100BASE-T1 Interoperability Test Suite

Interoperability Test Suite Specification

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Title	100BASE-T1 Interoperability Test Suite
Version	1.2
Date	December 3, 2024
Status	Final
Restriction Level	Public

100BASE-T1 Interoperability Test Suite. This document aims to be a guide to implement and carry out the necessary procedures to test the grade of interoperability between devices with 100BASE-T1 capabilities.

Content

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2 Introduction

2.1 Overview

The goal of this document is to define a set of tests that on one hand ensure interoperability between multiple devices that use 100BASE-T1 capable PHYs. In particular, this requires each PHY to be able to establish a stable link within a given time limit, to be able to reliably monitor and signal the current link status to an upper layer and to be able to transmit data with an upper bit error rate limit.

Furthermore, on the other hand, this document addresses a set of test cases that verify the reliability of important supported features of an automotive Ethernet PHY (often also called transceiver), e.g. for diagnostic purposes for automotive Ethernet PHY's. In particular, signal quality index (SQI) and harness defects detection.

Finally this test specification defines a set of tests that ensure the wake-up/sleep interoperability between IEEE802.3bw (100BASE_T1) PHYs and Switches.

Note: The tests do not solely cover the respective PHYs/Switches, but also takes into account PHY/Switches configuration and an external filter, if applicable. The results of the Interoperability Test Suite will not only depend of the PHY/switches, but also from the general configuration of Implementation Under Test, the Link Partner, the chokes and the communication channel conditions.

2.2 Normative References

[1] IEEE P802.3bw™ Physical Layer Specifications and Management Parameters for 100 Mb/s Operation over a Single Balanced Twisted Pair Cable (100BASE-T1)

[2] IEEE P802.3bp™: Physical Layer Specifications and Management Parameters for 1 Gb/s Operation over a Single Twisted Pair Copper Cable

[3] IEEE P802.3-2015 IEEE Standard for Ethernet

[4] OPEN ALLIANCE: 100BASE-T1 PHY Control Test Suite – Revision 1.0

[5] OPEN ALLIANCE: 100BASE-T1 Physical Media Attachment Test Suite – Revision 1.0

[6] OPEN ALLIANCE: 100BASE-T1 Physical Coding Sublayer Test Suite – Revision 1.1

[7] OPEN ALLIANCE: 100BASE-T1 EMC Test Specification for Transceivers – Revision 2.0

[8] OPEN ALLIANCE: 100BASE-T1 EMC Test Specification for Common Mode Chokes – Revision 2.0

[9] OPEN ALLIANCE: 100BASE-T1 Definitions for Communication Channel – Revision 1.0

[10] OPEN ALLIANCE: 100BASE-T1 system implementation specification – Revision 1.0

[11] OPEN ALLIANCE: Advanced diagnostic features for 100BASE-T1 automotive Ethernet PHYs – Revision 1.0

[12] OPEN ALLIANCE: Automotive Ethernet ECU Test Specification– Revision 3.0

[13] OPEN ALLIANCE: 100BASE-T1 EMC Test Specification for ESD suppression devices – Revision 2.0

[14] OPEN ALLIANCE: Sleep/Wake-up Specification for Automotive Ethernet – Revision 2.0

2.3 Abbreviations and definitions

ID: 100BASET1_L1_IOP_1

Type: Information

Abbreviation	Glossary term	Glossary definition
CRC	Cyclic Redundancy Check	
ISO/OSI		Layer model of communication systems
MAC	Media Access Control	Abbreviation for the sub layer of the data link layer (layer 2) of the OSI model or for the physical device that implements the Media Access Control functions.
MDI	Media dependent interface	
PHY	Physical Layer	Abbreviation for the physical layer (layer 1) of the OSI model or for the device that implements layer 1 of the OSI model.
100BASE-T1	Open Alliance 100BASE-T1	
DUT	Device under test	Combination of uC, PHY/Switch component, PHY/Switch configuration and filter that is being tested.
LP	Link partner	cf. list of definitions (100BASET1_L1_IOP_2).
ETH_N		Negative MDI pin or cable connected to a PHY's negative MDI pin.
ETH_P		Positive MDI pin or cable connected to a PHY's positive MDI pin.
SQI	Signal quality indicator	The PHY's estimated signal quality of the channel or a comparable value from which a quality indicator for the communication channel can be derived. The SQI value shall be stored in a register. In general it should be composed by 8 levels (between "000" = worst value and "111" = 7 = best value).
CIDM	Characteristic Impedance Differential mode	
IL	Insertion Loss	
RL	Return Loss	

Abbreviation	Glossary term	Glossary definition
S-Parameter	Scattering Parameter	
TDR	Time domain reflection	
SCC	Standalone Communication Channel	
WUR	Wake-up Request	The Wake-Up Request (WUR) is a command to indicate a wake-up request to the link partner. It can be sent by a node PHY or switch PHY to distribute the wake-up request over a link, which is already active. The WUR is unique as it may be recognized independently of other defined command like loc_rcvr_status as specified in IEEE802.3bw. The WUR is encoded in the scrambler stream as defined in section 7.3 of [14]. The WUR command must be send for a minimum of 64 bits. The detection of a WUR command is left to the implementer.
WUP	Wake-up Pulse	The Wake-up pulses (WUP) indicate a wake-up request to the link partner. WUP are link training codes transmitted on the network by a node in tx_mode=SEND_I or switch PHY to distribute the wake-up request over a link, which is down. The activity on the twisted-pair lines will be detected by the partner PHY as a remote wake-up. The wake-up pulse has a minimum duration of 1ms (+/-0.3ms) to allow reliable detection. The energy detection of a WUP command is left to the implementer.
LPS	Low Power Sleep	The Low Power Sleep (LPS) is a command to indicate a sleep request to the link partner. It is sent by a node requesting a transition to SLEEP, while the link is up. The LPS is encoded in the scrambler stream as defined in section 7.3 of [14]. The LPS command must be send for a minimum of 64 bits. The detection of a LPS command is left to the implementer.
INH	Inhibit	The high level Inhibit variable describes the state of the inhibit pin.

Table 1: List of Abbreviations.

ID: 100BASET1_L1_IOP_2

Type: Information

Glossary term	Glossary definition
MAY	This word or the adjective "OPTIONAL", mean that an item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because the vendor feels that it enhances the product while another vendor may omit the same item. An implementation which does not include a particular option MUST be prepared to interoperate with another implementation which does include the option, though perhaps with reduced functionality. In the same way an implementation which does include a particular option MUST be prepared to interoperate with another implementation which does not include the option (except, of course, for the feature the option provides.)
MUST	This word, or the terms "REQUIRED" or "SHALL", mean that the definition is an absolute requirement of the specification.
MUST NOT	This phrase or the phrase "SHALL NOT", mean that the definition is an absolute prohibition of the specification.
SHOULD	This word, or the adjective "RECOMMENDED", mean that there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course.
SHOULD NOT	This phrase, or the phrase "NOT RECOMMENDED" mean that there may exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
Link status	The link state that is indicated via a PHY's status registers. The link state can be a combination of various PHY status bits.
Link partner	Device that is connected to a Device under Test to perform the interoperability tests. A link partner must use a well-known PHY, PHY configuration and external PHY filter (if necessary).
External PHY filter or external filter.	Additional circuit that is connected directly to the PHY and filters the in- and outgoing physical layer signaling. The PHY vendor typically provides a reference filter design.
PHY configuration	Variable settings that affect the PHY's behavior (e.g., sensitivity of internal equalizers, or shaping of outgoing physical layer signaling). The PHY configuration could be set by an upper layer

Glossary term	Glossary definition
	(e.g., by software) or could be hardcoded, e.g., via dedicated PHY configuration pins.
Test case	Description of one or more test steps and a set of conditions that define whether the observed behavior when executing the test steps matches the expected results.
Test iteration	The execution of all test steps of a given test case.
Test instance	A test instance defines different test parameters for a given test case, such as the DUT's PHY MASTER/SLAVE configuration, or used cable to connect the link partner. The test case itself is not altered.
Soft reset	Reset of a PHY by software, usually triggered by writing to a control register.
Hard reset	Reset of a PHY via a dedicated reset-pin, or by toggling the PHYs power supply.
Channel	Synonym for physical layer communication channel (cf. [4]).
Passive link	Connection between 100BASE-T1 devices without established link-up condition.
Active link	Connection between 100BASE-T1 devices with established link-up condition.

Table 2: List of Definitions.

2.4 Organization of Tests

In this chapter the main structure of the test cases as well as the elementary test cases structure will be introduced.

2.4.1 Elementary test structure

The main structure description of a test case is shown in Table 3. A brief description about the meaning of each field is provided.

Synopsis	A short description of the purpose of the test case is given here.
Prerequisites	A list of requirements and capabilities needed for a proper tests conduction
Test Setup	The respective test environment setup is specified (e. g. if different test case sequences will require different test system configuration)
Test procedure	The first note here describes the total sum of test case executions due to setup variations to give the test implementer a first impression of the specific test case. As the second part of the test case execution, the test steps are described dealing with the setup being applied and what is observed and measured at each execution etc. All actions of the test environment shall be described explicitly in this item.
Pass criteria	In this response cell, a description is given about what is expected as the result. The Pass criteria are also specified in this point.
Test iterations	Amount of test repetitions. See Appendix - 7.1 Suggested Iterations
Notes	When necessary a note will be added complementing the information of the test case.

Table 3 - Main test structure

2.4.2 Test case instances structure

Together with the test definition and all its parameters, the test case instances will also be defined that are part of each test case.

A test case instance can be defined as a repetition of the same test case modifying certain configurations of the DUT and the test environment without losing focus on the test purpose.

Instance Test Case #		Parameter 1	Parameter 2	Parameter 3	…	Parameter N
	Parameter A	<LABEL>_IOP_X			…	
	Parameter B		<LABEL>_IOP_Y		…	
…	**…**	…	…	…	…	…
	Parameter Z			<LABEL>_IOP_Z	…	

Table 4 - Test case instances definition

An example definition of a test case is shown in Table 5. In this case, first the behavior of the DUT will be tested when acting as a MASTER with the conditions established by the corresponding test case. Next, the test will be performed with the DUT acting as a SLAVE.

Instance Test Case #	DUT / LP configuration	LP as SLAVE	LP as MASTER
X.X.X.#	**DUT as MASTER**	100BASET1_L1_IOP_XX_SR_M_S	
X.X.X.#	**DUT as SLAVE**		100BASET1_L1_IOP_XX_SR_S_M

Table 5 - Example of test case instances

3 Layer 1 Interoperability

3.1 General Requirements

ID: 100BASET1_L1_IOP_3

Type: Information

A Device under Test (DUT) shall be defined by the used PHY/Switch (identified by its manufacturer, model and revision number), the used external filter (if required by the PHY/Switch vendor) and used PHY/Switch configuration.

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ID: 100BASET1_L1_IOP_4

Type: Requirement

The PCB layout of the DUT shall adhere to PHY vendor's reference design. In particular, this includes schematic and specific parts installed, power supply, power decoupling and interface between the PHY and microcontroller.

ID: 100BASET1_L1_IOP_5

Type: Requirement

The DUT configuration and software interface used for the IOP tests shall adhere to the specification of the DUT vendor. This requires the DUT vendor to define which registers shall be used, e.g., to evaluate the DUT's link status, to enter in SLEEP mode, to send wake-up requests or to detect the wake-up source.

ID: 100BASET1_L1_IOP_6

Type: Requirement

All monitoring activities (e.g. register readout for active link, wake-up and sleep) shall be done by an interrupt or periodic polling. To ensure to get valid results, the polling period has to be chosen according to the timing requirements of the test case (e.g., much lower than the timing requirement).

ID: 100BASET1_L1_IOP_7

Type: Requirement

For all Layer 1 Interoperability test cases defined in chapter 4 and 6, the DUT shall be tested against a defined set of link partners, unless explicitly defined otherwise in the test case description. A link partner is defined by the same requirements that apply to the DUT. If multiple qualified link partners are available, the test against multiple link partners is mandatory.

ID: 100BASET1_L1_IOP_8

Type: Requirement

For all PHY feature set tests defined in chapter 5, the DUT must be tested against a known link partner. The link partner is defined by the same requirements that apply to the DUT. The link partner configuration must be included in the test results. Tests against additional link partners are optional.

ID: 100BASET1_L1_IOP_9

Type: Requirement

For each test case, the test results shall be documented individually for each combination of DUT and link partner, for each variation point and for each test instance.

