1000BASE-T1 Ethernet ECU Test Specification Layer 1

TC8 Test specification for Interoperability (IOP) and Physical Media Attachment (PMA) testing on ECU level.

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Table of Contents

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1 ABBREVIATION/SYMBOLS

ISO	international standards organisation
IUT	implementation under test
EMC	electromagnetic compatibility
GND	ground
PHY	physical layer
MDI	media dependent interface
OSI	open systems interconnection
PMA	physical medium attachment

2 SCOPE

2.1 Overview

This IUT Specification is designed to determine if a product conforms to specifications defined in OPEN Alliance specifications or related requirements. This specification is a collection of all test cases which are recommended to be considered for automotive use and should be referred to by car manufacturers within their quality control processes.

Successful execution and passing all relevant tests gives an Implementation Under Test (IUT) a minimum approval that the device's basic implementations are done correctly.

2.2 Definition of test scopes

2.2.1 Test scope automotive Ethernet

Scope automotive Ethernet includes the following ISO/OSI layers:

- Layer 1: IEE802.3bp (Physical Layer)

3 NORMATIVE REFERENCES

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

IEEE Std 802.3bp™ – 2016 Amendment 4: *Physical Layer Specifications and Management parameters for 1 Gb/s operation over a Single Twisted Pair Cable*

OPEN Alliance 1000BASE-T1 *Interoperability test suite 1v0*

OPEN Alliance 1000BASE-T1 physical media attachment test suite version 1.1

OPEN Alliance 1000BASE-T1, *Channel and Components Requirements for 1000BASE-T1 Link Segment Type A, version 2.3(UTP)*

OPEN Alliance 1000BASE-T1, *Channel and Components Requirements for 1000BASE-T1 Link Segment Type A, version 2.0 (STP)*

4 TEST SCOPE LAYER 1 OF AUTOMOTIVE ETHERNET

4.1 Interoperability tests

4.1.1 General

The following test specifications are adapted from [1] to fit the general requirements of an IUT.

4.1.2 Link-up time

This test case is based on 1000BASET1_IOP_21 and 1000BASET1_IOP_22 [1].

Three test cycles:

- Power on link partner
- Power on IUT
- Wake-up IUT

Table 1 specifies the CT_OABR_LINKUP_01 – Link-up time – Trigger: Power on link partner.

Item	Content
CT # – Title	CT_OABR_LINKUP_01 – Link-up time – Trigger: Power on link partner
Purpose	Shall ensure that the link is established within a given time without a high time variation.
Reference	Not applicable
Prerequisites	1 The IUT is connected to a stable power supply. 2 The IUT must be operated in normal mode. 3 The test system provides special awake conditions for the IUT such as a wakeup line or network management CAN messages if necessary. 4 If the IUT contains a switch, all links have to be tested separately. 5 The mean start up time of the link partner is available: $\bar{t}_{ready}$
IUT set-up	The IUT must be connected to the link partner with opposite master/slave configuration. The polarity of the communication channel must be correct. The power supplies are controlled by the test system. See Figure 1.
Test description	1 IUT shall be active and ready to build up a link. 2 to 5 Test iterations 6 Calculate according to equation (1).
Test iterations	Repeat step 2 to step 5; n = 100 times 2 Power on link partner. $t_{start} = t_{PowerOnLinkPartner}$ 3 Polling of link partner status register. If link_control = active link: $t_{stop} = t_{ActiveLink}$ 4 Calculate the time tup between power on and link up: $t_{up} = t_{stop} - t_{start}$ 5 Power off link partner. End of repeat
Test response	$\sigma t \leq 50\ \text{ms}$; $t_{\min} > 10\ \text{ms} + \bar{t}_{ready}$; $t_{\max} < 100\ \text{ms} + \bar{t}_{ready}$
Notes	This test has to be performed for each port of the IUT, if it has a switch inside. In dependency of the design of the link partner, the test system may switch also the power supply of the µC together with the power supply of the PHY.

Table 1 — CT_OABR_LINKUP_01 – Link-up time – Trigger: Power on link partner

Definition of equation **(1)**

$$\bar{t} = \frac{1}{n}\sum_{i=1}^{n} t_{up}(i); \sigma t = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(t_{up}(i) - \bar{t})^2}$$

$$t_{\min} = \min\left(t_{up}(i)\right); t_{\max} = \max\left(t_{up}(i)\right)$$

Figure 1 shows the test system for CT_OABR_LINKUP_01 – Link-up time – Trigger: Power on link partner

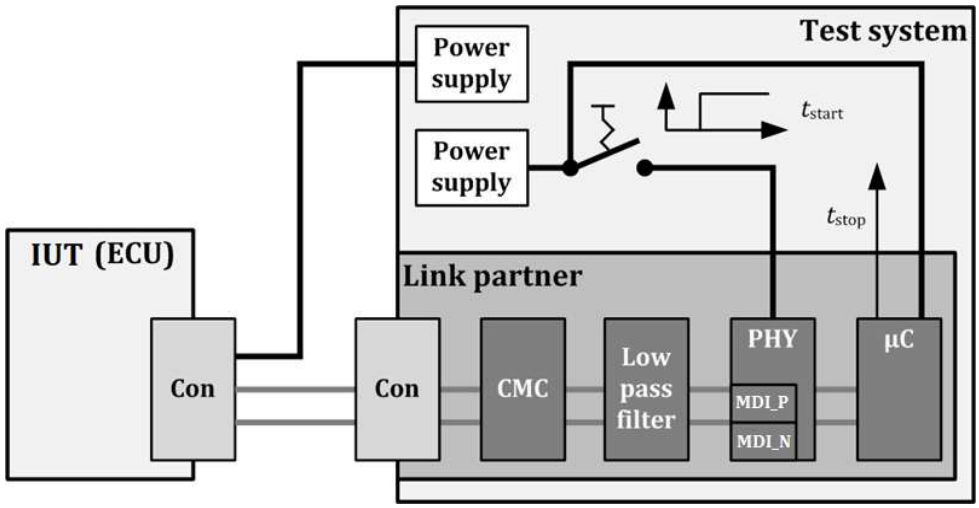


Figure 1 — Test system for CT_OABR_LINKUP_01 – Link-up time – Trigger: Power on link partner

Table 2 specifies the CT_OABR_LINKUP_02 – Link-up time – Trigger: Power on IUT.

Item	Content
CT # – Title	CT_OABR_LINKUP_02 – Link-up time – Trigger: Power on IUT
Purpose	Shall ensure that the link is established within a given time without a high time variation.
Reference	Not applicable
Prerequisites	1 The link partner is connected to a stable power supply. 2 The test system provides special awake conditions for the IUT such as a wakeup line or network management CAN messages, if necessary. 3 The manufacturer has to provide the mean start up time of the IUT: $\bar{t}_{ready}1$
IUT set-up	The IUT must be connected to the link partner with opposite master/slave configuration. The polarity of the communication channel must be correct. The power supplies are controlled by the test system. See Figure 2.
Test description	1 Link partner shall be active and ready to build up a link. 2 to 5 Test iterations 6 Calculate according to equation (2).
Test iterations	Repeat step 2 to step 5; n = 100 times 2 Power on IUT. tstart = $t_{PowerOnIUT}$ 3 Polling of link partner status register. If link_control = active link: $t_{stop} = t_{ActiveLink}$ 4 Calculate the time tup between power on and link up: tup = $t_{stop} - t_{start}$ 5 Power off IUT. End of repeat
Test response	$\sigma t \leq 50\ \text{ms}$; $t_{min} > 10\ \text{ms} + \bar{t}_{ready1}$; $t_{max} < 100\ \text{ms} + \bar{t}_{ready1}$
Notes	This test has to be performed for each port of the IUT, if it has a switch inside.

