
**Road vehicles — Clock extension
peripheral interface (CXPI) —**

**Part 7:
Data link and physical layer
conformance test plan**

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

*Partie 7: Plan de test de conformité des couches de liaison de données
et physique*

ISO 20794-7:2020

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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.

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 Condition) 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);

- 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^[1] and ISO/IEC 10731^[2], 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^[7];
- vehicle diagnostic communication framework, which is composed of ISO 14229-1^[3], ISO 14229-2^[4], and ISO 14229-8^[5];
- presentation layer standards, e.g. vehicle manufacturer specific or ISO 22901-1 ODX^[9];
- lower OSI layers framework, which is composed of ISO 20794-3^[6], ISO 20794-4, ISO 20794-5, ISO 20794-6^[8] and this document.

ISO 20794 (all parts) and ISO 14229-8^[5] are based on the conventions specified in the OSI Service Conventions (ISO/IEC 10731^[2]) as they apply for all layers and the diagnostic services.

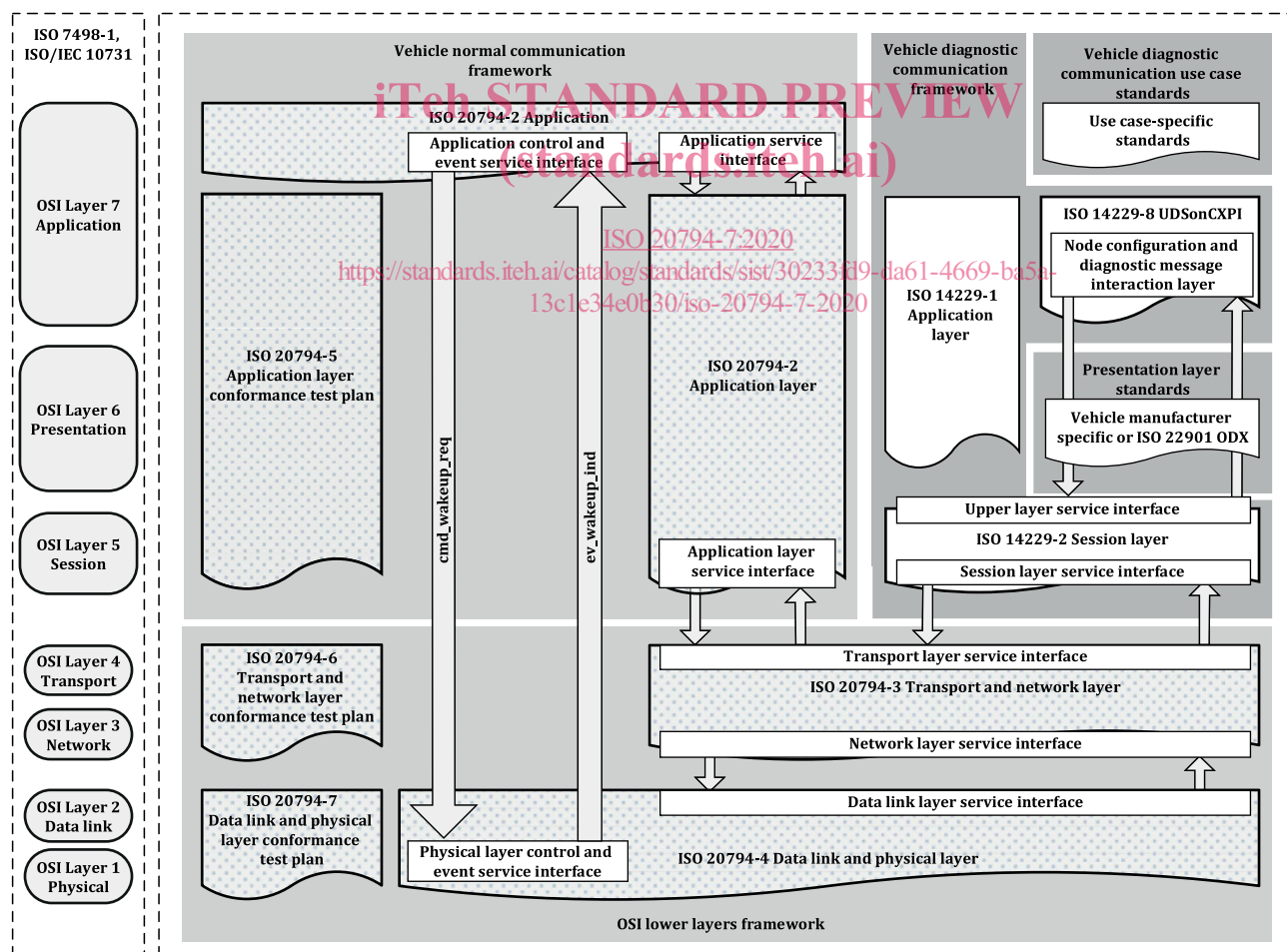


Figure 1 — ISO 20794 documents reference according to OSI model

Road vehicles — Clock extension peripheral interface (CXPI) —

Part 7: Data link and physical layer conformance test plan

1 Scope

This document specifies the conformance test plans for the CXPI data link layer and the CXPI physical layer. It also specifies the conformance test plan for error detection.

Additionally, this document describes the concept of conformance test plan operation.

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 7498-1:1994, *Information processing systems — Open systems interconnection — Basic reference model*

ISO 20794-2:2020, *Road vehicles — Clock extension peripheral interface (CXPI) — Part 2: Application layer*

ISO 20794-4:2020, *Road vehicles — Clock extension peripheral interface (CXPI) — Part 4: Data link layer and physical layer*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20794-2, ISO 20794-4 and ISO/IEC 7498-1 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 cell/undefined
C_{BUS}	total bus capacitance
C_{PG}	capacity of pulse generator/data generator
C_{SLAVE}	capacity of slave node
kbit/s	kilobit per second

R_{MASTER}	master node resistor
R_{SLAVE}	slave node resistor
t_{bit}	bit time
$t_{\text{rx_dif_cont}}$	difference of the dominant time between logical value 1 and logical value 0
$t_{\text{rx_wakeup_clk}}$	time that the receiving clock master detects the width of dominant level as the wake-up pulse