ID: 100BASET1_L1_IOP_10

Type: Information

The tests do not necessarily aim at qualifying a single DUT, but the combination of DUT and link partner. This also means that if a test fails, not the DUT's PHY, but the combination of DUT and link partner is faulty. Other DUT/link partner combinations might be free from defects and may qualify.

ID: 100BASET1_L1_IOP_11

Type: Requirement

A link-up condition is defined in terms of the following bits:

- Scrambler Locked (SL);
- Local receiver status (LRS);
- Remote receiver status (RRS);
- Link status bit (LS)

And the PHY status

- PHY_Status (SEND IDLE OR DATA) - PCS Status of IEEE 802.3 Fig 96-18

Link-up-> (SL==1 AND LRS==1 AND RRS==1 AND LS==1) AND PHY_Status == SEND IDLE OR DATA

ID: 100BASET1_L1_IOP_12

Type: Requirement

A link-down condition is defined in terms of the following bits:

- Scrambler Locked (SL);
- Local receiver status (LRS);
- Remote receiver status (RRS);
- Link status bit (LS)

Link-down-> (SL==0 or LRS==0 or RRS==0 or LS==0)

ID: 100BASET1_L1_IOP_13

Type: Requirement

A wake-up condition could be verified by using the service primitive Wake-up.indication.

ID: 100BASET1_L1_IOP_14

Type: Requirement

A sleep condition could be verified by the following two options:

- The INH pin changes its status from one (1) to zero (0).
- Polling the PHYs identification register or any other well known register until its value is no longer available.

3.2 Test coverage / variation points

ID: 100BASET1_L1_IOP_15

Type: Requirement

The tests shall be performed with a “Channel Type 1” and with a “Channel Type 2” as set forth in section 9 of [10]..

ID: 100BASET1_L1_IOP_16

Type: Requirement

The tests shall be performed at an ambient temperature of - 40°C, at room temperature and at an ambient temperature of either + 105° C or + 125° C, according to the maximum ambient operating temperature specified in the DUT datasheet.

ID: 100BASET1_L1_IOP_17

Type: Requirement

A test instance of a test case shall be considered as passed, if no test iteration failed. The number of suggested test iterations is defined in chapter 7.1 .

3.3 Channels definition

This definition shall be used for defining a test wiring harness that simulates various communication channels according to the channel definitions of IEEE Std. 802.3bw [1] for interoperability tests of 100Base-T1 transceivers.

3.3.1 Channel Type 1

ID: 100BASET1_L1_IOP_18

Type: Requirement

The parameters of the type 1 channel are derived from the limit definition for a communication channel according to. the channel definitions of[1] and [10].

For setting up a real test harness upper and lower limits are added for each parameter. The type 1 channel implementation shall fulfill these limits at (23±2)°C ambient temperature (RT).

All parameters are defined in Section 9.2 of [10].

3.3.1 Channel Type 2

ID: 100BASET1_L1_IOP_19

Type: Requirement

The Type 2 channel is derived from a 5m link segment scaled from the type 1 cable.

All parameters are defined in Section 9.3 of [10].

3.3.2 Channel Type 3

ID: 100BASET1_L1_IOP_20

Type: Requirement

The Type 3 channel is derived from a 1.5m link segment scaled from the type 1 cable.

All parameters are defined in Section 9.4 of [10].

3.4 Artificial degradation of channel quality

ID: 100BASET1_L1_IOP_21

Type: Requirement

In order to artificially reduce the quality of the communication channel a differential directional coupler shall be inserted between the DUT and the LP introducing differential bandlimited level adjustable Gaussian noise into DUT direction.

On section 7.2 an example for practical implementation can be found.

3.5 Multiple Link Partners

This section describes a concept to adopt multiple link partners, increasing the coverage in terms of diversity of interoperability in the ecosystem without necessarily increasing the test periods and efforts.

ID: 100BASET1_L1_IOP_22

Type: Requirement

Each device having passed the tests listed below could be considered as potential link partner candidate

a) Conformance Tests
   1. OA- PHY Control Test Suite
   2. OA- Physical Media Attachment Test Suite
   3. OA- Physical Coding Sub-layer Test Suite

b) Interoperability Tests
   1. OA- Interoperability Test Suite - At least all test cases in groups #1 and # 2; disregarding the *PHY features set tests* chapter (SQI + Diagnostic)

ID: 100BASET1_L1_IOP_23

Type: Requirement

The respective silicon vendors should provide enough samples to be placed in the test system as link partners

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ID: 100BASET1_L1_IOP_24

Type: Requirement

"Link-up for starting communication" .
Communication_Link-up_DUT -> (SL_DUT==1 AND LRS_DUT==1 AND RRS_DUT==1 AND LS_DUT==1)

Following information will be logged during the test execution with a resolution of up to 1ms between each signal change:

- *Link-up*
- *scr_status*
- *loc_rcvr_status*
- *rem_rcvr_status*
- *PCS Status of IEEE 802.3 (Fig 40-16a)*

This information shall be available with no restrictions from LP and DUT side in order to provide additional information when a failure is observed.

ID: 100BASET1_L1_IOP_25

Type: Requirement

The respective silicon vendors must commit to provide support if interoperability issues are identified and the root cause is unclear for their part to be considered as a link partner for this testing.

ID: 100BASET1_L1_IOP_26

Type: Requirement

A matrix with all LP combination shall be added at the beginning of the report document with a Pass / Fail for each combinations.

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4 Test Cases

ID: 100BASET1_L1_IOP_27

Type: Requirement

The test cases defined in this section are mandatory for all 100BASE-T1 PHYs.

4.1 Group 1, Link status

ID: 100BASET1_L1_IOP_28

Type: Information

The test cases defined in this section shall ensure that the PHY signals the correct link state to upper layers. In particular, a PHY must not signal an active link when no data can be transmitted.

4.1.1 Reliability of indicated link status directly after link-up / PHY reset

ID: 100BASET1_IOP_16

Type: Requirement

Synopsis	Shall ensure that the data can be transmitted as soon as the PHY signals an active link.
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT is able to indicate a link-up condition via its status registers within 0.5ms after having detected an active link. 3. DUT must be able to send frames, for that a xMII interface must be available on the DUT: a. if *Comm_ready* is supported (see [11]) within 1ms after *comm ready status* is met, otherwise b. within 2ms after detecting a link-up and is able to send a new frame each 1ms. This includes any processing time by the DUT's application software and networking stack. 4. DUT and link partner must be able to detect any lost frames by the networking stack or by the application. 5. The test system must be able to monitor the link status of the DUT and LP during the test iterations. 6. Link partner, or device that is connected to the link partner, must be able to receive all frames sent by the DUT.
Test Setup	DUT must be connected to an active link partner with opposite MASTER/SLAVE configuration. Depending on the test instance, the link partner is either connected with correct, or with swapped polarity (i.e., DUT ETH_N ⇔ LP ETH_P and DUT ETH_P⇔ LP ETH_N).
Test procedure	1. Link partner shall be active and ready to receive frames. 2. DUT shall soft reset and reconfigure its PHY. 3. If required by PHY vendor: DUT must wait until PHY has accepted MASTER/SLAVE configuration. 4. The DUT's PHY configuration must be finished within 20ms after reset.

	5. DUT shall set an internal *counter* variable to 0. 6. DUT shall wait until the PHY indicates an active link (e.g., by polling the link state or by using an interrupt). 7. DUT shall send out a frame with the current counter value 2ms after link-up. Or, if implemented, right after Communication_ ready (Comm_ready) status switches from NOT_OK to OK status. 8. Every subsequent 1ms, the DUT shall increment its counter variable and send out a frame with the new counter. 9. Repeat step 8 until the link partner receives the first frame by the DUT or the link goes down. 10. The link partner must store the *counter* value of the first received frame.
Pass criteria	If any frames have been lost or discarded above layer 1 (e.g., in the receive/send buffer of the link partner or if the MAC has discarded a frame because of a CRC error), the result of the test iteration must be ignored. Each test iteration shall be classified as passed, if all of the following condition(s) are fulfilled : o Link partner receives the first frame sent by DUT (*counter* == 0). o Link does not go down after test step 5, i.e., link stayed active for the whole iteration.
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	Test instance 100BASET1_ IOP_16_SR_S_M_P is only applicable if the DUT's PHY supports automatic polarity detection when configured as SLAVE.

Table 6: Main test structure of 100BASET1_IOP_16

Instance Test Case #	DUT / LP configuration	LP as SLAVE	LP as MASTER	LP is MASTER, LP connected with swapped polarity of ETH_N and ETH_P
4.1.1.1	**DUT as SLAVE**		100BASET1_IOP_16 _SR_S_M	
4.1.1.2	**DUT as SLAVE**			100BASET1_IOP_16 _SR_S_M_P
4.1.1.3	**DUT as MASTER**	100BASET1_IOP_16 _SR_M_S		

Table 7: Test case instances of 100BASET1_IOP_16

4.1.2 Reliability of indicated link status when connected to link partner with same MASTER/SLAVE configuration

ID: 100BASET1_IOP_17

Type: Requirement

Synopsis	Shall ensure that the PHY does not signal an active link when connected to a link partner with equal MASTER/SLAVE configuration.
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT is able to detect a link-up
Test Setup	DUT must be connected to an active link partner with equal MASTER/SLAVE configuration.
Test procedure	1. Link partner shall be active. 2. DUT shall soft reset and reconfigure its PHY. 3. If required by PHY vendor: DUT must wait until its PHY has accepted MASTER/SLAVE configuration. 4. The DUT's PHY configuration must be finished within 20ms after reset. 5. DUT shall monitor the link status condition for at least 750ms.
Pass criteria	Each test iteration shall be classified as passed, if all of the following condition(s) are fulfilled: ○ DUT does not detect any link-up condition.
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	-

Table 8: Main test structure of 100BASET1_IOP_17

Instance Test Case #	DUT / LP configuration	LP as SLAVE	LP as MASTER
4.1.2.1	**DUT as SLAVE**	100BASET1_ IOP_17 _SR_S_S	
4.1.2.2	**DUT as MASTER**		100BASET1_ IOP_17 _SR_M_M

Table 9: Test case instances of 100BASET1_IOP_17

4.1.3 Reliability of indicated link status when connected to link partner with swapped polarity for PHYs without automatic polarity correction

ID: 100BASET1_IOP_18

Type: Requirement

Synopsis	Shall ensure that the PHY does not signal an active link when connected to a link partner with swapped polarity (i.e., DUT ETH_N ⇔ LP ETH_P and DUT ETH_P ⇔ LP ETH_N). This test is only applicable for PHYs without automatic polarity correction. The test must not be performed for PHYs with automatic polarity correction or for combinations where the LP's PHY supports automatic polarity correction.
Prerequisites	1. DUT's PHY has no automatic polarity correction. 2. DUT with the capability to reset and configure its PHY. 3. DUT is able to detect a link-up.
Test Setup	DUT must be connected to an active link partner with opposite MASTER/SLAVE configuration.
Test procedure	1. Swap polarity of bus lines (i.e., DUT ETH_N ⇔ LP ETH_P and DUT ETH_P ⇔ LP ETH_N). 2. Link partner shall be active. 3. DUT shall soft reset and reconfigure its PHY. 4. If required by PHY vendor: DUT must wait until its PHY has accepted MASTER/SLAVE configuration. 5. The DUT's PHY configuration must be finished within 20ms after reset. 6. DUT shall monitor the link status condition for at least 750ms.
Pass criteria	Each test iteration shall be classified as passed, if all of the following condition(s) are fulfilled. ○ DUT does not detect any link-up condition. ○ DUT shall indicate the swapped polarity detection via its registers
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	-

Table 10: Main test structure if 100BASET1_IOP_18

Instance Test Case #	DUT / LP configuration	LP as SLAVE	LP as MASTER
4.1.3.1	**DUT as SLAVE**		100BASET1_ IOP_18 _SR_S_M_P
4.1.3.2	**DUT as MASTER**	100BASET1_ IOP_18 _SR_M_S_P	

Table 11: Test case instances of 100BASET1_IOP_18

4.1.4 Revoke of link status after link-down

ID: 100BASET1_IOP_19

Type: Requirement

Synopsis	Shall ensure that the PHY does detect and signal a link-down within a given time limit after the link has been interrupted, e.g., by a reset or power-down of the link partner. The DUT must be tested against at least one known link partner. A test against a complete set of link partners is optional. The link partner configuration must be included in the test results.
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT must be able to read the current link status.
Test Setup	DUT must be connected to an active link partner with opposite MASTER/SLAVE configuration.
Test procedure	1. Link partner shall be active. 2. DUT shall soft reset and reconfigure its PHY. 3. If required by PHY vendor: DUT must wait until its PHY has accepted MASTER/SLAVE configuration. 4. The DUT's PHY configuration must be finished within 20ms after reset. 5. Wait until the DUT's PHY signals an active link. 6. Apply in the link partner a permanent hard reset condition and start timer t0. 7. Wait until the DUT's PHY indicated link status changes from link-up to link-down and stop timer t0.
Pass criteria	Each test iteration shall be classified as passed, if all of the following condition(s) are fulfilled. o DUT detected the link-down within 5ms after applying a permanent hard reset condition in the link partner. (t0 <= 5ms).
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	-

Table 12: Main test structure of 100BASET1_IOP_19

Instance Test Case #	DUT / LP configuration	LP as SLAVE	LP as MASTER
4.1.4.1	**DUT as SLAVE**		100BASET1_ IOP_19 _SR_S_M
4.1.4.2	**DUT as MASTER**	100BASET1_ IOP_19 _SR_M_S	

Table 13: Test case instances of 100BASET1_IOP_19

4.2 Group 2, Link-up

ID: 100BASET1_L1_IOP_29

Type: Information

The test cases defined in this section shall ensure that the PHY is able to establish an active link after reset and reconfiguration of itself, or of the link partner's PHY.

