter byte space
ID	identifier
IFS	inter frame space
ind	indicator
L_	link
LO	low
LSB	least significant byte
MSB	most significant byte
NM	network management
NRZ	non-return to zero
OSI	open systems interconnection
PDU	protocol data unit
PID	protected identifier
PHY	physical layer
PM	physical media
PMA	physical media attachment
PMD	physical media dependent
PS	physical signalling
PTYPE	protected type identifier
PWM	pulse width modulation
ReqId	request identifier
ReqTypeId	request type identifier
RX_{PWM}	PMA receiver interface signal
RXD_{NRZ}	PS receiver interface signal
SIP	service interface parameter
TH	threshold
TX_{PWM}	PMA transmit interface signal
TXD_{NRZ}	PS transmitter interface signal

5 Conventions

This document is based on the conventions discussed in the OSI Service Conventions as specified in ISO/IEC 10731.

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6 Introduction to data link layer and physical layer

6.1 Frames

Information on the CXPI network is sent in fixed format frames of different limited lengths. When the CXPI network is in idle state, any connected node is allowed to start the transmission of a Protected Identifier (PID). The CXPI network is in idle state when no frames are transmitted.

6.2 Frame collision avoidance

If two or more nodes start to transmit a PID value at the same time, the bus access conflict is resolved by content-based arbitration using the PID value. The transmitter with the PID value of the highest priority gains the bus access.

6.3 Error detection and indication

For detecting errors, the following measures are specified:

— byte value error (`Err_DLL_Byte`);

— cyclic redundancy check value error (`Err_DLL_CRC`);

— data length code value error (`Err_DLL_DLC`);

— data length code extension value error (`Err_DLL_DLCext`);

— parity value error (`Err_DLL_Parity`); and

— framing value error (`Err_DLL_Framing`).

To confirm an error occurrence during data transmission and reception, an error indication to the higher OSI layers is provided.

6.4 Clock transmission and detection

The node (master node by default), that generates the clock, continuously transmits the clock to the CXPI network. Clock existence is detected by the falling edge of the clock on the CXPI network. A node performs communication synchronised with the node, that generates the clock.

7 Service interface parameters (SIP)

7.1 SIP — General

The following subclauses specify the service interface parameters and data types, which are used by the CXPI data link and physical layer services.

7.2 SIP — Data type definitions

This requirement specifies the data type definitions of the CXPI service interface.

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REQ	0.1 SIP — Data type definitions
The data types shall be in accordance to: — `Enum` = 8-bit enumeration — `Unsigned Byte` = 8-bit unsigned numeric value — `Byte Array` = sequence of 8-bit aligned data — `2-bit Bit String` = 2-bit binary coded — `8-bit Bit String` = 8-bit binary coded — `16-bit Bit String` = 16-bit binary coded	

7.3 SIP — Ftype, frame type

This requirement specifies the frame type parameter value of the CXPI service interface.

REQ	0.2 SIP — Ftype, frame type
The `Ftype` parameter shall be of data type Enum and shall be used to identify the frame type and range of address information included in a service call. Range: [`NormalCom, DiagNodeCfg`]	

7.4 SIP — ReqId, request identifier

This requirement specifies the request identifier parameter value of the CXPI service interface.

REQ	0.3 SIP — ReqId, request identifier
The `ReqId` parameter shall be of data type `Unsigned Byte` and shall contain the request identifier. Range: [01_{16} to $7F_{16}$]	

7.5 SIP — ReqTypeId, request type identifier

This requirement specifies the request type identifier parameter value of the CXPI service interface.

REQ	0.4 SIP — ReqTypeId, request type identifier
The `ReqTypeId` parameter shall be of data type `Unsigned Byte` and shall contain the request type identifier. Range: [00_{16}] in DLL NOTE `ReqTypeId` is used by the application to enable the polling method. It has a fixed value.	

7.6 SIP — PDU, protocol data unit

This requirement specifies the protocol data unit parameter value of the CXPI service interface.

REQ	0.5 SIP — PDU, protocol data unit
The `PDU` parameter shall be of data type `Byte Array` and shall contain the frame data (PDU) content of the request or response frame to be transmitted/received. Range: [00_{16} to FF_{16}]	

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7.7 SIP — Length, length of PDU

This requirement specifies the length parameter value of the CXPI service interface.