Table 2 — CT_OABR_LINKUP_02 – Link-up time – Trigger: Power on IUT

Definition of equation **(2)**

$$\bar{t} = \frac{1}{n}\sum_{i=1}^{n} t_{up}(i); \sigma t = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(t_{up}(i) - \bar{t})^2}$$

$$t_{min} = \min\left(t_{up}(i)\right); t_{max} = \max\left(t_{up}(i)\right)$$

Figure 2 shows the test system – Link-up time – Trigger, power on IUT.

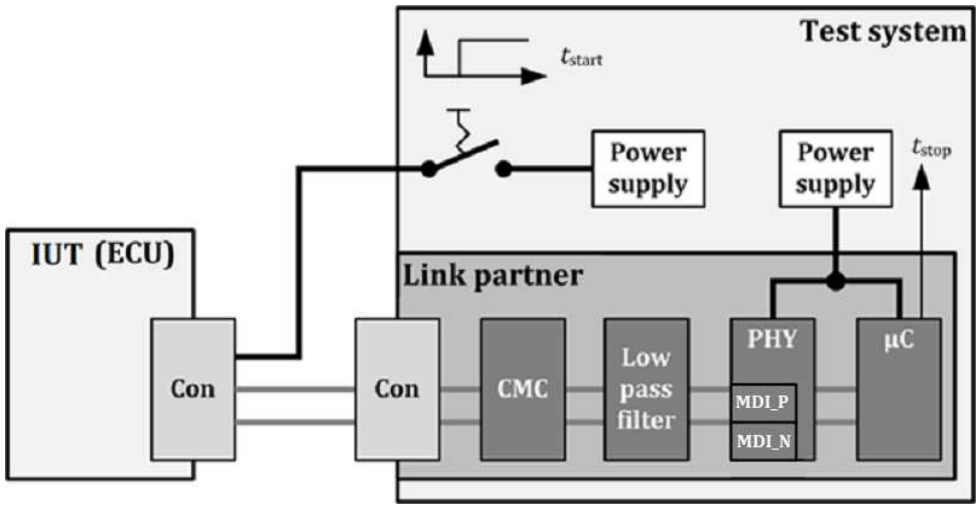


Figure 2 — Test system – Link-up time – Trigger, power on IUT

Table 3 specifies the CT_OABR_LINKUP_03 – Link-up time – Trigger: Wake up IUT.

Item	Content
CT # – Title	CT_OABR_LINKUP_03 – Link-up time – Trigger: Wake up IUT
Purpose	Shall ensure that the link is established within a given time without a high time variation.
Reference	Not applicable
Prerequisites	1 The IUT and the link partner are connected to a stable power supply. 2 The IUT must be operated in normal mode. 3 Wake up message is necessary. The test system provides special awake conditions for the IUT such as a wakeup line or network management CAN messages. 4 The manufacturer has to provide the value I_{sleep}. 5 The manufacturer has to provide the mean wake up time of the IUT: $\bar{t}_{ready2}$
IUT set-up	The IUT must be connected to the link partner with opposite master/slave configuration. The polarity of the communication channel must be correct. The power supplies are controlled by the test system. See Figure 3.
Test description	1 IUT shall be in sleep mode and link partner shall be active and ready to build up a link. 2 to 5 Test iterations 7 Calculate according to equation (3).
Test iterations	Repeat step 2 to step 5; n = 100 times 2 Turn on Wake up signal for IUT. 3 $t_{WakeUpIUT}$ if IIUT> I_{sleep} , $t_{start} = t_{WakeUpIUT}$ 4 Polling of link partner status register. If link_control = active link: $t_{stop} = t_{ActiveLink}$ 5 Calculate the time tup between wake up and link up: tup = $t_{stop} – t_{start}$ 6 Switch IUT to sleep mode. End of repeat
Test response	$\sigma t \leq 50\ \text{ms}$; $t_{min} > 10\ \text{ms} + \bar{t}_{ready2}$; $t_{max} < 100\ \text{ms} + \bar{t}_{ready2}$
Notes	This test has to be performed for each port of the IUT, if it has a switch inside.

Table 3 — CT_OABR_LINKUP_03 – Link-up time – Trigger: Wake up IUT

Definition of equation **(3)**

$$\bar{t} = \frac{1}{n}\sum_{i=1}^{n} t_{up}(i); \sigma t = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(t_{up}(i) - \bar{t})^2}$$

$$t_{\min} = \min\left(t_{up}(i)\right); t_{\max} = \max\left(t_{up}(i)\right)$$

Figure 3 shows the link-up time – Trigger, wake up IUT.

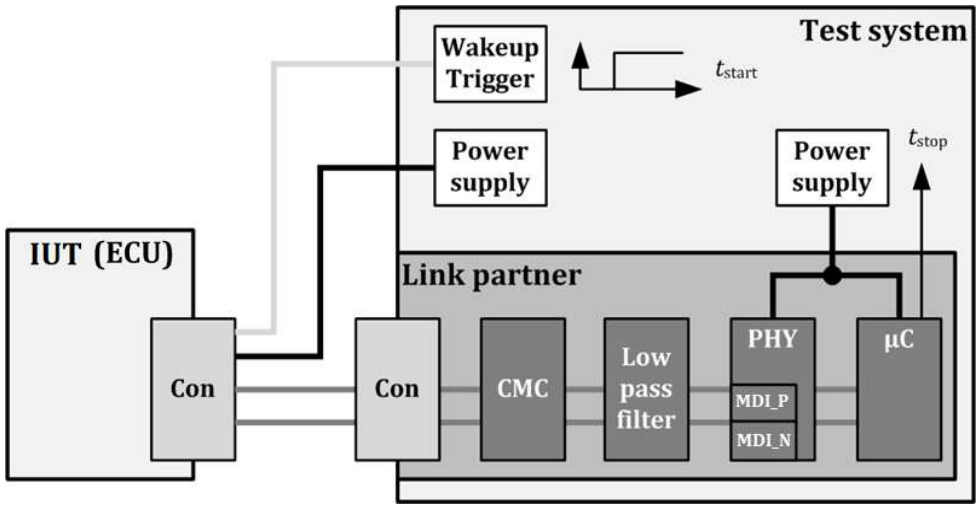


Figure 3 — Link-up time – Trigger, wake up IUT

4.1.3 Signal quality

This test case is based on 1000BASET1_IOP_24a [1].