4.2.1 Link-up after PHY-reset

ID: 100BASET1_IOP_21

Type: Requirement

Synopsis	Shall ensure that the PHY is able to establish a link after being reset and reconfigured within a given time limit.
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT is able to indicate a link-up condition via its status registers within 0.5ms after having detected an active link.
Test Setup	DUT is connected to an active link partner with opposite MASTER/SLAVE configuration. Depending on the test instance, the link partner is either connected with correct, or with swapped polarity (i.e., DUT ETH_N ⇔ LP ETH_P and DUT ETH_P ⇔ LP ETH_N).
Test procedure	1. DUT shall soft-/hard reset and reconfigure its PHY. 2. The DUT's PHY configuration must be finished within 20ms after reset. 3. After finished configuration, the DUT shall start timer t0. 4. DUT shall wait until the PHY indicates an active link and stop timer t0. 5. If [LQ.LTT] register, as defined in [11], is supported, once PHY indicates an active link read the Linkup Total Time from [LQ.LTT] register; (lcl_rcv AND rem_rcv). 6. DUT shall monitor whether the link status remains active for at least 750ms after initial link-up.
Pass criteria	Each test iteration shall be classified as passed, if all of the following condition(s) are fulfilled. ○ DUT's PHY achieved link-up within 100ms after finished configuration (t0 <= 100ms). ○ Link did not go down after test step 4.
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	Test instances 100BASET1_IOP_21_SR_S_M_P and 100BASET1_IOP_21_HR_S_M_P are only applicable if the DUT's PHY supports automatic polarity detection when configured as SLAVE.

Table 14: Main test structure of 100BASET1_IOP_21

Instance Test Case #	DUT / LP configuration	LP as SLAVE	LP as MASTER	LP is MASTER, LP connected with swapped polarity of ETH_N and ETH_P
4.2.1.1	**DUT is SLAVE; PHY is soft reset**		100BASET1_ IOP_21 _SR_S_M	
4.2.1.2	**DUT is SLAVE; PHY is soft reset**			100BASET1_ IOP_21 _SR_S_M_P
4.2.1.3	**DUT is MASTER PHY is soft reset**	100BASET1_ IOP_21 _SR_M_S		
4.2.1.4	**DUT is SLAVE; PHY is hard reset**		100BASET1_ IOP_21 _HR_S_M	
4.2.1.5	**DUT is SLAVE; PHY is hard reset**			100BASET1_ IOP_21 _HR_S_M_P
4.2.1.6	**DUT is MASTER PHY is hard reset**	100BASET1_ IOP_21 _HR_M_S		

Table 15: Test case instances of 100BASET1_IOP_21

4.2.2 Link-up after reset of link partner

ID: 100BASET1_L1_IOP_22

Type: Requirement

Synopsis	Shall ensure that the PHY is able to establish a link after the link partner's PHY has been reset and reconfigured within a given time limit.
Prerequisites	1. Link partner with the capability to reset and configure its PHY. 2. DUT must be able to trigger the PHY reset of the link partner, or must be able to detect the time of the LP's PHY reset. 3. DUT must be able to detect a link-up within 0.5ms after the PHY indicates an active link via its status registers.
Test Setup	DUT must be connected to an active link partner with opposite MASTER/SLAVE configuration.
Test procedure	1. DUT shall soft-/hard reset and reconfigure its PHY. 2. DUT shall trigger a soft-/hard reset of the link partner's PHY or wait until the link partner has reset its PHY. 3. DUT shall start timer t0 directly after the reset of the LP's PHY. 4. The link partner must configure its PHY within 20ms after the reset. 5. DUT must ignore any indicated active links within 25ms after the reset. 6. 25ms after LP's reset: DUT shall wait until the PHY indicates an active link and stop timer t0. The lowest possible indicated link-up time can be 25ms, even if the actual link-up was established quicker. 7. DUT shall monitor whether the link status remains active for at least 750ms after initial link-up.
Pass criteria	Each test iteration shall be classified as passed, if all of the following condition(s) are fulfilled. ○ DUT's PHY reported link-up within 120ms after reset of the LP's PHY (t0 <= 120ms). ○ Link did not go down after test step 5.
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	Test instances IOP_22_SR_S_M_P and IOP_22_HR_S_M_P are only applicable if the DUT's PHY supports automatic polarity detection when configured as SLAVE.

Table 16: Main test structure of 100BASET1_IOP_22

Instance Test Case #	DUT / LP configuration	LP is SLAVE; PHY is soft reset	LP is MASTER; PHY is soft reset	LP is SLAVE; PHY is hard reset	LP is MASTER; PHY is hard reset
4.2.2.1	**DUT is SLAVE**		100BASET1_ IOP_22 _SR_S_M		
4.2.2.2	**DUT is SLAVE**				100BASET1_ IOP_22 _HR_S_M
4.2.2.3	**DUT is SLAVE, LP connected with swapped polarity of ETH_N and ETH_P**		100BASET1_ IOP_22 _SR_S_M_P		
4.2.2.4	**DUT is SLAVE, LP connected with swapped polarity of ETH_N and ETH_P**				100BASET1_ IOP_22 _HR_S_M_P
4.2.2.5	**DUT is MASTER**	100BASET1_ IOP_22 _SR_M_S			
4.2.2.6	**DUT is MASTER**			100BASET1_ IOP_22 _HR_M_S	

Table 17: Test case instances of 100BASET1_IOP_22

5 100BASE-T1 PHY features set tests

ID: 100BASET1_L1_IOP_30

Type: Information

The test cases defined in this chapter shall ensure that optional PHY features, such as an estimation of the channel quality or cable diagnostics, provide expected and comparable results under known test conditions. If a PHY supports a given feature, the associated test cases are mandatory. Else, the test case shall be ignored.

5.1 Group 3, Signal Quality

ID: 100BASET1_L1_IOP_31

Type: Information

The tests in this section are only applicable for 100BASE-T1 PHYs that support an estimation of the signal quality of the communication channel. The signal quality can either be read directly from a PHY register, or may be derived based on one or more PHY register values.

5.1.1 Indicated signal quality for channel with decreasing quality

ID: 100BASET1_IOP_24a

Type: Requirement

Synopsis	Shall ensure that the PHY's indicated signal quality decreases for a channel with decreasing channel quality.
Prerequisites	1. Test system that allows varying and determining the quality of the communication channel that connects the DUT and LP. 2. DUT must be able to monitor the signal quality indicated by the PHY.
Test Setup	DUT must be connected to an active link partner with opposite MASTER/SLAVE configuration. Test setup shall be able to apply artificial noise to communication channel.
Test procedure	1. Remove any artificial channel degradation, to ensure that the highest possible signal quality is reached on both the DUT and LP. 2. DUT shall soft reset and reconfigure its PHY. 3. Measure the PHY's SQI value for at least 100 times. Determine and store the minimum and maximum read values. 4. Increase artificial noise level by one step, i.e. by 100mV Gaussian noise generator amplitude. 5. Repeat steps 3 and 4 until ten additional noise levels after the PHY can no longer establish a link. 6. Draw minimum and maximum curves with the values obtained in each artificial noise step

Pass criteria	Each test iteration shall be classified as passed, if all of the following condition(s) are fulfilled. ○ SQI values ○ Steadily and monotonic decreased by one step each ○ SQI values are only valid if link-up condition is present ○ Link status ○ Link-up status remains for SQI values higher than 0 ○ No link instabilities with intermittently link drops should be observed between SQI values higher than 0.
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	To guarantee comparability of the results, a graphic disclosing SQI value (y-axis) vs. associated noise level on the network *[Vpp]* (x axis) shall be given in the test report for each test iteration. The noise level seen by the DUT is relevant; this means the noise source level divided by the coupling factor of the differential directional coupler.

Table 18: Main test structure of 100BASET1_IOP_24a

Instance Test Case #	DUT / LP configuration	LP is SLAVE; PHY is soft reset	LP is MASTER; PHY is soft reset
5.1.1.1	DUT is SLAVE		100BASET1_ IOP_24a _SR_S_M
5.1.1.2	DUT is MASTER	100BASET1_ IOP_24a _SR_M_S	

Table 19: Test case instances of 100BASET1_IOP_24a

5.1.2 Indicated signal quality for channel with increasing quality

ID: 100BASET1_IOP_24b

Type: Requirement

Synopsis	Shall ensure that the PHY's indicated signal quality increases for a channel with increasing channel quality.
Prerequisites	1. Test system that allows varying and determining the quality of the communication channel that connects the DUT and LP. 2. DUT must be able to monitor the signal quality indicated by the PHY.
Test Setup	DUT must be connected to an active link partner with opposite MASTER/SLAVE configuration. Test setup shall be able to apply artificial noise to communication channel.
Test procedure	1. Start with the highest artificial noise channel degradation The DUT's PHY can no longer establish a link. 2. DUT shall soft reset and reconfigure its PHY. 3. Decrease artificial noise level until link can be established. 4. Measure the PHY's SQI value for at least 100 times. Determine and store the minimum and maximum read values. 5. Decrease artificial noise by one step, i.e. by 100mV Gaussian noise generator amplitude. 6. Repeat steps 4 and 5 until no artificial noise is applied. 7. Draw minimum and maximum curves with the values obtained in each artificial noise step.
Pass criteria	Each test iteration shall be classified as passed, if all of the following condition(s) are fulfilled. ○ SQI values ○ Steadily and monotonic increased by one step each ○ SQI values are only valid if link-up condition is present ○ Link Status ○ Link-up status remains for SQI values higher than 0 ○ No link instabilities with intermittently link drops should be observed between SQI values higher than 0.
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	To guarantee comparability of the results, a graphic disclosing SQI value (y-axis) vs. associated noise level on the network *[Vpp]* (x axis) shall be given in the test report for each test iteration. The noise level seen by the DUT is relevant; this means the noise source level divided by the coupling factor of the differential directional coupler.

Table 20: Main test structure of 100BASET1_IOP_24b

Instance Test Case #	DUT / LP configuration	LP is SLAVE	LP is MASTER
5.1.2.1	DUT is SLAVE		100BASET1_ IOP_24b _SR_S_M
5.1.2.2	DUT is MASTER	100BASET1_ IOP_24b _SR_M_S	

Table 21: Test case instances of 100BASET1_IOP_24b

5.2 Group 4, Cable Diagnosis

5.2.1 Cable diagnostics for error-free channel

ID: 100BASET1_IOP_31

Type: Requirement

Synopsis	Shall ensure that the PHY's cable diagnostic does not indicate a short or open for an error-free channel.
Prerequisites	1. DUT must be able to trigger the PHY's cable diagnostic feature. 2. The link partner shall terminate the channel properly. The link partner should not be transmitting any signal (typically "SEND_Z" or as SLAVE).
Test Setup	DUT is connected to a properly terminated link partner.
Test procedure	1. DUT shall soft reset and reconfigure its PHY.. 2. DUT shall start cable diagnostic of its PHY. 3. DUT shall wait until the PHY finished cable diagnostics. 4. DUT shall read out the indicated result.
Pass criteria	Each test iteration shall be classified as passed, if all of the following condition(s) are fulfilled. ○ Cable diagnostic reported no errors (i.e., no short / open of the bus lines).
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	-

Table 22: Main test structure of 100BASET1_IOP_31

Instance Test Case #	-
5.2.1.1	100BASET1_IOP_31_SR

Table 23: Main test structures of 100BASET1_IOP_31

5.2.2 Cable diagnostics for near and far end open

ID: 100BASET1_IOP_32

Type: Requirement

Synopsis	Shall ensure that the PHY'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 DUT, and for a far end open at the connector of the LP.
Prerequisites	1. DUT must be able to trigger the PHY's cable diagnostic feature. 2. The link partner shall terminate the channel properly. The link partner should not be transmitting any signal (typically "SEND_Z" or as SLAVE)
Test Setup	DUT is connected to a properly terminated link partner. One or both of the bus wires have a near or far end open.
Test procedure	1. DUT shall soft reset and reconfigure its PHY. 2. DUT shall start cable diagnostic of its PHY. 3. DUT shall wait until the PHY finished cable diagnostics. 4. DUT shall read out the indicated result.
Pass criteria	Each test iteration shall be classified as passed, if all of the following condition(s) are fulfilled. ○ Cable diagnostic reported an open of the bus line(s).
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	For a near end open, one or both bus lines shall be disconnected directly at the connector of the DUT. For a far end open, one or both bus lines shall be disconnected directly at the connector of the LP.