$t_{\text{rx_wakeup}}$	time that the receiving node detects each width of dominant level in the wake-up pulse from first dominant pulse
$t_{\text{rx_wakeup_space}}$	limitation time of acceptance second dominant pulse in the wake-up pulse from first dominant pulse
$t_{\text{tx_wakeup}}$	time that the transceiver node transmits the dominant voltage of the wake-up pulse
$t_{\text{tx_wakeup_space}}$	interval time between two of dominant level of transmitting wake-up pulse
$t_{\text{tx_0_lo}}$	dominant time of logical value 0
$t_{\text{tx_0_lo_dom}}$	dominant time of logical value 0 ($TH_{\text{tx_dom}} = 30\% \text{ of } V_{\text{SUP}}$)
$t_{\text{tx_0_lo_rec}}$	dominant time of logical value 0 ($TH_{\text{tx_rec}} = 70\% \text{ of } V_{\text{SUP}}$)
$t_{\text{tx_0_pd}}$	at the time of logical value 0 outputs, time from the LO-level detection of the CXPI network until falling the voltage $TH_{\text{tx_dom}} = 30\% \text{ of } V_{\text{SUP}}$
$t_{\text{tx_1_lo}}$	dominant time of logical value 1
$t_{\text{tx_1_lo_dom}}$	dominant time of logical value 1 ($TH_{\text{tx_dom}} = 30\% \text{ of } V_{\text{SUP}}$)
$t_{\text{tx_1_lo_rec}}$	dominant time of logical value 1 ($TH_{\text{tx_rec}} = 70\% \text{ of } V_{\text{SUP}}$)
$TH_{\text{tx_dom}}$	dominant threshold voltage of the driver node
$TH_{\text{tx_rec}}$	recessive threshold voltage of the driver node
V_{BUS}	voltage of CXPI network
$V_{\text{BUS_CNT}}$	centre recessive threshold voltage of the received node
V_{HYS}	hysteresis voltage between the recessive threshold voltage and the dominant threshold voltage of the received node
$V_{\text{th_dom}}$	measured value of the dominant threshold voltage of the received node
$V_{\text{th_rec}}$	measured value of the recessive threshold voltage of the received node
$V_{\text{rec_master}}$	maximum recessive level of logical value 1

4.2 Abbreviated terms

AC	alternating current
CRC	cyclic redundancy check
DLC	data length code

DLL	data link layer
ECU	electronic control unit
FI	frame information
HI	high
IBS	inter byte space
ID	identifier
IFS	inter frame space
LO	low
N/A	not applicable
NM	network management
OSI	open systems interconnection
PID	protected identifier
PHY	physical layer
PMA	physical media attachment
PMD	physical media dependent
PS	physical signalling
PWM	pulse width modulation
RX_{PWM}	PMA receiver interface signal
SUT	system under test
TH	threshold
TX_{PWM}	PMA transmits interface signal
TYPE	frame type

5 Conventions

This document is based on OSI service conventions as specified in ISO/IEC 10731^[2] and ISO/IEC 9646-1^[1] for conformance test system set-up.