Table 4 specifies the CT_OABR_SIGNAL_01 – Indicated signal quality for channel with decreasing quality.

Item	Content
CT # – Title	CT_OABR_SIGNAL_01 – Indicated signal quality for channel with decreasing quality
Purpose	Shall ensure that the IUT's indicated signal quality decreases for a channel with decreasing channel quality and that there is coherence between the SQI indicated values on the IUT and the respective artificial noise injection.
Reference	Not applicable
Prerequisites	1 The IUT and the link partner are connected to a stable power supply. 2 The IUT must be operated in normal mode. 3 The test system allows varying and determining the quality of the communication channel that connects the IUT and link partner. 4 IUT must be able to monitor the signal quality indicated by the PHY. The information of the signal quality can be provided by an applicative message. To be able to obtain the IUT information of the signal quality with the respective applied channel degradation step, an additional communication channel like CAN should be available.
IUT set-up	See sub-clause 7.3 artificial degradation of channel quality [1].
Test description	See Test description of 1000BASET1_IOP_24a [1].
Test iterations	Not applicable
Test response	See pass criteria of 1000BASET1_IOP_24a [1].
Notes	This test must be performed for each port of the IUT, if it has a switch inside. The artificial noise level may be increased by one step, i.e. by 25mV Gaussian noise generator amplitude.

Table 4 — CT_OABR_SIGNAL_01 – Indicated signal quality for channel with decreasing quality

This test case is based on 1000BASET1_IOP_24b [1].

Table 5 specifies the CT_OABR_SIGNAL_02 – Indicated signal quality for channel with increasing quality.

Item	Content
CT # – Title	CT_OABR_SIGNAL_02 – Indicated signal quality for channel with increasing quality
Purpose	Shall ensure that the IUT's indicated signal quality increases for a channel with increasing channel quality and that there is coherence between the SQI indicated values on the IUT and the respective artificial noise injection.
Reference	Not applicable
Prerequisites	1 The IUT and the link partner are connected to a stable power supply. 2 The IUT must be operated in normal mode. 3 The test system allows varying and determining the quality of the communication channel that connects the IUT and link partner. 4 IUT must be able to monitor the signal quality indicated by the PHY. The information of the signal quality can be provided by an applicative message. To be able to obtain the IUT information of the signal quality with the respective applied channel degradation step, an additional communication channel like CAN should be available.
IUT set-up	See sub-clause 7.3 artificial degradation of channel quality [1].
Test description	See Test description of 1000BASET1_IOP_24b [1].
Test iterations	Not applicable
Test response	See Pass criteria of 1000BASET1_IOP_24b [1].
Notes	This test must be performed for each port of the IUT, if it has a switch inside. The artificial noise level may be decreased by one step, i.e. by 25mV Gaussian noise generator amplitude.

Table 5 — CT_OABR_SIGNAL_02 – Indicated signal quality for channel with increasing quality

4.1.4 Cable diagnostics

This test case is based on 1000BASET1_IOP_32 [1].

Table 6 specifies the CT_OABR_CABLE_01 – Cable diagnostics for near and far end open.

Item	Content
CT # – Title	CT_OABR_CABLE_01 – Cable diagnostics for near and far end open
Purpose	Shall ensure that the IUT's cable diagnostic reliably detects an open of one or both of the bus lines. The test shall be performed for both a near end open at the connector of the IUT, and for a far end open at the connector of the link partner.
Reference	Not applicable
Prerequisites	1 The channel should be terminated properly. 2 The IUT must be capable to start cable diagnostic of its PHY. 3 The IUT must be able to detect any cable errors. This means the IUT must provide the possibility to trigger the cable diagnostic feature. The result of the IUT's cable diagnostic can be provided by an applicative Ethernet message, an UDS communication or another communication channel like CAN. 4 The link partner should not be transmitting any signal (typically SEND_Z or configured as slave).
IUT set-up	See Figure 4
Test description	The following steps shall be applied to test near and far end open cable diagnostics: 1 Link partner configured to cease transmission (either SEND_Z or configured as slave) 2 The IUT cable diagnostic feature is triggered. The IUT cable diagnostics must be executed within t_{error}. 3 The test system creates a cable error for a defined time t_{error}. 4 After the wait time t the test system reads out all identified cable errors QC from the IUT. 5 Repeat step 2 to 4 for all error combinations (alternately MDI+ and/or MDI- are open). For additional information regarding the test instances, please refer to test instances table of 1000BASET1_IOP_32 [1].
Test iterations	Repeat 5 times: step 2 to 5
Test response	Each test iteration shall be classified as passed, if the IUT reports all expected cable errors.
Notes	For additional information regarding the near and far end open, please refer to Notes of 1000BASET1_IOP_32 [1]. The results shall be reported for each 1000BASE-T1 port available in the IUT.

Table 6 — CT_OABR_CABLE_01 – Cable diagnostics for near and far end open

Figure 4 shows the cable diagnostics for near and far end open.