REQ	0.6 SIP — Length, length of PDU
The `Length` parameter shall be of data type `Unsigned Byte` and shall contain the length of the PDU to be transmitted/received. Range: [00_{16} to FF_{16}]	

7.8 SIP — ev_wakeup_ind, event wake-up indication (optional)

This requirement specifies the event wake-up indication parameter value of the CXPI service interface.

REQ	0.7 SIP — ev_wakeup_ind, event wake-up indication (optional)
The `ev_wakeup_ind` parameter shall be of data type `Enum` and shall include the network management information in the response, which is composed of wake-up indication information of a CXPI node. Table 1 describes the network management information values. Range: [`ev_wakeup_pulse_detect`, `ev_dominant_pulse_detect`, `ev_clk_detect`, `ev_clk_loss`]	

Table 1 — ev_wakeup_ind, event wake-up indication (optional)

Enum values	Description
`ev_wakeup_pulse_detect`	This service primitive parameter value indicates the reception of the wake-up pulse event from the DLL. This parameter is optional if `cmd_wakeup_pulse_on` in Table 2 is (optional).
`ev_dominant_pulse_detect`	This service primitive parameter value indicates the reception of the dominant pulse event from the DLL. This parameter is optional if `cmd_wakeup_pulse_on` in Table 2 is (optional).
`ev_clk_detect`	This service primitive parameter value indicates the reception of the clock detection event from the DLL.
`ev_clk_loss`	This service primitive parameter value indicates the reception of the clock loss event from the DLL.

7.9 SIP — cmd_wakeup_req, command wake-up request

This requirement specifies the command wake-up request parameter value of the CXPI service interface.

REQ	0.8 SIP — cmd_wakeup_req, command wake-up request
The `cmd_wakeup_req` parameter shall be of data type `Enum` and shall include the wake-up request command information to wake-up a CXPI node. Table 2 describes the `cmd_wakeup_req` values. Range: [`cmd_clk_generator_on`, `cmd_clk_generator_off`, `cmd_wakeup_pulse_on`]	

Table 2 — cmd_wakeup_req values

Enum values	Description
`cmd_clk_generator_on`	This service primitive parameter value commands the clock generator to turn on the clock transmission to the DLL.
`cmd_clk_generator_off`	This service primitive parameter value commands the clock generator to turn off the clock transmission to the DLL.
`cmd_wakeup_pulse_on (optional)`	This service primitive parameter value commands the transmission of the wake-up pulse to the DLL.

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7.10 SIP — NMInfo, network management information

This requirement specifies the network management information parameter value of the CXPI service interface.

REQ	0.9 SIP — NMInfo, network management information
The `NMInfo` parameter shall be of data type `Enum` and shall contain the NM information in the response field. Type: `Enum` Range: 00_2 = [no request for `wakeup_ind, sleep_ind` prohibition] 01_2 = [no request for `wakeup_ind, sleep_ind` permission] 10_2 = [request for `wakeup_ind, sleep_ind` prohibition] 11_2 = [request for `wakeup_ind, sleep_ind` permission]	

7.11 SIP — SCT, sequence count

This requirement specifies the sequence count parameter value of the CXPI service interface.

REQ	0.10 SIP — SCT, sequence count
The `SCT` parameter shall be of data type `Unsigned Byte` and shall contain the sequence count information in the response field to be transmitted/received. Type: `2-bit Unsigned Byte` Range: [00_2 to 11_2]	

7.12 SIP — Result, result

This requirement specifies the result parameter value of the CXPI service interface.

REQ	0.11 SIP — Result, result
The `Result` parameter shall be of data type `Bit String` and shall contain the status relating to the outcome of a ReqField or RespField execution. Range: [`OK, DLL_Arb_Lost, Err_DLL_Byte, Err_DLL_CRC, Err_DLL_DLC, Err_DLL_DLCext, Err_DLL_Parity, Err_DLL_Framing`] Range: [0_2 to 1_2]	

8 Data link layer (DLL)

8.1 SI — L_Data.req and L_Data.ind service interface

The service interface defines the service primitives and parameter mapping to the DLL.

Figure 2 shows the DLL `L_Data.req` and `L_Data.ind` service interface.