Table 24: Main test structure of 100BASET1_IOP_32

Instance Test Case #	DUT / LP configuration	Test setup	Open is on ETH_N or ETH_P	Open on both ETH_N and ETH_P
5.2.2.1	DUT is SLAVE	**Near-end open (on connector of DUT).**	100BASET1_ IOP_32 _SR_O1_NEAR_S_M	
5.2.2.2	DUT is SLAVE	**Near-end open (on connector of DUT).**		100BASET1_ IOP_32 _SR_O2_NEAR_S_M
5.2.2.3	DUT is SLAVE	**Far-end open (on connector of LP).**	100BASET1_ IOP_32 _SR_O1_FAR_S_M	
5.2.2.4	DUT is SLAVE	**Far-end open (on connector of LP).**		100BASET1_ IOP_32 _SR_O2_FAR_S_M
5.2.2.5	DUT is MASTER	**Near-end open (on connector of DUT).**	100BASET1_ IOP_32 _SR_O1_NEAR_M_S	
5.2.2.6	DUT is MASTER	**Near-end open (on connector of DUT).**		100BASET1_ IOP_32 _SR_O2_NEAR_M_S
5.2.2.7	DUT is MASTER	**Far-end open (on connector of LP).**	100BASET1_ IOP_32 _SR_O1_FAR_M_S	
5.2.2.8	DUT is MASTER	**Far-end open (on connector of LP).**		100BASET1_ IOP_32 _SR_O2_FAR_M_S

Table 25: Test case instances of 100BASET1_IOP_32

5.2.3 Cable diagnostics for near and far end short

ID: 100BASET1_IOP_33

Type: Requirement

Synopsis	Shall ensure that the PHY's cable diagnostic reliably detects a short of the bus lines. The test shall be performed for both a near end short at the connector of the DUT, and for a far end short at the connector of the LP.
Prerequisites	1. DUT must be able to trigger the PHY's cable diagnostic feature. 2. The link partner shall terminate the channel properly. The link partner should not be transmitting any signal (typically "SEND_Z" or as SLAVE)
Test Setup	DUT is connected to a properly terminated link partner. The bus wires are connected via a <= 1 Ohm resistor to: • 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 (VBAT) , far and near end.
Test procedure	1. DUT shall soft reset and reconfigure its PHY. 2. DUT shall start cable diagnostic of its PHY. 3. DUT shall wait until the PHY finished cable diagnostics. 4. DUT shall read out the indicated result.
Pass criteria	Each test iteration shall be classified as passed, if all of the following condition(s) are fulfilled. ○ Cable diagnostic reported a short between the bus wires and to ground or supply line.
Test iterations	See suggested test iterations in Appendix – 7.1 Suggested Iterations
Notes	For a near end short, both bus lines and to ground or battery (see respective test instances Table) shall be connected via a <= 1 Ohm resistor directly at the connector of the DUT. For a far end short, both bus lines shall be connected via a <= 1 Ohm resistor directly at the connector of the LP.

Table 26: Main test structure of 100BASET1_IOP_33

Instance Test Case #	DUT / LP configuration	Test setup	
5.2.3.1	DUT is SLAVE	**Near-end short (on connector of DUT).**	100BASET1_ IOP_33 _SR_NEAR_S_M
5.2.3.2	DUT is SLAVE	**Far-end short (on connector of LP).**	100BASET1_ IOP_33 _SR_FAR_S_M
5.2.3.3	DUT is SLAVE	**Near-end short (on connector of DUT).**	100BASET1_ IOP_33 _SR_NEAR_GND_S_M
5.2.3.4	DUT is SLAVE	**Far-end short (on connector of LP).**	100BASET1_ IOP_33 _SR_FAR_GND_S_M
5.2.3.5	DUT is SLAVE	**Near-end short (on connector of DUT).**	100BASET1_ IOP_33 _SR_NEAR_VBAT_S_M
5.2.3.6	DUT is SLAVE	**Far-end short (on connector of LP).**	100BASET1_ IOP_33 _SR_FAR_VBAT_S_M
5.2.3.7	DUT is MASTER	**Near-end short (on connector of DUT).**	100BASET1_ IOP_33 _SR_NEAR_M_S
5.2.3.8	DUT is MASTER	**Far-end short (on connector of LP).**	100BASET1_ IOP_33 _SR_FAR_M_S
5.2.3.9	DUT is MASTER	**Near-end short (on connector of DUT).**	100BASET1_ IOP_33 _SR_NEAR_GND_M_S
5.2.3.10	DUT is MASTER	**Far-end short (on connector of LP).**	100BASET1_ IOP_33 _SR_FAR_GND_M_S
5.2.3.11	DUT is MASTER	**Near-end short (on connector of DUT).**	100BASET1_ IOP_33 _SR_NEAR_VBAT_M_S
5.2.3.12	DUT is MASTER	**Far-end short (on connector of LP).**	100BASET1_ IOP_33 _SR_FAR_VBAT_M_S

Table 27: Test case instances of 100BASET1_IOP_33

6 Wake-up/Sleep

ID: WAKE_IOP_1

Type: Requirement

The test cases defined in this section except WAKE_IOP_8 are mandatory for all 100BASE-T1 devices supporting the wake-up/sleep functionality defined in [14]. WAKE_IOP_8 is mandatory if the PHY supporting wakeup and sleep signaling over dedicated I/O pins.

6.1 Group 5, Wake-up reception and signalizing

ID: WAKE_IOP_2

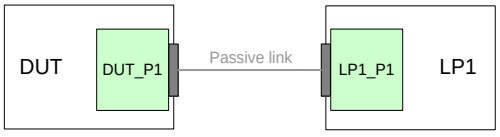
Type: Information

The test cases defined in this section shall ensure that a wake-up (WUP/WUR) can be received and signalized to the upper layer as described in [14].

6.1.1 Reception of a wake-up pulse (WUP)

ID: WAKE_IOP_3

Type: Requirement

Synopsis	Shall ensure that a DUT is able to receive a WUP over a passive link, signalize the wake-up event and upon this to establish a link within an expected time. Parameters to be measured: • *t_wkp_unpwrd*: Time between wake-up request on the LP and DUT wake-up signalization. • *t_wkp_link-up*: Time between DUT wake-up signalization and link-up. • Link stability after a wake-up condition.
Prerequisites	1. DUT with the capability to reset and configure its PHYs. 2. DUT with the capability to set its PHYs into sleep mode. 3. Link partner, or device that is connected to the DUT, shall be able to send a wake-up pulse (WUP). 4. The test system shall be able of providing time measurement capabilities synchronized with the test steps events.
Test Setup	 • DUT shall be connected to a link partner (LP1) with a passive link with opposite MASTER/SLAVE configuration. • DUT shall be in sleep state. • LP1 including LP1_P1 shall be powered and connected to the DUT with a passive link.
Test	1. Reset timer t_0

procedure	2. Trigger a wake-up request on LP1 3. Start timer t_0 4. Wait until the DUT signalizes a wake-up condition 5. Readout timer value ($t\_wkp\_unpwrd = t_0$) 6. Configuration of the DUT must be finished within 20ms after wake-up. 7. Wait until DUT signalizes a link-up condition 8. Readout timer value ($t\_wkp\_link\text{-}up = t_0 - t\_wkp\_unpwrd$ – *20ms (configuration time)*) 9. Monitor the link status for additional 750ms
Pass criteria	For all the executed iterations the following pass criterion shall be fulfilled: • t_wkp_unpwrd < TWU_Link_Passive + T_Powersupply_Stable + T_PHY_Initialization t_wkp_unpwrd < 17 ms • $t\_wkp\_link\text{-}up \leq 100$ ms • No link drop is observed after link-up condition has been reached.
Test iterations	See suggested test iterations in Appendix- 7.1 Suggested Iterations
Notes	The test shall be executed for each DUT 100BASE-T1 port

Table 28: Main test structure of WAKE_IOP_3

Instance Test Case #	**DUT / LP configuration**	**LP as SLAVE**	**LP as MASTER**	**LP is MASTER, LP connected with swapped polarity of ETH_N and ETH_P**
6.1.1.1	DUT as SLAVE		WAKE_IOP_3_S_M	
6.1.1.2	DUT as MASTER	WAKE_IOP_3_M_S		
6.1.1.3	DUT as SLAVE			WAKE_IOP_3_S_M_P

Table 29: Test case instances of WAKE_IOP_3

6.1.2 Reception of a wake-up request (WUR)

ID: WAKE_IOP_4

Type: Requirement

Synopsis	Shall ensure that DUT is able to receive a WUR over an active link and to signalize it. Parameter to be measured: • *TWU_Link_active*: Wake-up transmission time over an active link. • Link stability during and after WUR event.
Prerequisites	1. DUT with the capability to reset and configure its PHYs. 2. Link partner, or device that is connected to the DUT, shall be able to send a wake-up request (WUR). 3. The test system shall be able of providing time measurement capabilities synchronized with the test steps events.
Test Setup	 • DUT shall be connected to an active link partner (LP1) with opposite MASTER/SLAVE configuration. • A stable link-up condition shall be present at the moment of starting the test execution.
Test procedure	1. Reset timer t_0 2. Trigger a wake-up request on LP1 3. Start timer t_0 4. Wait until the DUT signalizes a wake-up condition 5. Readout timer value (*TWU_Link_active* = t_0) 6. Monitor the link status for additional 750ms
Pass criteria	For all the executed iterations the following pass criterion shall be fulfilled: • *TWU_Link_active* < 2 ms • No link drop is observed during the test execution.
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	The test shall be executed for each DUT 100BASE-T1 port

Table 30: Main test structure of WAKE_IOP_4

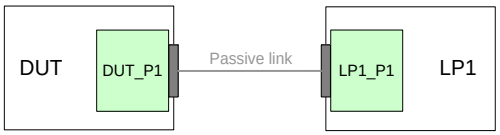
Instance Test Case #	DUT / LP configuration	LP as SLAVE	LP as MASTER
6.1.2.1	DUT as SLAVE		WAKE_ IOP_4_S_M
6.1.2.2	DUT as MASTER	WAKE_ IOP_4_M_S	

Table 31: Test case instances of WAKE_IOP_4

6.1.3 Reception of a wake-up pulse (WUP) on an already active DUT

ID: WAKE_IOP_5

Type: Requirement

Synopsis	Shall ensure that a DUT is able to receive a WUP over a passive link, signalize the wake-up event and upon this to establish a link while another DUT´s port link is already established. Parameters to be measured: • *TWU_Link_passive*: Wake-up transmission time over a passive link. • *t_wkp_link-up*: Time between DUT wake-up signalization and link-up. • Link stability after a wake-up condition.
Prerequisites	1. DUT shall have more than one port. 2. DUT with the capability to reset and configure its PHYs. 3. DUT with the capability to set its PHYs into sleep mode. 4. Link partner, or device that is connected to the DUT, shall be able to send a wake-up pulse (WUP). 5. Link partner shall have local wake-up input available. 6. The test system shall be able of providing time measurement capabilities synchronized with the test steps events.
Test Setup	 • DUT shall be connected to a link partner (LP1) with a passive link with opposite MASTER/SLAVE configuration. • LP1 including LP1_P1 shall be powered and connected to the DUT with a passive link. • DUT including DUT_P1 shall be powered and connected to the LP1 with a passive link.
Test procedure	1. Reset timer t_0 2. Trigger a wake-up request on LP1 3. Start timer t_0 4. Wait until the DUT signalizes a wake-up condition 5. Readout timer value (*TWU_Link_passive* = t_0) 6. Configuration of the DUT must be finished within 20ms after wake-up. 7. Wait until DUT signalizes a link-up condition 8. Readout timer value (*t_wkp_link-up* = t_0 - *TWU_Link_passive – 20ms (configuration time)*) 9. Configuration of the DUT must be finished within 20ms after wake-up. 10. Monitor the link status for additional 750ms
Pass criteria	For all the executed iterations the following pass criterion shall be fulfilled: • *TWU_Link_passive* < 2 ms • *t_wkp_link-up* ≤ 100 ms

	• No link drop is observed after link-up condition has been reached.
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	Test can be skipped for DUTs with one port. The test shall be executed for each DUT 100BASE-T1 port

Table 32: Main test structure of WAKE_IOP_5

Instance Test Case #	DUT / LP configuration	LP as SLAVE	LP as MASTER
6.1.3.1	DUT as SLAVE		WAKE_IOP_5_S_M
6.1.3.2	DUT as MASTER	WAKE_IOP_5_M_S	

Table 33: Test case instances of WAKE_IOP_5

6.2 Group 6, Wake-up transmission

ID: WAKE_IOP_6

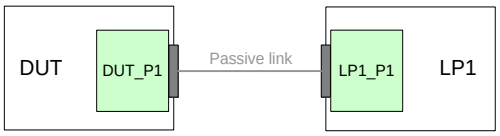
Type: Information

The test cases defined in this section shall ensure that a wake-up (WUP/WUR) can be transmitted and signaled to the upper layer as described in [14].