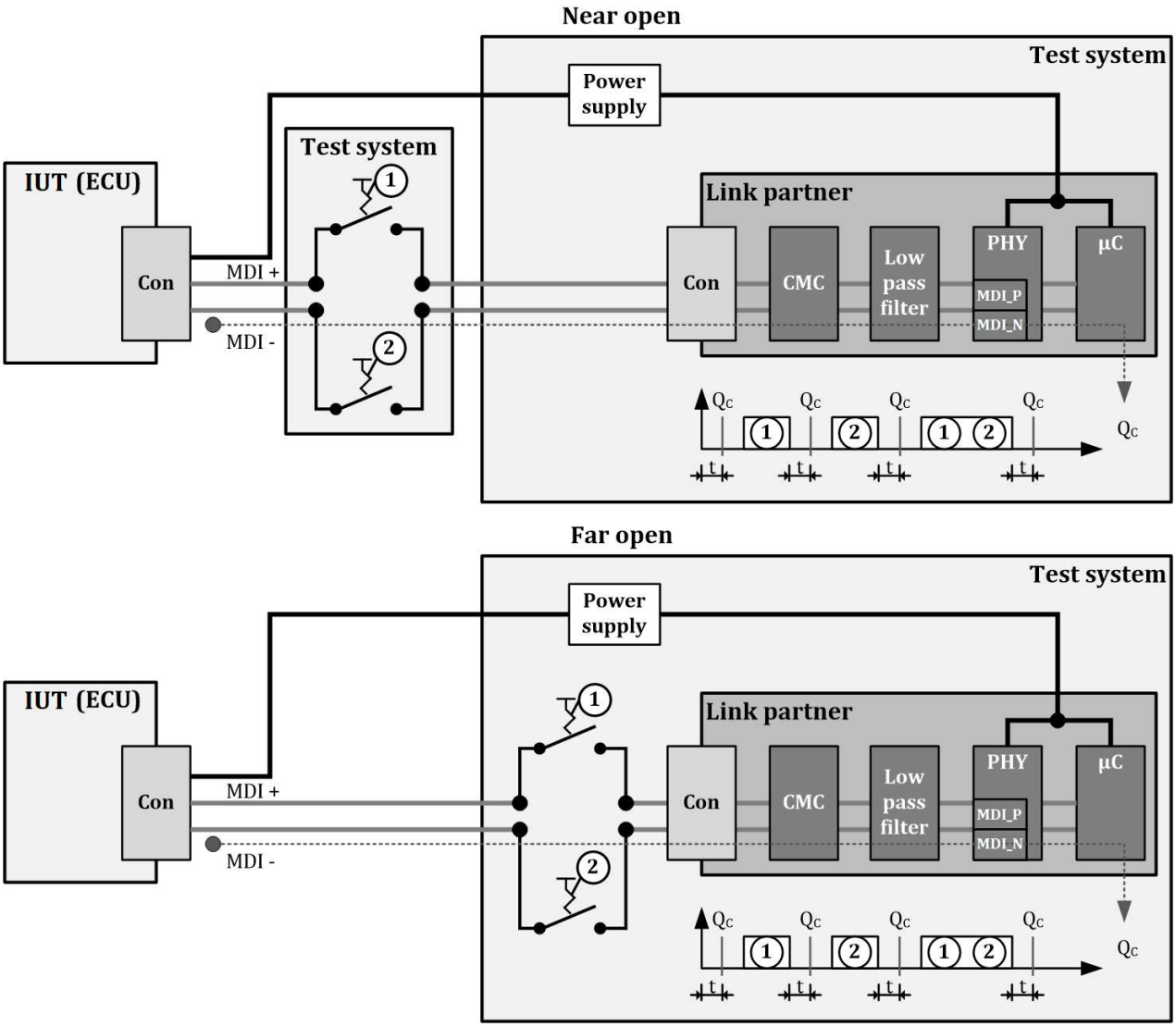


Figure 4 — Cable diagnostics for near and far end open

This test case is based on 1000BASET1_IOP_33 [1].

Table 7 specifies the CT_OABR_CABLE_02 – Cable diagnostics for near and far end short.

Item	Content
CT # – Title	CT_OABR_CABLE_02 – Cable diagnostics for near and far end short
Purpose	Shall ensure that the IUT's cable diagnostic reliably detects a short of one or both of the bus lines. The test shall be performed for both a near end short at the connector of the IUT, and for a far end short at the connector of the link partner.
Reference	Not applicable
Prerequisites	1 The channel should be terminated properly. 2 The IUT must be capable to start cable diagnostic of its PHY. 3 The IUT must be able to detect any cable errors. This means the IUT must provide the possibility to trigger the cable diagnostic feature. The result of the IUT's cable diagnostic can be provided by an applicative Ethernet message, an UDS communication or another communication channel like CAN. 4 The link partner should not be transmitting any signal (typically SEND_Z or configured as slave)
IUT set-up	IUT is connected to a properly terminated link partner. The bus wires are connected via a ≤ 1 Ohm resistor during following error situations: • SHORT between both bus wires, far and near end. • SHORT of both conductors to ground (GND), far and near end. • SHORT of both conductors to supply line (V_{BAT}), far and near end. Please note that Figure 5 only presents the 1st error scenario (SHORT between both bus wires, far and near end). The 2nd and 3rd error scenario, where the two wires MDI+ and MDI- are additionally connected to GND resp. VBAT, are not presented here. See Figure 5
Test description	The following steps shall be applied to test near and far end shorted cable diagnostics: 1 Link partner configured to cease transmission (either SEND_Z or configured as slave) 2 The IUT cable diagnostic feature is triggered. The IUT cable diagnostics must be executed within t_{error}. 3 The test system creates a cable error for a defined time t_{error}. 4 After the wait time t the test system requests all identified cable errors QC from the IUT. 5 Repeat step 2 to 4 for all error combinations. For additional information regarding the test instances, please refer to test instances table of 1000BASET1_IOP_33 [1].
Test iterations	Repeat 5 times: step 2 to 5
Test response	Each test iteration shall be classified as passed, if the IUT reports all expected cable errors.
Notes	For additional information regarding the near and far end short, please refer to notes of 1000BASET1_IOP_33 [1]. The results shall be reported for each 1000BASE-T1 port available in the IUT.

Table 7 — CT_OABR_CABLE_02 – Cable diagnostics for near and far end short

Figure 5 shows the cable diagnostics for near and far end short.