6 General test specification considerations

6.1 General

This document covers the conformance test cases (CTC) to verify the requirements described in ISO 20794-4:2020 data link layer and physical layer document.

6.2 Test conditions

Tests can be performed at room temperature, if the temperature is in the range of 15° C to 35° C. Also, the tests shall be performed under room EMI (electro-magnetic interference) conditions.

6.3 IUT requirements

The occurrence of the error specified in ISO 20794-2:2020, 9.6.8 shall be notified to the other nodes. IUT shall be initialised in the test case respectively.

6.4 CTC definition

The definition of each test case specifies, whether the IUT is a master or slave node. Each CTC is defined in the structure as defined in [Table 1](#).

Table 1 — CTC definition example

Item	Content
CTC # – Title	[OSI layer #].CTC_[number_name] E.g. 2.CTC_2.6 – L_FI_DLC ≠ 1111 ₂ and frame data verification 2 if DLC is 1101 ₂ or 1110 ₂
Purpose	This CTC verifies that the DLC field for the frame of L_FI_DLC ≠ 1111 ₂ complies with the CXPI specification.
Reference	ISO 20794-4:2020; — REQ 2.10 DLL – L_FI_DLC (data length code); — REQ 2.30 DLL – Function models – DLL – Transmission logic; — REQ 2.31 DLL – Function models – DLL – Reception logic.
Prerequisite	The test system set-up shall be in accordance with Figure 2 .
Set-up	— The IUT shall be configured as a master node or a slave node. — The IUT shall be configured to L_ErrDet1 (see 6.6.4) and in addition support TST_FRM_01_REQ_PID, TST_FRM_11_RESP_12, TST_FRM_05_REQ_PID_ERRBIT, and TST_FRM_18_RESP_ERRBIT_0-12. — The bit rate shall be set to the default value (see 6.6.2). — The SUT shall be initialised to default (see 6.7).
Step	1. The LT shall transmit TST_FRM_01_REQ_PID and TST_FRM_11_RESP_12 changing the DLC value as specified in Table 22 . 2. The IUT does not detect any error and reports the result to higher OSI layers. 3. The LT shall transmit TST_FRM_05_REQ_PID_ERRBIT (refer to remark 1). 4. The IUT transmits TST_FRM_05_REQ_PID_ERRBIT (refer to remark 2) and TST_FRM_18_RESP_ERRBIT_0-12. 5. The LT shall observe TST_FRM_18_RESP_ERRBIT_0-12 with the result of detect error bit on the CXPI network.
Iteration	Steps are executed for each test case specified in Table 22 ; REPEAT step 1 to step 5, 2 times; The LT shall set L_FI_DLC as specified in Table 22 ; REPEAT END.
Expected response	After step 1: The IUT receives TST_FRM_11_RESP_12 as 12 data bytes regardless of L_FI_DLC value. After step 4: The IUT transmits TST_FRM_18_RESP_ERRBIT_0-12 with the error bit = FALSE.

Table 1 (continued)

Item	Content
	After step 5: The LT shall receive TST_FRM_18_RESP_ERRBIT_0-12 with the error bit = FALSE.
Remark	<ol style="list-style-type: none"> 1. If the IUT transmits the TST_FRM_18_RESP_ERRBIT_0-12 then the LT is expected to transmit this TST_FRM_05_REQ_PID_ERRBIT message. 2. Step 4 can be skipped if step 3 is required.