6.2.1 Transmission of a wake-up pulse (WUP)

ID: WAKE_IOP_7

Type: Requirement

Synopsis	Shall ensure that the DUT is able to send a WUP over a passive link within an expected time and to properly signalize the action. Parameters to be measured: • TWU_forward_passive: Time between local wake-up event on the DUT and LP1 wake-up signalization. • *t_wkp_link-up* : Time between DUT wake-up signalization and link-up. • Link stability after a wake-up condition.
Prerequisites	1. DUT with the capability to reset and configure its PHYs. 2. DUT with the capability to set its PHYs into sleep mode. 3. Link partner, or device that is connected to the DUT, shall be able to receive a wake-up pulse (WUP). 4. DUT implementation shall have local wake-up input available. 5. The test system shall be able of providing time measurement capabilities synchronized with the test steps events.
Test Setup	 • DUT shall be connected to a link partner (LP1) with a passive link with opposite MASTER/SLAVE configuration. • LP1 including LP1_P1 shall be powered and connected to the DUT with a passive link. • DUT including DUT_P1 shall be powered and connected to the LP1 with a passive link.
Test procedure	1. Reset timer t_0 2. Trigger a wake-up request on DUT 3. Start timer t_0 4. Wait until LP1 signalizes a wake-up condition 5. Readout timer value (TWU_link_passive = t_0) 6. Configuration of the DUT must be finished within 20ms after wake-up. 7. Wait until DUT signalizes a link-up condition

	8. Readout timer value ($t\_wkp\_link\text{-}up = t_0$ - TWU_link_passive– *20ms (configuration time)*) 9. Monitor the link status for additional 750ms
Pass criteria	For all the executed iterations the following pass criterion shall be fulfilled: • TWU_link_passive < 2 ms • $t\_wkp\_link\text{-}up \leq 100$ ms • No link drop is observed after link-up condition has been reached.
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	The test shall be executed for each DUT 100BASE-T1 port

Table 34: Main test structure of WAKE_IOP_7

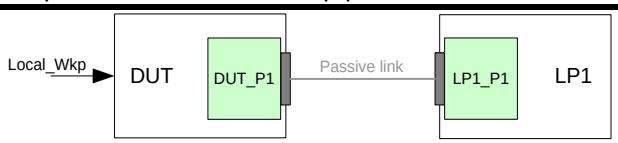
Instance Test Case #	**DUT / LP configuration**	**LP as SLAVE**	**LP as MASTER**	**LP is MASTER, LP connected with swapped polarity of ETH_N and ETH_P**
6.2.1.1	DUT as SLAVE		WAKE_IOP_7_S_M	
6.2.1.2	DUT as MASTER	WAKE_IOP_7_M_S		
6.2.1.3	DUT as SLAVE			WAKE_IOP_7_S_M_P

Table 35: Test case instances of WAKE_IOP_7

6.2.2 Transmission of a wake-up pulse after local wake-up (WUP)

ID: WAKE_IOP_8

Type: Requirement

Synopsis	Shall ensure that the DUT is able to send a WUP over a passive link within an expected time and to properly signalize the action. Parameters to be measured: • *t_wkp_unpwrd*: Time between local wake-up event on the DUT and LP1 wake-up signalization. • *t_wkp_link-up* : Time between DUT wake-up signalization and link-up. • Link stability after a wake-up condition.
Prerequisites	1. DUT with the capability to reset and configure its PHYs. 2. DUT with the capability to set its PHYs into sleep mode. 3. Link partner, or device that is connected to the DUT, shall be able to receive a wake-up pulse (WUP). 4. DUT implementation shall have local wake-up input available. 5. The test system shall be able of providing time measurement capabilities synchronized with the test steps events. 6. The DUT provides a local wake-up pin.
Test Setup	 • DUT shall be connected to a link partner (LP1) with a passive link with opposite MASTER/SLAVE configuration. • DUT shall be in sleep state. • LP1 including LP1_P1 shall be powered and connected to the DUT with a passive link.
Test procedure	1. Reset timer t_0 2. Apply a local wake pulse to DUT for at least 50us 3. Start timer t_0 4. Wait until LP1 signalizes a wake-up condition 5. Readout timer value (*t_wkp_unpwrd* = t_0) 6. Configuration of the DUT must be finished within 20ms after wake-up. 7. Wait until DUT signalizes a link-up condition 8. Readout timer value (*t_wkp_link-up* = t_0 - *t_wkp_unpwrd – 20ms (configuration time)*) 9. Monitor the link status for additional 750ms
Pass criteria	For all the executed iterations the following pass criterion shall be fulfilled: • *t_wkp_unpwrd* < TWU_WakeIO + TWU_Link_passive + (T_Powersupply_Stable + T_PHY_Initialization) *t_wkp_unpwrd* < 1ms + 2ms + (15ms) *t_wkp_unpwrd* < 18 ms • *t_wkp_link-up* ≤ 100 ms • No link drop is observed after link-up condition has been reached.

Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	The test shall be executed for each DUT 100BASE-T1 port

Table 36: Main test structure of WAKE_IOP_8

Instance Test Case #	DUT / LP configuration	LP as SLAVE	LP as MASTER
6.2.2.1	DUT as SLAVE		WAKE_IOP_8_S_M
6.2.2.2	DUT as MASTER	WAKE_IOP_8_M_S	

Table 37: Test case instances of WAKE_IOP_8

6.2.3 Transmission of a wake-up request (WUR)

ID: WAKE_IOP_9

Type: Requirement

Synopsis	Shall ensure that the DUT is able to send a WUR over an active link. Parameters to be measured: • *TWU_Link_active*: Wake-up transmission time over an active link. • Link stability after a wake-up condition.
Prerequisites	1. DUT with the capability to reset and configure its PHYs. 2. Link partner, or device that is connected to the DUT, shall be able to receive a wake-up request (WUR). 3. The test system shall be able of providing time measurement capabilities synchronized with the test steps events.
Test Setup	 • DUT shall be connected to an active link partner (LP1) with opposite MASTER/SLAVE configuration. • A link-up condition shall be present at the moment of starting the test execution.
Test procedure	1. Reset timer t_0 2. Trigger a WUR on the DUT 3. Start timer t_0 4. Wait until the LP1 signalizes a wake-up condition 5. Readout timer value (*TWU_Link_active* = t_0)
Pass criteria	For all the executed iterations the following pass criterion shall be fulfilled: • *TWU_Link_active* < 2 ms
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	The test shall be executed for each DUT 100BASE-T1 port

Table 38: Main test structure of WAKE_IOP_9

Instance Test Case #	DUT / LP configuration	LP as SLAVE	LP as MASTER
6.2.3.1	DUT as SLAVE		WAKE_ IOP_9_S_M
6.2.3.2	DUT as MASTER	WAKE_ IOP_9_M_S	

Table 39: Test case instances of WAKE_IOP_9

6.3 Group 7, Wake-up forwarding

ID: WAKE_IOP_10

Type: Information

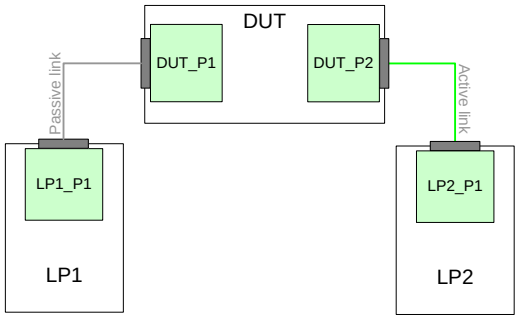
The test cases defined in this section shall ensure that a wake-up request can be forwarded as described in [14].

This section applies for multi-port DUTs.

6.3.1 Forwarding wake-up request from active to passive link

ID: WAKE_IOP_11

Type: Requirement

Synopsis	Shall ensure that a wake-up request received by a DUT over an active link can be forwarded within the expected time to a LP via a passive link. Parameters to be measured: • *t_wkp_fwd*: Time between triggering the WUR on LP2 and LP1 wake-up signalization.
Prerequisites	7. DUT shall have more than one port. 8. DUT with the capability to reset and configure its PHYs. 9. DUT with the capability to set its PHYs into sleep mode. 10. Link partner, or device that is connected to the DUT, shall be able to send and receive a wake-up pulse (WUP). 11. The test system shall be able of providing time measurement capabilities synchronized with the test steps events.
Test Setup	 • DUT ports shall be connected to their LPs with opposite MASTER/SLAVE configuration. • DUT port *DUT_P1* shall be connected to LP1. • LP1 including LP1_P1 shall be powered and the link between DUT_P1 and LP1_P1 shall be passive at the moment of starting the test execution. • DUT port *DUT_P2* shall be connected to LP2. • LP2 shall be in normal mode and the link between DUT_P2 and LP2_P1 shall be active at the moment of starting the test execution.
Test	1. Reset timer t_0

procedure	2. Trigger a WUR on LP2 3. Start timer t_0 4. Wait until the LP1 signalizes a wake-up condition 5. Readout timer value ($t\_wkp\_fwd = t_0$)
Pass criteria	Each test iteration shall be classified as pass, if all of the following condition(s) are fulfilled : • t_wkp_fwd < TWU_Link_active + TWU_Forwarding + TWU_Link_passive t_wkp_fwd < 2ms + 1ms + 2ms t_wkp_fwd < 5ms
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	The test shall be executed for each DUT 100BASE-T1 port

Table 40: Main test structure of WAKE_IOP_11

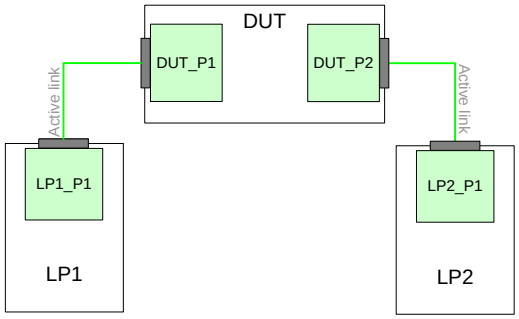
Instance **Test Case #**	**DUT / LP** **configuration**	**LP1 as SLAVE, LP2 as SLAVE**	**LP1 as MASTER, LP2 as MASTER**	**LP1 as MASTER, LP2 as SLAVE**	**LP1 as SLAVE, LP2 as MASTER**
6.3.1.1	DUT_P1 as SLAVE, DUT_P2 as MASTER			WAKE_ IOP_11_SM_MS	
6.3.1.2	DUT_P1 as MASTER, DUT_P2 as SLAVE				WAKE_ IOP_11_MS_SM
6.3.1.3	DUT_P1 as MASTER, DUT_P2 as MASTER	WAKE_ IOP_11_MM_SS			
6.3.1.4	DUT_P1 as SLAVE, DUT_P2 as SLAVE		WAKE_ IOP_11_SS_MM		