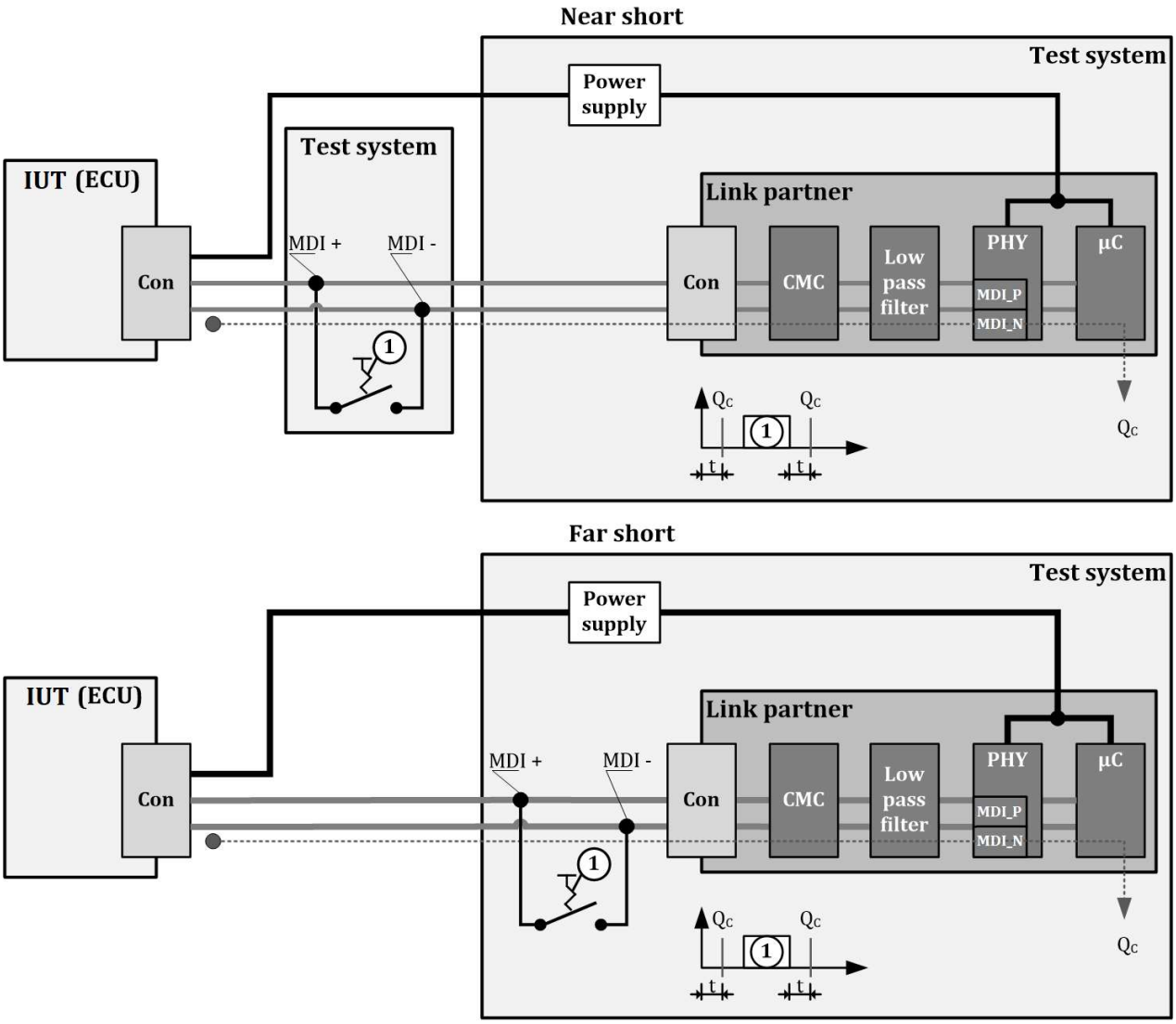


Figure 5 — Cable diagnostics for near and far end short

This test case is based on 1000BASET1_IOP_31 [1].

Table 8 specifies the CT_OABR_CABLE_03 – Cable diagnostics for good cable.

Item	Content
CT # – Title	CT_OABR_CABLE_03 – Cable diagnostics for good cable
Purpose	Shall ensure that the IUT's cable diagnostic reliably detects a good connection of the bus lines.
Reference	Not applicable
Prerequisites	1 The channel should be terminated properly. 2 The IUT must be capable to start cable diagnostic of its PHY. 3 The IUT must be able to detect any cable errors. This means the IUT must provide the possibility to trigger the cable diagnostic feature. The result of the IUT's cable diagnostic can be provided by an applicative Ethernet message, an UDS communication or another communication channel like CAN. 4 The link partner should not be transmitting any signal (typically SEND_Z or configured as slave)
IUT set-up	IUT is connected to a properly terminated link partner
Test description	The following steps shall be applied to test near and far end shorted cable diagnostics: 1 Link partner configured to cease transmission (either SEND_Z or configured as slave) 2 The IUT cable diagnostic feature is triggered. 3 The test system is configured for an error-free channel. 4 The test system requests all identified cable errors from the IUT.
Test iterations	Repeat 5 times: step 2 to 5
Test response	Each test iteration shall be classified as passed, if the IUT reports all expected status for a good cable.
Notes	For additional information regarding the cable diagnostics for error free channel, please refer to notes of 1000BASET1_IOP_31 [1]. The results shall be reported for each 1000BASE-T1 port available in the IUT.

Table 8 — CT_OABR_CABLE_03 – Cable diagnostics for good cable

4.2 PMA

4.2.1 General

This sub-clause shall be used for evaluation of the physical layer of a 1000BASE-T1 interface on IUT level. Except otherwise stated, the measurements shall be conducted by room temperature (RT = 23°C ± 5°C).

The tests shall be carried out based on the definitions of the related test specifications [9] and 011].

The test classification indicates whether the test must be done or not in terms of qualification.

Mandatory: The test is required and must be evaluated according to the specified pass/fail criterion.

Optional: The test could be executed but is not required for an official qualification pass/fail criterium. Background of the optional test is, for PHY that already passed the tests according to [9], parameters are already checked and do not need to be retested.

4.2.2 Transmitter electrical specifications

The following test cases specify the requirements of the transmitter side (measurement point: MDI).

Table 9 specifies the CT_OABR_PMA_TX_01 – Check the transmitter output droop.

Item	Content
CT # – Title	CT_OABR_PMA_TX_01 – Check the transmitter output droop
Purpose	Verification of the transmitter output droop. The test case shall be executed according to the definitions in [9], test 97.1.1.
Reference	Not applicable
Test Classification	Optional
Prerequisites	1 The IUT is connected to a stable power supply. 2 Use link partner or an interface to set the IUT's PHY into test mode operation (via 1000BASE-T1, standard Ethernet, CAN, FlexRay e.g.). 3 IUT must be able to set its PHY into test mode 6.
IUT set-up	according to [9], test 97.1.1
Test description	according to [9], test 97.1.1
Test iterations	Accumulate min. 10 measurements to increase the accuracy at one sample.
Test response	according to [9], test 97.1.1
Notes	The test shall be executed for each port of the IUT if it has a switch inside.

Table 9 — CT_OABR_PMA_TX_01 – Check the transmitter output droop

Table 10 specifies the CT_OABR_PMA_TX_02 – Check the transmitter timing jitter in master mode.

Item	Content
CT # – Title	CT_OABR_PMA_TX_02 – Check the MDI transmitter timing jitter
Purpose	Verification of the transmitter timing jitter in master mode. The test case shall be executed according to the definitions in [9], test 97.1.3, Case 3.
Reference	Not applicable
Test Classification	Mandatory
Prerequisites	1 The IUT is connected to a stable power supply. 2 Use link partner or an interface to set the IUT's PHY into test mode operation (via 1000BASE-T1, standard Ethernet, CAN, FlexRay e.g.). 3 IUT must be able to set its PHY into test mode 2.
IUT set-up	according to [9], test 97.1.3, Case 3
Test description	according to [9], test 97.1.3, Case 3
Test iterations	Accumulate min. 10 measurements to increase the accuracy at one sample.
Test response	according to [9], test 97.1.3, Case 3
Notes	The test shall be executed for each port of the IUT if it has a switch inside.

Table 10 — CT_OABR_PMA_TX_02 – Check the MDI transmitter timing jitter

Table 11 specifies the CT_OABR_PMA_TX_03 – Check the transmit clock frequency.

Item	Content
CT # – Title	CT_OABR_PMA_TX_03 – Check the transmit clock frequency
Purpose	Verification of the transmit clock frequency. The test case shall be executed according to the definitions in [9], test 97.1.6.
Reference	Not applicable
Test Classification	Mandatory
Prerequisites	1 The IUT is connected to a stable power supply. 2 Use link partner or an interface to set the IUT's PHY into test mode operation (via 1000BASE-T1, standard Ethernet, CAN, FlexRay e.g.). 3 IUT must be able to set its PHY into test mode 2.
IUT set-up	according to [9], test 97.1.6
Test description	according to [9], test 97.1.6
Test iterations	Accumulate min. 10 measurements to increase the accuracy at one sample.
Test response	according to [9], test 97.1.5
Notes	As the test is realized on three corner temperatures use a test cable that does not influence the test result. The test shall be executed for each port of the IUT if it has a switch inside. The corner temperatures of the IUT for the test must be provided by the IUT manufacturer.

Table 11 — CT_OABR_PMA_TX_03 – Check the transmit clock frequency

Table 12 specifies the CT_OABR_PMA_TX_04 – Check the Transmitter Power Spectral Density (PSD).