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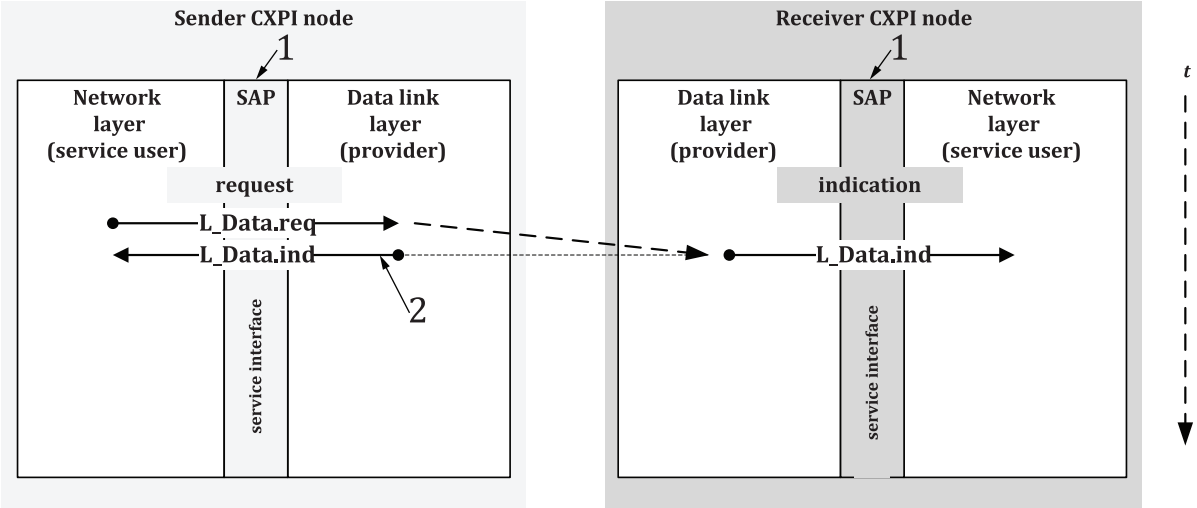

Key

1 service access point

2 read back from CXPI network provided by lower OSI layer

t time

Figure 2 — DLL L_Data.req and L_Data.ind service interface

For normal communication (NormalCom) the sender node transmits, if master node, either a request protected type identifier field (polling method), or a request protected identifier field (`L_Data.req`). All nodes receive the request protected identifier field of type NormalCom (`L_Data.ind`). The node, which has corresponding PDU data transmits the response PDU (`L_Data.req`) and all nodes receive the response PDU (`L_Data.ind`).

For diagnostic and node configuration (DiagNodeCfg) the sender node transmits a request message including a protected identifier field and the N_PDU (`L_Data.req`) onto the CXPI network. All nodes receive the DiagNodeCfg request message (`L_Data.ind`). The node(s), which is (are) targeted by the request message, transmit a DiagNodeCfg response message (`L_Data.req`) onto the CXPI network.

8.2 SI — L_Data.req and L_Data.ind service interface parameter mapping

This requirement specifies the data link layer service interface parameter mapping to lower OSI layers.

REQ	**2.1 SI — L_Data.req and L_Data.ind service interface parameter mapping**
The `L_Data.req` and `L_Data.ind` service interface parameter mapping is specified in Table 3.	

The normal communication frame (NormalCom) either consists of a `L_ReqId (L_PID)` only (`L_Length = NULL`) or `L_ReqId (L_PID)` and a response `L_PDU (L_Length ≥ 00`$_{16}$`)`.

The diagnostic and node configuration frame (DiagNodeCfg) always consist of a `L_ReqId (L_PID)` and a response `L_PDU`. Therefore, the `L_Length > 00`$_{16}$.

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Table 3 — L_Data.req and L_Data.ind service interface parameter mapping

Higher OSI layers (service user)	Data link layer (service provider)	L_Data.req and L_Data.ind parameter validity					
		NormalCom with L_Length = NULL		NormalCom with L_Length ≥00_{16}		DiagNodeCfg with L_Length >00_{16}	
		.req	.ind	.req	.ind	.req	.ind
N_Ptype	L_Ftype	X[a]	X[a]	X[a]	X[a]	X[a]	X[a]
N_Length	L_Length	—[c]	—[c]	X[a]	X[a]	X[a]	X[a]
N_ReqId	L_ReqId	X[a]	X[a]	X[a]	X[a]	X[a]	X[a]
N_ReqTypeId[b]	L_ReqTypeId[b]	X[a]	X[a]	—[c]	—[c]	—[c]	—[c]
N_PDU	L_DATA	—[c]	—[c]	X[a]	X[a]	X[a]	X[a]
N_NMInfo	L_NMInfo	—[c]	—[c]	X[a]	X[a]	X[a]	X[a]
N_SCT	L_SCT	—[c]	—[c]	X[a]	X[a]	X[a]	X[a]
N_Result	L_Result	—[c]	X[a]	—[c]	X[a]	—[c]	X[a]

NOTE A service interface call either includes a `ReqId` or a `ReqTypeId` parameter.