Table 41: Test case instances of WAKE_IOP_11

6.3.2 Forwarding a wake-up request from active to active link

ID: WAKE_IOP_12

Type: Requirement

Synopsis	Shall ensure that a wake-up request received by a DUT over an active link can be forwarded within the expected time to a LP via an active link. Parameters to be measured: • *t_wkp_fwd*: Time between triggering the WUR on LP2 and LP1 wake-up signalization.
Prerequisites	1. DUT shall have more than one port. 2. DUT with the capability to reset and configure its PHYs. 3. DUT with the capability to set its PHYs into sleep mode. 4. Link partner, or device that is connected to the DUT, shall be able to receive a wake-up request (WUR). 5. The test system shall be able of providing time measurement capabilities synchronized with the test steps events.
Test Setup	 • DUT ports shall be connected to their LPs with opposite MASTER/SLAVE configuration. • DUT port *DUT_P1* test shall be connected to LP1. • LP1 shall be powered and the link between DUT_P1 and LP1_P1 shall be active at the moment of starting the test execution. • DUT port *DUT_P2* test shall be connected to LP2. • LP2 shall be in normal mode and the link between DUT_P2 and LP2_P1 shall be active at the moment of starting the test execution.
Test procedure	1. Reset timer t_0 2. Trigger a WUR on LP2 3. Start timer t_0 4. Wait until the LP1 signalizes a wake-up condition 5. Readout timer value ($t\_wkp\_fwd = t_0$)
Pass criteria	Each test iteration shall be classified as pass, if all of the following condition(s) are fulfilled : • *t_wkp_fwd* < TWU_Link_active + TWU_Forwarding + TWU_Link_active *t_wkp_fwd* < 2ms + 1ms + 2ms *t_wkp_fwd* < 5ms

Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	The test shall be executed for each DUT 100BASE-T1 port

Table 42: Main test structure of WAKE_IOP_12

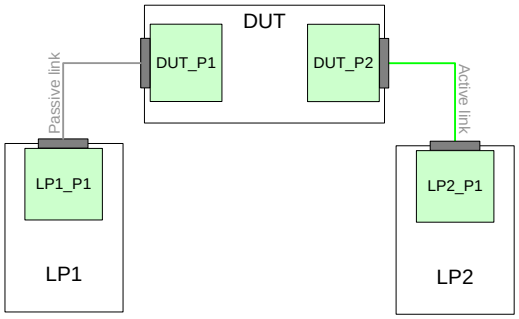
Instance **Test Case #**	**DUT / LP configuration**	**LP1 as SLAVE, LP2 as SLAVE**	**LP1 as MASTER, LP2 as MASTER**	**LP1 as MASTER, LP2 as SLAVE**	**LP1 as SLAVE, LP2 as MASTER**
6.3.2.1	DUT_P1 as SLAVE, DUT_P2 as MASTER			WAKE_ IOP_12_SM_MS	
6.3.2.2	DUT_P1 as MASTER, DUT_P2 as SLAVE				WAKE_ IOP_12_MS_SM
6.3.2.3	DUT_P1 as MASTER, DUT_P2 as MASTER	WAKE_ IOP_12_MM_SS			
6.3.2.4	DUT_P1 as SLAVE, DUT_P2 as SLAVE		WAKE_ IOP_12_SS_MM		

Table 43: Test case instances of WAKE_IOP_12

6.3.3 Forwarding a wake-up request from passive to active link

ID: WAKE_IOP_13

Type: Requirement

Synopsis	Shall ensure that a wake-up request received by a DUT over a passive link can be forwarded within the expected time to a LP via an active link. Parameters to be measured: • *t_wkp_fwd*: Time between triggering the WUR on LP1 and LP2 wake-up signalization.
Prerequisites	1. DUT shall have more than one port. 2. DUT with the capability to reset and configure its PHYs. 3. DUT with the capability to set its PHYs into sleep mode. 4. Link partner, or device that is connected to the DUT, shall be able to receive a wake-up request (WUR). 5. The test system shall be able of providing time measurement capabilities synchronized with the test steps events.
Test Setup	 • DUT ports shall be connected to their LPs with opposite MASTER/SLAVE configuration. • DUT port *DUT_P1* test shall be connected to LP1. • LP1 including LP1_P1 shall be powered and the link between DUT_P1 and LP1_P1 shall be passive at the moment of starting the test execution. • DUT port *DUT_P2* test shall be connected to LP2. • LP2 shall be in normal mode and the link between DUT_P2 and LP2_P1 shall be active at the moment of starting the test execution.
Test procedure	1. Reset timer t_0 2. Trigger a wake-up request on LP1 3. Start timer t_0 4. Wait until the LP2 signalizes a wake-up condition 5. Readout timer value ($t\_wkp\_fwd = t_0$)
Pass criteria	Each test iteration shall be classified as pass, if all of the following condition(s) are fulfilled : • *t_wkp_fwd* < TWU_Link_passive + TWU_Forwarding + TWU_Link_active *t_wkp_fwd* < 2ms + 1ms + 2ms *t_wkp_fwd* < 5ms

Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	The test shall be executed for each DUT 100BASE-T1 port

Table 44: Main test structure of WAKE_IOP_13

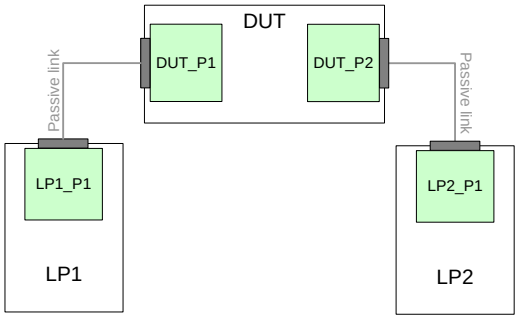
Instance **Test Case #**	**DUT / LP** **configuration**	**LP1 as SLAVE, LP2 as SLAVE**	**LP1 as MASTER, LP2 as MASTER**	**LP1 as MASTER, LP2 as SLAVE**	**LP1 as SLAVE, LP2 as MASTER**
6.3.3.1	DUT_P1 as SLAVE, DUT_P2 as MASTER			WAKE_ IOP_13_SM_MS	
6.3.3.2	DUT_P1 as MASTER, DUT_P2 as SLAVE				WAKE_ IOP_13_MS_SM
6.3.3.3	DUT_P1 as MASTER, DUT_P2 as MASTER	WAKE_ IOP_13_MM_SS			
6.3.3.4	DUT_P1 as SLAVE, DUT_P2 as SLAVE		WAKE_ IOP_13_SS_MM		

Table 45: Test case instances of WAKE_IOP_13

6.3.4 Forwarding a wake-up request from passive to passive link

ID: WAKE_IOP_14

Type: Requirement

Synopsis	Shall ensure that a wake-up request received by a DUT over a passive link can be forwarded within the expected time to a LP via a passive link. Parameters to be measured: • *t_wkp_fwd*: Time between triggering the WUR on LP1 and LP2 wake-up signalization.
Prerequisites	1. DUT shall have more than one port. 2. DUT with the capability to reset and configure its PHYs. 3. DUT with the capability to set its PHYs into sleep mode. 4. Link partner, or device that is connected to the DUT, shall be able to receive a wake-up pulse (WUP). 5. The test system shall be able of providing time measurement capabilities synchronized with the test steps events.
Test Setup	 • DUT ports shall be connected to their LPs with opposite MASTER/SLAVE configuration. • DUT port *DUT_P1* test shall be connected to LP1. • LP1 including LP1_P1 shall be powered and the link between DUT_P1 and LP1_P1 shall be passive at the moment of starting the test execution. • DUT port *DUT_P2* test shall be connected to LP2. • LP1 including LP1_P2 shall be powered and the link between DUT_P1 and LP1_P1 shall be passive at the moment of starting the test execution.
Test procedure	1. Reset timer t_0 2. Trigger a wake-up request on LP1 3. Start timer t_0 4. Wait until the LP2 signalizes a wake-up condition 5. Readout timer value ($t\_wkp\_fwd = t_0$)
Pass criteria	Each test iteration shall be classified as pass, if all of the following condition(s) are fulfilled : • *t_wkp_fwd* < TWU_Link_passive + TWU_Forwarding + TWU_Link_passive *t_wkp_fwd* < 2ms + 1ms + 2ms *t_wkp_fwd* < 5 ms

Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	The test shall be executed for each DUT 100BASE-T1 port

Table 46: Main test structure of WAKE_IOP_14

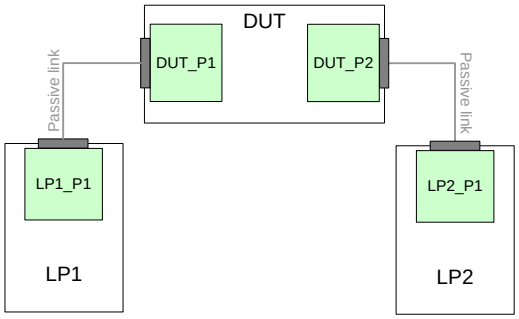
Instance **Test Case #**	**DUT / LP** **configuration**	**LP1 as SLAVE, LP2 as SLAVE**	**LP1 as MASTER, LP2 as MASTER**	**LP1 as MASTER, LP2 as SLAVE**	**LP1 as SLAVE, LP2 as MASTER**
6.3.4.1	DUT_P1 as SLAVE, DUT_P2 as MASTER			WAKE_ IOP_14_SM_MS	
6.3.4.2	DUT_P1 as MASTER, DUT_P2 as SLAVE				WAKE_ IOP_14_MS_SM
6.3.4.3	DUT_P1 as MASTER, DUT_P2 as MASTER	WAKE_ IOP_14_MM _SS			
6.3.4.4	DUT_P1 as SLAVE, DUT_P2 as SLAVE		WAKE_ IOP_14_SS_MM		

Table 47: Test case instances of WAKE_IOP_14

6.3.5 Forwarding a wake-up request from passive to passive link, DUT in sleep

ID: WAKE_IOP_15

Type: Requirement

Synopsis	Shall ensure that a wake-up request received by a DUT over a passive link can be forwarded within the expected time to a LP via a passive link. Parameters to be measured: • *t_wkp_fwd*: Time between triggering the WUR on LP1 and LP2 wake-up signalization.
Prerequisites	6. DUT shall have more than one port. 7. DUT with the capability to reset and configure its PHYs. 8. DUT with the capability to set its PHYs into sleep mode. 9. Link partner, or device that is connected to the DUT, shall be able to receive a wake-up pulse (WUP). 10. The test system shall be able of providing time measurement capabilities synchronized with the test steps events.
Test Setup	 • DUT ports shall be connected to their LPs with opposite MASTER/SLAVE configuration. • DUT port *DUT_P1* test shall be connected to LP1. • LP1 including LP1_P1 shall be powered and the link between DUT_P1 and LP1_P1 shall be passive at the moment of starting the test execution. • DUT port *DUT_P2* test shall be connected to LP2. • LP1 including LP1_P2 shall be powered and the link between DUT_P1 and LP1_P1 shall be passive at the moment of starting the test execution.
Test procedure	6. Reset timer t_0 7. Trigger a wake-up request on LP1 8. Start timer t_0 9. Wait until the LP2 signalizes a wake-up condition 10. Readout timer value ($t\_wkp\_fwd = t_0$)
Pass criteria	Each test iteration shall be classified as pass, if all of the following condition(s) are fulfilled : • *t_wkp_fwd* < TWU_Link_Passive + (T_Powersupply_Stable + T_PHY_Initialization) + TWU_Forwarding + TWU_Link_Passive *t_wkp_fwd* < 2ms + (15ms) + 1ms + 2ms *t_wkp_fwd* < 20 ms

Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	The test shall be executed for each DUT 100BASE-T1 port

Table 48: Main test structure of WAKE_IOP_15

Instance **Test Case #**	**DUT / LP** **configuration**	**LP1 as SLAVE, LP2 as SLAVE**	**LP1 as MASTER, LP2 as MASTER**	**LP1 as MASTER, LP2 as SLAVE**	**LP1 as SLAVE, LP2 as MASTER**
6.3.5.1	DUT_P1 as SLAVE, DUT_P2 as MASTER			WAKE_ IOP_15_SM_MS	
6.3.5.2	DUT_P1 as MASTER, DUT_P2 as SLAVE				WAKE_ IOP_15_MS_SM
6.3.5.3	DUT_P1 as MASTER, DUT_P2 as MASTER	WAKE_ IOP_15_MM_SS			
6.3.5.4	DUT_P1 as SLAVE, DUT_P2 as SLAVE		WAKE_ IOP_15_SS_MM		

Table 49: Test case instances of WAKE_IOP_15

6.4 Group 8, Sleep

ID: WAKE_IOP_16

Type: Requirement

The test cases defined in this section shall ensure that the PHY is able to make the transition to sleep as requested.