Item	Content
CT # – Title	CT_OABR_PMA_TX_04 – Check the Transmitter Power Spectral Density (PSD)
Purpose	Verification of the transmitter power spectral density. The test case shall be executed according to the definitions in [9], test 97.1.4.
Reference	Not applicable
Test Classification	Optional
Prerequisites	1 The IUT is connected to a stable power supply. 2 Use link partner or an interface to set the IUT's PHY into test mode operation (via 1000BASE-T1, standard Ethernet, CAN, FlexRay e.g.). 3 IUT must be able to set its PHY into test mode 5.
IUT set-up	according to [9], test 97.1.4
Test description	according to [9], test 97.1.4
Test iterations	If performing the test with a DSO, the averaging function of the scope shall be set at least to 50 times.
Test response	according to [9], test 97.1.4
Notes	The test shall be executed for each port of the IUT if it has a switch inside.

Table 12 — CT_OABR_PMA_TX_04 – Check the Transmitter Power Spectral Density (PSD)

Table 13 specifies the CT_OABR_PMA_TX_05 – Check MDI return loss.

The test case definition is based on sub-clause 97.7.2.1 MDI return loss of [11] and test 97.3.1 of [9].

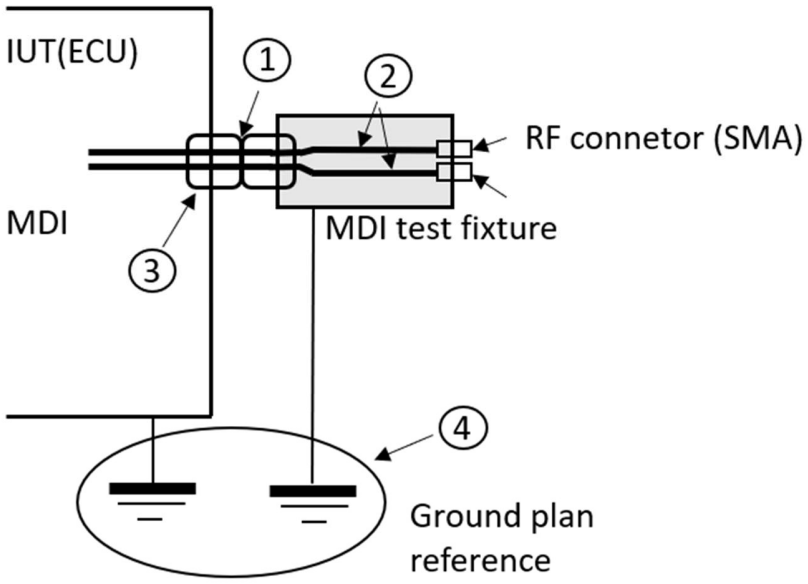
Item	Content	
CT # – Title	CT_OABR_PMA_TX_05 – Check MDI return loss	
Purpose	Shall ensure that the IUT respects the limits for the return loss.	
Reference	Not applicable	
Test Classification	Mandatory	
Prerequisites	1 The IUT is connected to a stable power supply. 2 Use link partner or an interface to set the IUT's PHY into slave mode operation (via 1000BASE-T1, standard Ethernet, CAN, FlexRay e.g.). 3 IUT must be able to set its PHY into slave mode operation.	
IUT set-up	The measurement of the return loss shall be carried out with a network analyzer. See Figure 6. To achieve a high degree of reliability of measurement results, the use of a specific test fixture for the connection to the IUT connector MDI pins is required. A test fixture according to the diagram shall be used. The ground pin(s) of the IUT shall be directly connected to the ground plane of the test fixture. If possible, the original harness connector shall be used. It shall be a fixed part of the test fixture. The calibration reference plane is defined at the beginning of the harness connector on the test fixture. The following VNA settings shall be used for the measurement:	
	Parameter	Value
	Sweep f_{Start}	1 MHz
	Sweep f_{Stop}	1 GHz
	Sweep type	Logarithmic
	Sweep points	1600
	Output power	minimum -10 dBm
	Measurement bandwidth	100 Hz
	Logic port impedance differential mode	100 Ω
	Logic port impedance common mode	25 Ω
	Data calibration kit (VNA)	used kit for calibration
	Averaging function	16 times
	Smoothing function	deactivated

Test description	1	The IUT PHY is in slave mode operation.
	2	Use a test fixture as described in the test setup.
	3	Connect the MDI via the test fixture to the network analyzer.
	4	Measure the value return loss (Sdd11).
	5	Analyse the waveform.
	6	Report the result with a resolution that shows: No limit violation was detected.
Test iterations	Single VNA measurement with enabled averaging function set to at least 16 times.	
Test response	The test shall be classified as passed, if the value of the MDI return loss (Sdd11) fulfils the limit defined in sub-clause 97.7.2.1 MDI return loss of [11].	
Notes	The test shall be executed for each port of the IUT if it has a switch inside.	

Table 13 — CT_OABR_PMA_TX_05 – Check MDI return loss

Figure 6 and Figure 7 show the MDI return loss test setups.

General MDI Test Head description UTP. For more Information refer to [8] chapter 7.1



Key:

1 Measurement reference plane

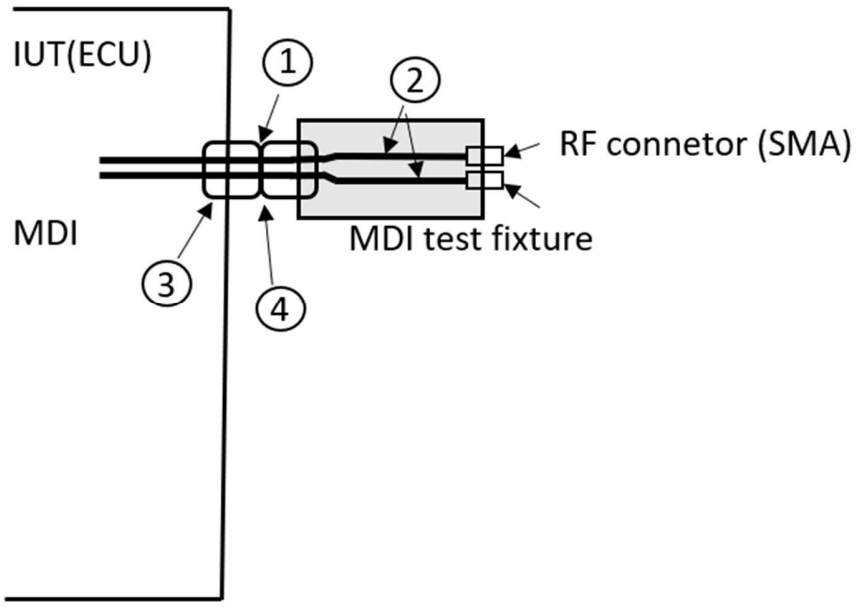
2 Line impedance 50 Ω

3 IUT connector cable side

4 Connection IUT GND pinto ground plane of test fixture

Figure 6 — MDI Test fixture for UTP

General MDI Test Head description STP. For more Information refer to [12] chapter 7.1



Key:

1	Measurement reference plane
2	Line impedance 50 Ω
3	IUT connector cable side
4	Connection IUT GND ground plane of test fixture

Figure 7 — MDI Test fixture for STP

Fehler! Verweisquelle konnte nicht gefunden werden. specifies the CT_OABR_PMA_TX_06 – Check MDI mode conversion.
The test case definition is based on sub-clause 97.7.2.1 MDI mode conversion loss of [11], test 97.3.2 of [9].