6.5 Test system set-up

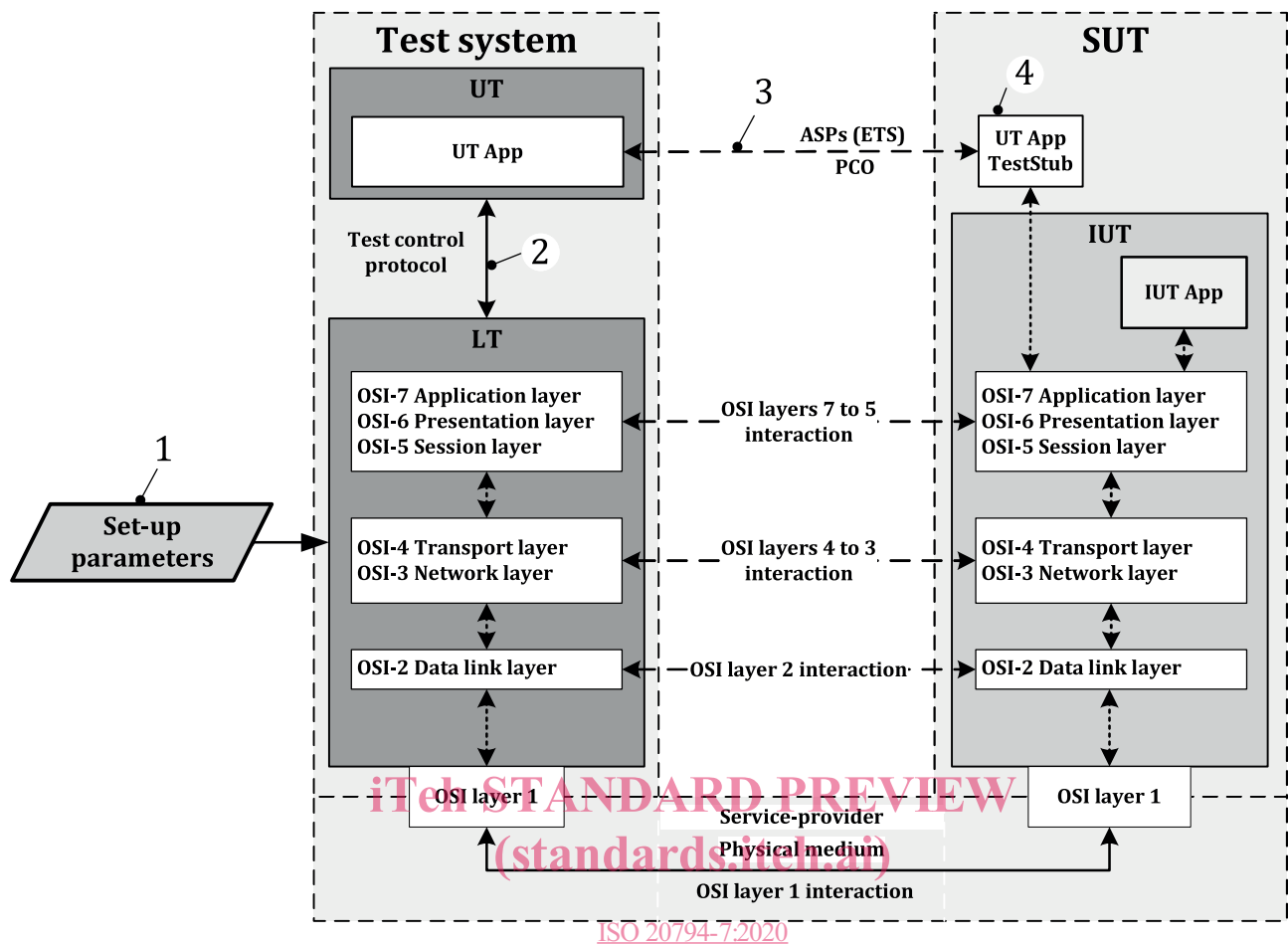
The test system set-up follows the ISO/IEC 9646-1 and consists of a test system and a system under test (SUT) connected via the physical medium. The test system implements an UT and a LT. The UT uses the test control protocol (see [Figure 2](#), key 2) to control the LT. The LT supports the functionality required to test the OSI layers (see [Figure 2](#), key 4) of the IUT. The test system uses the IUT-specific set-up parameters (see [Figure 2](#), key 1) for testing the communication with the IUT.

The control and measurement functionality is provided by direct access to the service interface (see [Figure 2](#), key 3) and the associated parameters of the OSI layers as specified in the ISO 20794 series. The conformance test controller manipulates the service interface parameters of the OSI layers to fulfil the purpose of each conformance test case (CTC). The test system ensures the precision of the bit time and bit synchronisation of the master node as specified in ISO 20794-4:2020, 9.3.7. If the IUT is a master node then the LT functions as a slave node. If the IUT is a slave node then the LT functions as a master node.