6.4.1 Sleep request after link-up

ID: WAKE_IOP_17

Type: Requirement

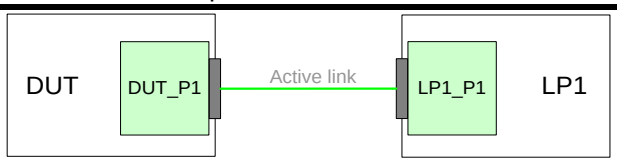
Synopsis	Shall ensure that the DUT is able to enter the sleep mode and remain in this state after link-up was established when the sleep request is issued on the DUT side.
Prerequisites	1. DUT with the capability to reset and configure its PHYs. 2. DUT with the capability to set its PHYs into sleep mode. 3. The test system shall be able of providing time measurement capabilities synchronized with the test steps events.
Test Setup	 • DUT shall be connected to an active link partner (LP1) with opposite MASTER/SLAVE configuration. • A stable link-up condition shall be present at the moment of starting the test execution.
Test procedure	1. Trigger a sleep request on the DUT 2. Start timer t_0 3. Wait until the DUT signalizes a sleep condition 4. Readout timer value ($t\_sleep = t_0$) 5. DUT and LP shall monitor whether the sleep condition remains for at least 750ms.
Pass criteria	Each test iteration shall be classified as pass, if all of the following condition(s) are fulfilled : • $t\_sleep < sleep\_req\_timer$ t_sleep < 16ms • Both the DUT and the LP must not leave the sleep condition after the SLEEP state has been entered.
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	The test shall be executed for each DUT 100BASE-T1 port

Table 50: Main test structure of WAKE_IOP_17

Instance Test Case #	DUT / LP configuration	LP as SLAVE	LP as MASTER
6.4.1.1	DUT as SLAVE		WAKE_ IOP_17_S_M
6.4.1.2	DUT as MASTER	WAKE_ IOP_17_M_S	

Table 51: Test case instances of WAKE_IOP_17

6.4.2 Remote sleep request after link-up

ID: WAKE_IOP_18

Type: Requirement

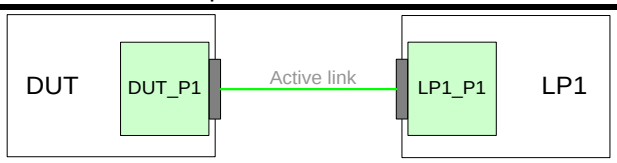
Synopsis	Shall ensure that the DUT is able to enter the sleep mode and remain in this state after link-up was established when the sleep request is issued on the LP side.
Prerequisites	4. DUT with the capability to reset and configure its PHYs. 5. DUT with the capability to set its PHYs into sleep mode. 6. The test system shall be able of providing time measurement capabilities synchronized with the test steps events.
Test Setup	 • DUT shall be connected to an active link partner (LP1) with opposite MASTER/SLAVE configuration. • A stable link-up condition shall be present at the moment of starting the test execution.
Test procedure	1. Trigger a sleep request on the LP1 2. Start timer t_0 3. Wait until the DUT signalizes a sleep condition 4. Readout timer value ($t\_sleep = t_0$) 5. DUT and LP shall monitor whether the sleep condition remains for at least 750ms.
Pass criteria	Each test iteration shall be classified as pass, if all of the following condition(s) are fulfilled : • *t_sleep < sleep_req_timer + sleep_ack_timer* *t_sleep < 16ms + 8ms* *t_sleep* < 24ms • Both the DUT and the LP must not leave the sleep condition after the SLEEP state has been entered.
Test iterations	See suggested test iterations in Appendix - 7.1 Suggested Iterations
Notes	The test shall be executed for each DUT 100BASE-T1 port

Table 52: Main test structure of WAKE_IOP_18

Instance Test Case #	DUT / LP configuration	LP as SLAVE	LP as MASTER
6.4.2.1	DUT as SLAVE		WAKE_ IOP_18_S_M
6.4.2.2	DUT as MASTER	WAKE_ IOP_18_M_S	

Table 53: Test case instances of WAKE_IOP_18

7 Appendix

7.1 Suggested Iterations

7.1.1 Nomenclature

The following parameters are to describe the test environment and if apply the kind of stress and its location.

Reference name	Description
100BASET1_IOP_XX	Test reference
SR	Soft Reset
HR	Hard Reset
O1	Open is on ETH_N or ETH_P
O2	Open on both ETH_N and ETH_P
NEAR	Open/Short near to DUT
FAR	Open/Short near to LP
M	MASTER
S	SLAVE
P	Swapped Polarity
C1	Channel Type 3 or combinations of Type 3 and Type 2 channels
C2	Channel Type 1
T1	Room Temperature
T2	-40°C
T3	105°C /125°C

Table 54: Nomenclature of test enviroment variables

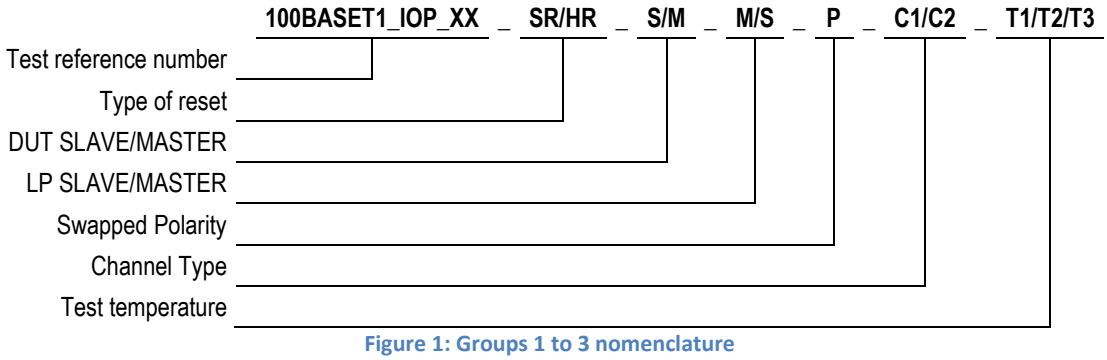


Figure 1: Groups 1 to 3 nomenclature

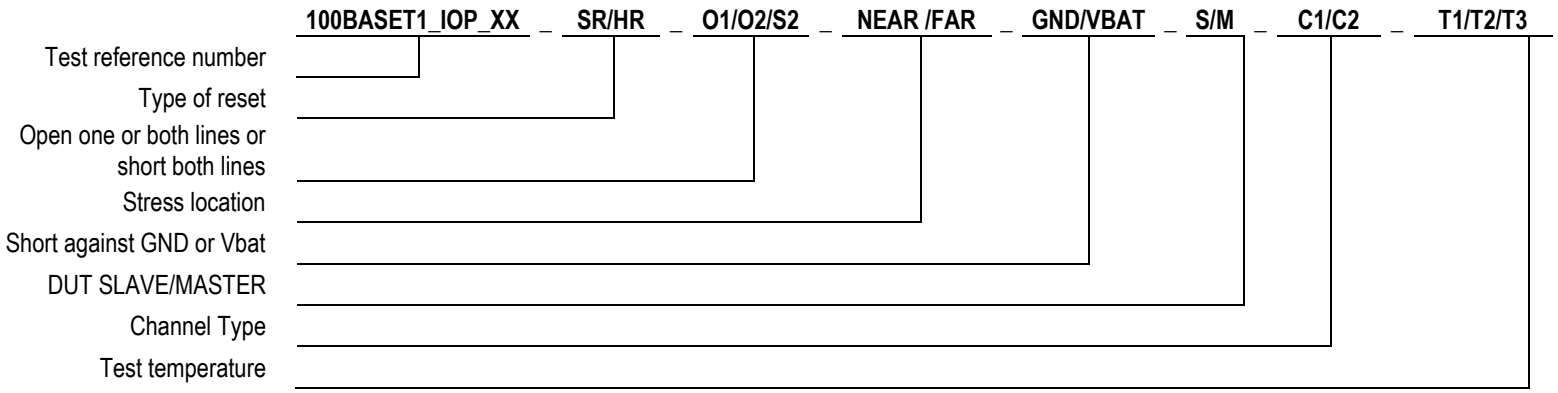


Figure 2: Group 4 nomenclature

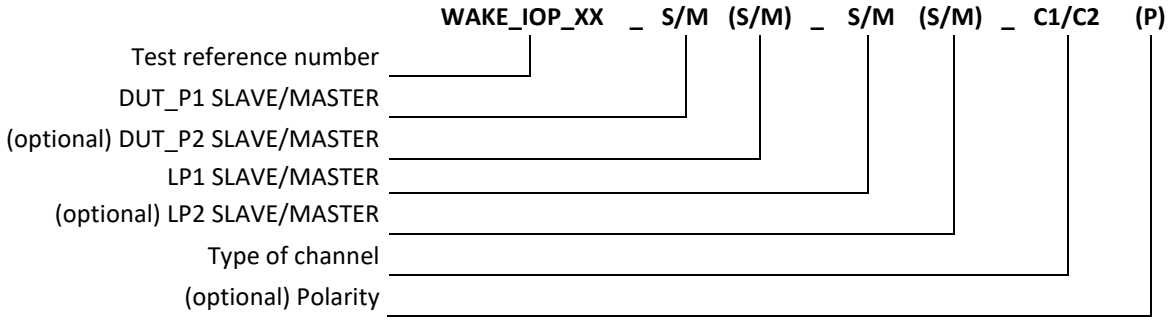


Figure 3: Groups 1 to 4 nomenclature

7.1.2 Group 1 test cases iterations

Group	Test Case	Minimal amount of iterations per LP*
Group 1: Link Status	IOP_16_SR_M_S_C1_T1	500.000
	IOP_16_SR_M_S_C2_T1	500.000
	IOP_16_SR_S_M_C1_T1	500.000
	IOP_16_SR_S_M_P_C1_T1	8.000
	IOP_16_SR_S_M_C2_T1	500.000
	IOP_16_SR_S_M_P_C2_T1	18.000
	IOP_17_SR_M_M_C2_T1	50.000
	IOP_17_SR_S_S_C2_T1	50.000
	IOP_18_SR_M_S_P_C2_T1	6.250
	IOP_18_SR_S_M_P_C2_T1	6.250
	IOP_19_SR_M_S_C2_T1	125.000
	IOP_19_SR_S_M_C2_T1	125.000

Table 55: Group 1 test cases suggested iterations

**When considering multiple link partners tests.*

7.1.3 Group 2 test cases iterations

Group	Test Case	Minimal amount of iterations per LP*
Group 2: Link-Up	IOP_21_HR_M_S_C1_T1	200
	IOP_21_HR_M_S_C1_T2	25
	IOP_21_HR_M_S_C1_T3	25
	IOP_21_HR_M_S_C2_T1	1.800
	IOP_21_HR_M_S_C2_T2	225
	IOP_21_HR_M_S_C2_T3	225
	IOP_21_HR_S_M_C1_T1	200
	IOP_21_HR_S_M_C1_T2	25
	IOP_21_HR_S_M_C1_T3	25
	IOP_21_HR_S_M_C2_T1	1.800
	IOP_21_HR_S_M_C2_T2	225
	IOP_21_HR_S_M_C2_T3	225
	IOP_21_HR_S_M_P_C1_T1	200
	IOP_21_HR_S_M_P_C1_T2	25
	IOP_21_HR_S_M_P_C1_T3	25
	IOP_21_HR_S_M_P_C2_T1	1.800
	IOP_21_HR_S_M_P_C2_T2	225
	IOP_21_HR_S_M_P_C2_T3	225
	IOP_21_SR_M_S_C1_T1	250.000
	IOP_21_SR_M_S_C1_T2	25.000
	IOP_21_SR_M_S_C1_T3	25.000
	IOP_21_SR_M_S_C2_T1	500.000
	IOP_21_SR_M_S_C2_T2	25.000
	IOP_21_SR_M_S_C2_T3	25.000
	IOP_21_SR_S_M_C1_T1	250.000
	IOP_21_SR_S_M_C1_T2	24.750
	IOP_21_SR_S_M_C1_T3	24.750
	IOP_21_SR_S_M_C2_T1	500.000
	IOP_21_SR_S_M_C2_T2	25.000
	IOP_21_SR_S_M_C2_T3	25.000
	IOP_21_SR_S_M_P_C1_T1	8.000
	IOP_21_SR_S_M_P_C1_T2	250
	IOP_21_SR_S_M_P_C1_T3	250
	IOP_21_SR_S_M_P_C2_T1	72.000
	IOP_21_SR_S_M_P_C2_T2	2.250
	IOP_21_SR_S_M_P_C2_T3	2.250
	IOP_22_HR_M_S_C1_T1	800
	IOP_22_HR_M_S_C1_T2	25
	IOP_22_HR_M_S_C1_T3	25
	IOP_22_HR_M_S_C2_T1	7.200
	IOP_22_HR_M_S_C2_T2	225
	IOP_22_HR_M_S_C2_T3	225