Item	Content	
CT # – Title	CT_OABR_PMA_TX_06 – Check MDI mode conversion	
Purpose	Shall ensure that the IUT respects the limits for the mode conversion. Shall ensure that the IUT front end respects the appropriate symmetry requirements.	
Reference	Not applicable	
Test Classification	Mandatory	
Prerequisites	1 The IUT is connected to a stable power supply. 2 Use link partner or an interface to set the IUT's PHY into slave mode operation (via 1000BASE-T1, standard Ethernet, CAN, FlexRay e.g.). 3 IUT must be able to set its PHY into slave mode operation.	
IUT set-up	The measurement of the mode conversion shall be carried out with a network analyser See Figure 8. To achieve a high degree of reliability of measurement results, the use of a specific test fixture for the connection to the IUT connector MDI pins is required. A test fixture according to the diagram below shall be used. The ground pin(s) of the IUT shall be directly connected to the ground plane of the test fixture. If possible, the original harness connector shall be used. It shall be a fixed part of the test fixture. The calibration reference plane is defined at the beginning of the harness connector on the test fixture. Additionally the used test fixture shall fulfil the limit for fixture self-conversion given in Table 7.2-1: MDI Test Head mode conversion requirement of [8] for the UTP application or [11] for STP application while the test fixture is not connected to the IUT (terminal left open). The following VNA settings shall be used for the measurement:	
	Parameter	Value
	Sweep f_{Start}	1 MHz
	Sweep f_{Stop}	1 GHz
	Sweep type	Logarithmic
	Sweep points	1600
	Output power	minimum -10 dBm
	Measurement bandwidth	100 Hz
	Logic port impedance differential mode	100 Ω
	Logic port impedance common mode	25 Ω
	Data calibration kit (VNA)	used kit for calibration
	Averaging function	16 times
	Smoothing function	deactivated
	Limit for test fixture self-conversion Table 7.2-1: MDI Test Head mode conversion requirement of [8], [12]	

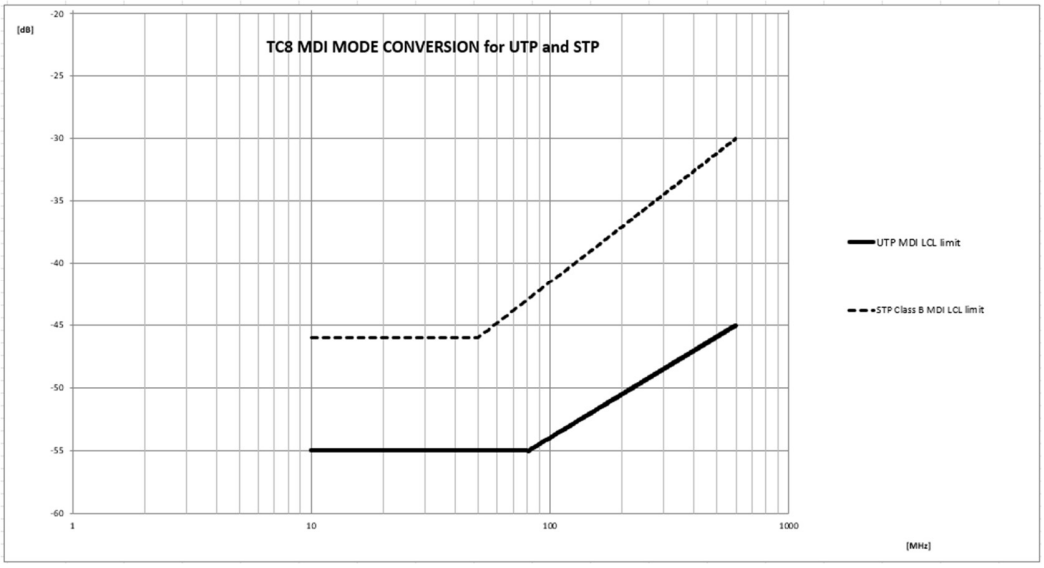
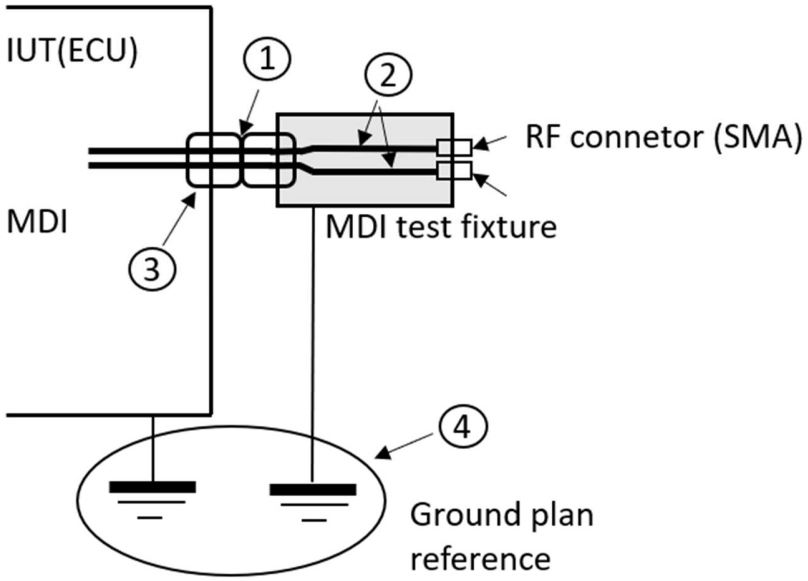
Test description	1 The IUT PHY is in slave mode operation. 2 Use a test fixture as described in the test setup. 3 Connect the MDI via the test fixture to the network analyser. 4 Measure the value mode conversion (Sdc11). 5 Analyse the waveform. 6 Report the result with a resolution that shows: No limit violation was detected.
Test iterations	Single VNA measurement with enabled averaging function set to at least 16 times.
Test response	The test shall be classified as passed, if the value of the MDI mode conversion (Sdc11) fulfils the limit defined below. For UTP IUT: $$\geq \begin{pmatrix} 55 & 10 \leq f \leq 80 \\ 77 - 11.51\log(f) & 50 < f \leq 600 \end{pmatrix} dB$$ $$10 \leq f \leq 600, frequency\ f\ in\ MHz$$ For STP IUT: $$\geq \begin{pmatrix} 46 & 10 \leq f \leq 50 \\ 71.2 - 14.83\log(f) & 50 < f \leq 600 \end{pmatrix} dB$$ $$10 \leq f \leq 600, frequency\ f\ in\ MHz$$ MDI mode conversion limits for UTP and STP: 
Notes	The test shall be executed for each port of the IUT, if it has a switch inside. For the MDI Test Head refer to chapter 7.1 of [8].

Table 14 — CT_OABR_PMA_TX_06 – Check MDI mode conversion

Figure 8 and Figure 10 show the MDI test fixture for UTP and STP.