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- Key**
- 1 set-up parameters (CXPI node's electronic data sheet)
 - 2 test control protocol
 - 3 abstract service primitives (ASPs) based on enhanced testability services (ETS) and points of control and observation (PCO)
 - 4 upper tester application test stub

Figure 2 — Test system set-up

6.6 Configuration of test system and IUT

6.6.1 General

The test system requires set-up parameters (see [Figure 2](#) key 1), which specify data link layer and physical layer properties of the IUT. The IUT-specific data sheet (see [Figure 2](#), key 1) includes set-up parameters, which the test system requires to perform the CTCs.

[Table 2](#) specifies the configuration of test system and the IUT in the CTCs. In each CTC description, configuration is specified in the 'configuration' column.

Table 2 — Configuration of test system and IUT

Configuration item	Configuration of test system and IUT				
	Default	L_ErrDet1	L_ErrDet2	L_Arbit	L_Unknown
Request identifier by test system	N/A	N/A	N/A	Higher priority	N/A
L_PID	Any valid	Any valid	Any invalid	Any valid	Any invalid
IBS	Less than 9-bit length and more than 1-bit length				
TST_FRM_05_REQ_PID_ERRBIT	N/A	Use	Use	N/A	N/A

[Table 3](#) specifies test message names, which are used by the IUT and the test system in the CTCs. In each CTC description, the message setting is specified in the 'description' column. The configuration described is a suitable configuration for each CTC. If there is no reference to [Table 3](#), the settings are specified in the CTC.

If the IUT is not able to support the given FrameId, it is possible to replace the given FrameId with the FrameId that the IUT can handle.

All frames used are selected so that they should be valid for the IUT. If the specification does not specify the direction (transmission or reception) of frame transfer, the IUT shall have both transmission and reception ability in principle.

Table 3 — Configuration of test frame used by IUT and test system

Name	Definition
TST_FRM_00_REQ_PTYPE	Test frame 00 ₁₆ of master node including a PtypeId value (00 ₁₆) of L_ReqId.
TST_FRM_01_REQ_PID	Test frame 01 ₁₆ of master or slave node including an L_PID value (01 ₁₆ to 7F ₁₆) of L_ReqId.
TST_FRM_03_REQ_PID_UNKNOWN	Test frame 03 ₁₆ of master or slave node including an unknown L_PID value of L_ReqId (not defined for reception/transmission by IUT).
TST_FRM_05_REQ_PID_ERRBIT	Test frame 05 ₁₆ of master or slave node including an error bit L_PID value (01 ₁₆ to 7F ₁₆) of L_ReqId. The value of this PID can use supplier-specific ReqId (3F ₁₆).
TST_FRM_10_RESP_0-12	Test frame 10 ₁₆ of master or slave node including an FI field, DATA field and CRC field determined by 00 ₁₆ ≤ L_Length ≤ 0C ₁₆ .
TST_FRM_12_RESP_LONG_0-255	Test frame 12 ₁₆ of master or slave node including an FI field, DATA field and CRC field determined by 00 ₁₆ ≤ L_Length ≤ FF ₁₆ .
TST_FRM_13_RESP_UNKNOWN_0-12	Test frame 13 ₁₆ of master or slave node including an FI field, DATA field and CRC field (not defined for reception/transmission by IUT) with a correct parity bit determined by 00 ₁₆ ≤ L_Length ≤ 0C ₁₆ .
TST_FRM_16_RESP_ERRBIT_0-12	Test frame 16 ₁₆ of master or slave node including an FI field, DATA field with an error bit and CRC field determined by 00 ₁₆ ≤ L_Length ≤ 0C ₁₆ .

6.6.2 IUT-specific set-up parameters

The IUT-specific set-up parameters include at least the following information.

- The request identifier uses 01₁₆ to 7F₁₆ and uses 00₁₆ in the request protected type identifier field. The usage of other values is invalid.
- The bit rate shall be set following each test case, and default bit rate is specified as 20 kbit/s.
- The delay between the L_PID field and response field shall comply with ISO 20794-4:2020, 8.6.1.
- If width of LO level of logical value 1 is maximum $t_{tx_1_lo_rec_TS} = 0,39 t_{bit} + 0,6 \tau$, then the test is done with $\tau = 5$.