Group	Test Case	Minimal amount of iterations per LP*
	IOP_22_HR_S_M_C1_T1	800
	IOP_22_HR_S_M_C1_T2	25
	IOP_22_HR_S_M_C1_T3	25
	IOP_22_HR_S_M_C2_T1	7.200
	IOP_22_HR_S_M_C2_T2	225
	IOP_22_HR_S_M_C2_T3	225
	IOP_22_HR_S_M_P_C1_T1	800
	IOP_22_HR_S_M_P_C1_T2	25
	IOP_22_HR_S_M_P_C1_T3	25
	IOP_22_HR_S_M_P_C2_T1	7.200
	IOP_22_HR_S_M_P_C2_T2	225
	IOP_22_HR_S_M_P_C2_T3	225
	IOP_22_SR_M_S_C1_T1	20.000
	IOP_22_SR_M_S_C1_T2	625
	IOP_22_SR_M_S_C1_T3	625
	IOP_22_SR_M_S_C2_T1	180.000
	IOP_22_SR_M_S_C2_T2	5.625
	IOP_22_SR_M_S_C2_T3	5.625
	IOP_22_SR_S_M_C1_T1	20.000
	IOP_22_SR_S_M_C1_T2	625
	IOP_22_SR_S_M_C1_T3	625
	IOP_22_SR_S_M_C2_T1	180.000
	IOP_22_SR_S_M_C2_T2	5.625
	IOP_22_SR_S_M_C2_T3	5.625
	IOP_22_SR_S_M_P_C1_T1	4.000
	IOP_22_SR_S_M_P_C1_T2	125
	IOP_22_SR_S_M_P_C1_T3	125
	IOP_22_SR_S_M_P_C2_T1	36.000
	IOP_22_SR_S_M_P_C2_T2	1.125
	IOP_22_SR_S_M_P_C2_T3	1.125

Table 56: Group 2 test cases suggested iterations

**When considering multiple link partners tests.*

7.1.4 Group 3 test cases iterations

Group	Test Case	Suggested amount of iterations	Minimal amount of iterations per LP*
Group 3: Signal Quality	IOP_24a_SR_M_S_C1_T1	1	n.a.
	IOP_24a_SR_S_M_C1_T1	1	n.a.
	IOP_24b_SR_M_S_C1_T1	1	n.a.
	IOP_24b_SR_S_M_C1_T1	1	n.a.

Table 57: Group 3 test cases suggested iterations

When considering multiple link partners tests.

7.1.5 Group 4 test cases iterations

Group	Test Case	Suggested amount of iterations	Minimal amount of iterations per LP*
Group 4: Cable Diagnostics	IOP_31_SR_C1_T1**	50	50
	IOP_31_SR_C2_T1**	450	450
	IOP_32_SR_O1_FAR_M_C2_T1	500	n.a.
	IOP_32_SR_O1_FAR_S_C2_T1	500	n.a.
	IOP_32_SR_O1_NEAR_M_C2_T1	500	n.a.
	IOP_32_SR_O1_NEAR_S_C2_T1	500	n.a.
	IOP_32_SR_O2_FAR_M_C2_T1	500	n.a.
	IOP_32_SR_O2_FAR_S_C2_T1	500	n.a.
	IOP_32_SR_O2_NEAR_M_C2_T1	500	n.a.
	IOP_32_SR_O2_NEAR_S_C2_T1	500	n.a.
	IOP_33_SR_S2_FAR_M_C2_T1	500	n.a.
	IOP_33_SR_S2_FAR_S_C2_T1	500	n.a.
	IOP_33_SR_S2_NEAR_M_C2_T1	500	n.a.
	IOP_33_SR_S2_NEAR_S_C2_T1	500	n.a.
	IOP_33_SR_S2_FAR_GND_M_C2_T1	500	n.a.
	IOP_33_SR_S2_FAR_GND_S_C2_T1	500	n.a.
	IOP_33_SR_S2_NEAR_GND_M_C2_T1	500	n.a.
	IOP_33_SR_S2_NEAR_GND_S_C2_T1	500	n.a.
	IOP_33_SR_S2_FAR_VBAT_M_C2_T1	500	n.a.
	IOP_33_SR_S2_FAR_VBAT_S_C2_T1	500	n.a.
	IOP_33_SR_S2_NEAR_VBAT_M_C2_T1	500	n.a.
	IOP_33_SR_S2_NEAR_VBAT_S_C2_T1	500	n.a.

Table 58: Group 4 test cases suggested iterations

When considering multiple link partners tests.
***Only Diagnostic test case (IOP 31)*

7.1.6 Group 5 test cases iterations

Group	Test Case	Suggested amount of iterations
Group 5: Wake-up reception and signalizing	WAKE_IOP_3_S_M_C1	2500
	WAKE_IOP_3_M_S_C1	2500
	WAKE_IOP_3_S_M_C2	2500
	WAKE_IOP_3_M_S_C2	2500
	WAKE_IOP_3_S_M_C1_P	5000
	WAKE_IOP_4_S_M_C1	5000
	WAKE_IOP_4_M_S_C1	5000
	WAKE_IOP_5_S_M_C1	2500
	WAKE_IOP_5_M_S_C1	2500
	WAKE_IOP_5_S_M_C2	2500
	WAKE_IOP_5_M_S_C2	2500
	WAKE_IOP_7_M_S_C1	2500
	WAKE_IOP_7_S_M_C1	2500
	WAKE_IOP_7_M_S_C2	2500
	WAKE_IOP_7_S_M_C2	2500
	WAKE_IOP_7_M_S_C1_P	5000

Table 59: Group 1 test cases suggested iterations

7.1.7 Group 6 test cases iterations

Group	Test Case	Suggested amount of iterations
Group 6: Wake-up transmission	WAKE_IOP_8_S_M_C1	2500
	WAKE_IOP_8_M_S_C1	2500
	WAKE_IOP_8_S_M_C2	2500
	WAKE_IOP_8_M_S_C2	2500
	WAKE_IOP_9_S_M_C1	5000
	WAKE_IOP_9_M_S_C1	5000

Table 60: Group 2 test cases suggested iterations

7.1.8 Group 7 test cases iterations

Group	Test Case	Suggested amount of iterations
Group 7: Wake-up forwarding	WAKE_IOP_11_MM_SS_C1	5000
	WAKE_IOP_11_SS_MM_C1	5000
	WAKE_IOP_11_MS_SM_C1	5000
	WAKE_IOP_11_SM_MS_C1	5000
	WAKE_IOP_12_MM_SS_C1	5000
	WAKE_IOP_12_SS_MM_C1	5000
	WAKE_IOP_12_MS_SM_C1	5000
	WAKE_IOP_12_SM_MS_C1	5000
	WAKE_IOP_13_MM_SS_C1	5000
	WAKE_IOP_13_SS_MM_C1	5000
	WAKE_IOP_13_MS_SM_C1	5000
	WAKE_IOP_13_SM_MS_C1	5000
	WAKE_IOP_14_MM_SS_C1	5000
	WAKE_IOP_14_SS_MM_C1	5000
	WAKE_IOP_14_MS_SM_C1	5000
	WAKE_IOP_14_SM_MS_C1	5000
	WAKE_IOP_15_MM_SS_C1	5000
	WAKE_IOP_15_SS_MM_C1	5000
	WAKE_IOP_15_MS_SM_C1	5000
	WAKE_IOP_15_SM_MS_C1	5000

Table 61: Group 3 test cases suggested iterations

7.1.9 Group 8 test cases iterations

Group	Test Case	Suggested amount of iterations
Group 8: Sleep	WAKE_IOP_17_S_M_C1	5000
	WAKE_IOP_17_M_S_C1	5000
	WAKE_IOP_18_S_M_C1	5000
	WAKE_IOP_18_M_S_C1	5000

Table 62: Group 4 test cases suggested iterations

7.2 Artificial degradation of channel quality

7.2.1 Description

Figure 4 shows an example approach to artificially reduce the quality of the communication channel with a differential directional coupler whose parameters are defined in Table 63.

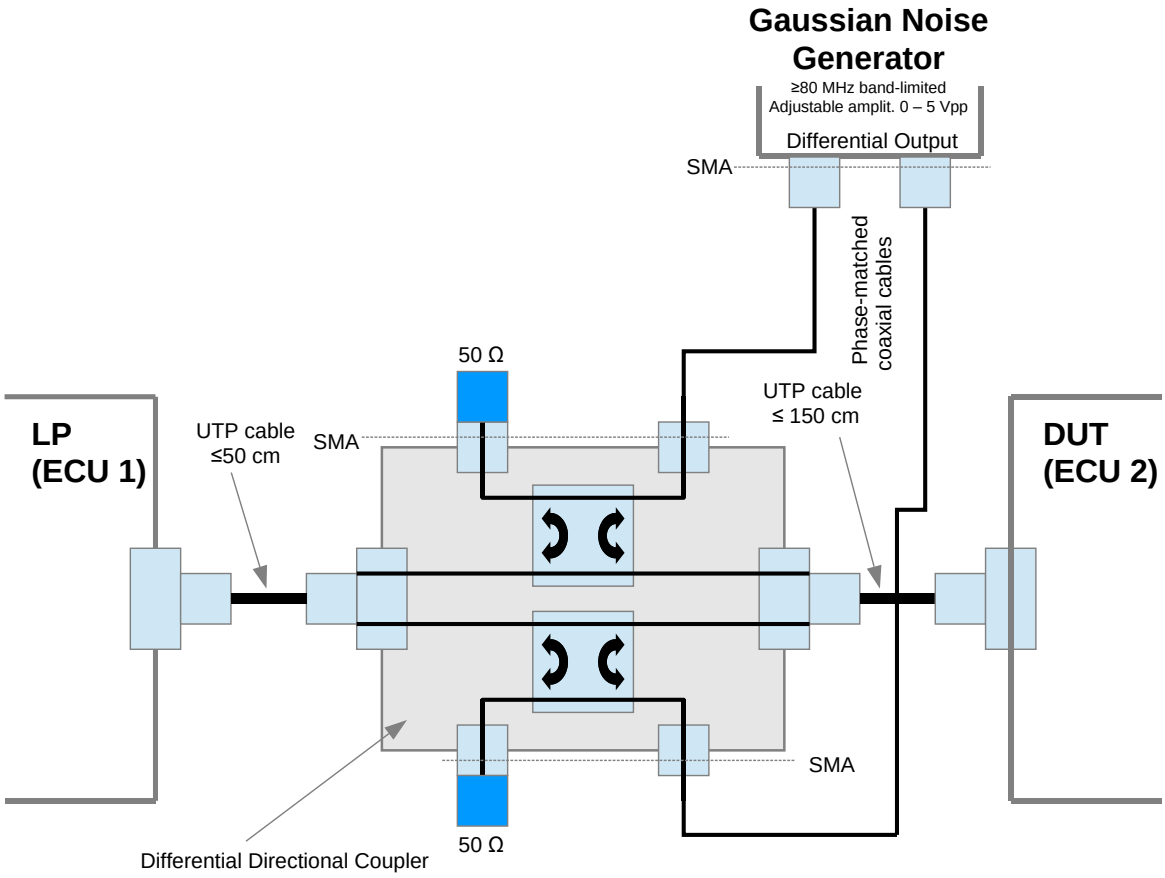


Figure 4: Example for artificial degradation of channel quality

Differential Directional Coupler		
Parameter	**Value**	**Frequency**
Insertion Loss	≤ 1 dB	1 – 66 MHz
Return Loss	18 dB 18 – 10 x log 10(f/20)	1 MHz ≤ f ≤ 20 MHz 20 MHz ≤ f ≤ 66 MHz
Coupling Flatness	± 1 dB	1 – 66 MHz
Coupling Attenuation Forward	20 dB ± 1 dB	
Coupling Attenuation Backward	21 dB ± 1 dB	

Table 63: Example for Differential Directional Coupler Parameters

7.3 List of tables

7.4 List of figures