[a] Supported "X".

[b] Not used if DiagNodeCfg.

[c] Not supported "—".

8.3 DLL — Service interface with L_Ftype parameter mapping

8.3.1 DLL — L_Data.req and L_Data.ind with L_Ftype = NormalCom (L_Length = NULL)

This requirement specifies the data link layer frame type NormalCom with `L_Length = NULL` via the `L_Data.req` and `L_Data.ind` interface.

REQ	2.2 DLL — L_Data.req and L_Data.ind with L_Ftype = NormalCom (L_Length = NULL)

The `L_Data.req` and `L_Data.ind` service interface with `L_Ptype = NormalCom` with `L_Length = NULL` shall use the service interface parameters specified in Table 3 and Figure 3.

If the DLL provider is the sender then the following mapping shall be implemented for a L_Data.req:

— `L_Ftype = N_Ptype(NormalCom);`

— `L_ReqTypeId = N_ReqTypeId;`

— `L_ReqTypeId[Bit 6 to Bit 0] = N_ReqTypeId;`

— `L_ReqTypeId[Bit 7] = ODD_Parity(N_ReqTypeId);`

— `L_ReqId[Bit 6 to Bit 0] = N_ReqId;`

— `L_ReqId[Bit 7] = ODD_Parity(N_ReqId);`

— `L_Length = NULL.`

If the DLL provider is the receiver then the following mapping shall be implemented for a `L_Data.ind`:

— `N_Ptype = L_Ftype(NormalCom);`

— `N_ReqTypeId = L_ReqTypeId;`

— `N_ReqId = L_ReqId;`

— `N_Length = NULL;`

— `N_Result = L_Result.`

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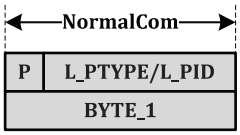

Figure 3 — DLL L_Data.req and L_Data.ind with L_Ftype = NormalCom (L_Length = NULL)

8.3.2 DLL — L_Data.req and L_Data.ind with L_Ftype = NormalCom (L_Length ≥ 0016)

This requirement specifies the data link layer frame type NormalCom with `L_Length` ≥ 00_{16} via the `L_Data.req` and `L_Data.ind` interface.

REQ	2.3 DLL — L_Data.req and L_Data.ind with L_Ftype = NormalCom (L_Length ≥ 00_{16})

The `L_Data.req` and `L_Data.ind` service interface with `L_Ftype = NormalCom` with `L_Length ≥ NULL` shall use the service interface parameters specified in Table 3 and Figure 4.

If the DLL provider is the sender then the following mapping shall be implemented for a L_Data.req:

— `L_Ftype = N_Ptype(NormalCom);`

— `L_ReqId[Bit 6 to Bit 0] = N_ReqId;`

— `L_ReqId[Bit 7] = ODD_Parity(N_ReqId);`

— `If (0 <= N_Length ≤ 12) then (L_FI_DLC = N_Length) else (L_FI_DLC =` 1111_2 `and L_FI_DLCext = N_Length);`

— `L_PDU = [F_FI, N_PDU, L_CRC];`

— `L_MNInfo = N_MNInfo;`

— `L_SCT = N_SCT.`

If the DLL provider is the receiver then the following mapping shall be implemented for a L_Data.ind:

— `N_Ptype = L_Ftype(NormalCom);`

— `N_ReqId = L_ReqId[Bit 6 to Bit 0];`

— `N_Length = L_Length;`

— `If (L_FI_DLC ≤ 12) then (N_Length = L_FI_DLC) else (N_Length = L_FI_DLCext);`

— `N_PDU = [L_PDU, w/o L_FI, w/o L_CRC];`

— `N_MNInfo = L_MNInfo;`

— `N_SCT = L_SCT;`

— `N_Result = L_Result.`

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