General MDI Test Head description for UTP. For more Information refer to [8] chapter 7.1



Key:

1 Measurement reference plane

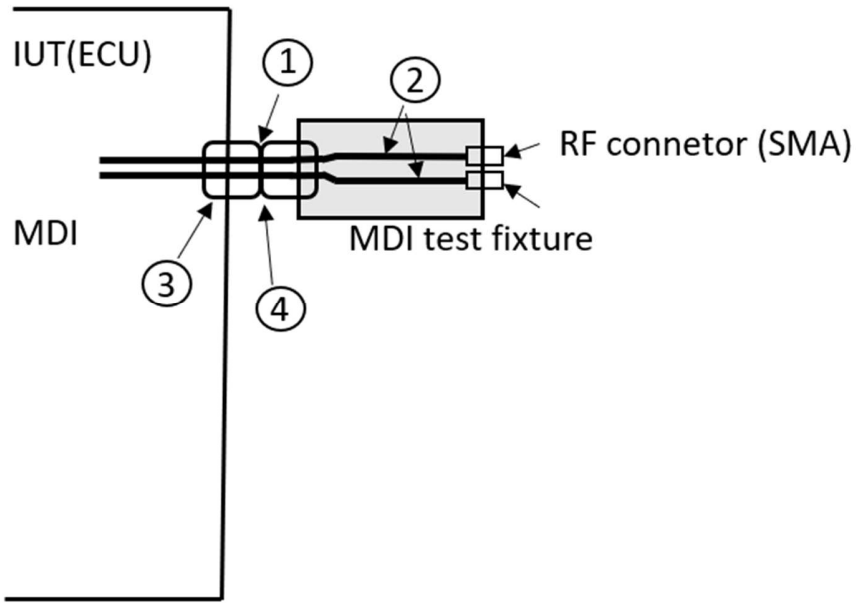
2 Line impedance 50 Ω

3 IUT connector cable side

4 Connection IUT GND ground plane of test fixture

Figure 8 MDI test fixture for UTP

General MDI Test Head description. For more Information refer to [12] chapter 7.1



Key:

1	Measurement reference plane
2	Line impedance 50 Ω
3	IUT connector cable side
4	Connection IUT GND ground plane of test fixture

Figure 9 MDI test fixture for STP

Table 14 specifies the CT_OABR_PMA_TX_07 – Check the transmitter distortion.

Item	Content
CT # – Title	CT_OABR_PMA_TX_07 – Check the transmitter distortion
Purpose	Verification of the transmitter distortion. The test case shall be executed according to the definitions in [9], test 97.1.2.
Reference	Not applicable
Test Classification	Optional
Prerequisites	1 The IUT is connected to a stable power supply. 2 Use link partner or an interface to set the IUT's PHY into test mode operation (via 1000BASE-T1, standard Ethernet, CAN, FlexRay e.g.). 3 IUT must be able to set its PHY into test mode 4.
IUT set-up	according to [9], test 97.1.2
Test description	according to [9], test 97.1.2
Test iterations	10 times
Test response	according to [9], test 97.1.2
Notes	The execution of this test is optional and not mandatory for the compliance test. In case of IUT test the TX_TCLK125 is not accessible. Therefore, it is necessary to recover the TX_TCLK form the signal Itself, see 4.2.3. Instead of a 100 Ω differential voltage generator, the test case may be executed also with a single-ended voltage generator and a balun.

Table 14 — CT_OABR_PMA_TX_07 – Check the transmitter distortion

Table 15 specifies the CT_OABR_PMA_TX_08 – Check the transmitter Peak Differential Output

Item	Content
CT # – Title	CT_OABR_PMA_TX_08 – Check the transmitter Peak Differential Output
Purpose	Verification of the transmitter peak differential output. The test case shall be executed according to the definitions in [9], test 97.1.5.
Reference	Not applicable
Test Classification	Optional
Prerequisites	1 The IUT is connected to a stable power supply. 2 Use link partner or an interface to set the IUT's PHY into test mode operation (via 1000BASE-T1, standard Ethernet, CAN, FlexRay e.g.). 3 IUT must be able to set its PHY into test mode 5.
IUT set-up	according to [9], test 97.1.5
Test description	according to [9], test 97.1.5
Test iterations	Accumulate min. 10 measurements to increase the accuracy.
Test response	according to [9], test 97.1.5
Notes	The test shall be executed for each port of the IUT if it has a switch inside.

Table 15 — CT_OABR_PMA_TX_08 – Check the transmitter Peak Differential Output

Table 16 specifies the CT_OABR_PMA_TX_09 – Check the transmitter Link Sync Pulse Amplitude

Item	Content
CT # – Title	CT_OABR_PMA_TX_09 – Check the transmitter Link Sync Pulse Amplitude
Purpose	Verification of the transmitter peak differential output. The test case shall be executed according to the definitions in [9], test 97.1.7.
Reference	Not applicable
Test Classification	Optional
Prerequisites	1 The IUT is connected to a stable power supply. 2 Use link partner and connect the IUT. 3 IUT is in normal operation.
IUT set-up	according to [9], test 97.1.7
Test description	according to [9], test 97.1.7
Test iterations	Accumulate min. 10 measurements to increase the accuracy.
Test response	according to [9], test 97.1.7
Notes	The test shall be executed for each port of the IUT if it has a switch inside. The test is only executed in Slave or Master configuration depending on the default Configuration of the IUT.

Table 16 — CT_OABR_PMA_TX_09 – Check the transmitter Link Sync Pulse Amplitude

4.2.3 Transmitter distortion test

Transmitter distortion test can be executed without TX_TCLK.

This part will give an overview of the test setup without TX_TCLK access, with disturber.

- The IUT is set in test mode 4 and the disturber signal of 3.6 Vpp 125 MHz sine wave is injected on the IUT transmitter.
- The main idea is to recover the TX_TCLK clock from the test mode 4 signal and apply the recovered timing to determine the right samples needed for [9], test 97.1.2.

Figure 10 shows the transmitter distortion test.

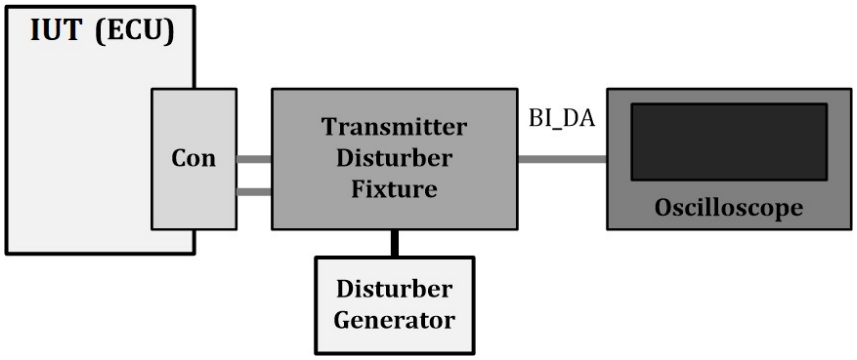


Figure 10 — Transmitter distortion test

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