10BASE-T1S Half-Duplex Interoperability Test Suite Specification

Interoperability Test Suite Specification

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VERSION AND RESTRICTION HISTORY OF THIS DOCUMENT

VERSION	DESCRIPTION	RESTRICTION LEVEL	DATE
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0.3_d07	Minor changes, text added in explanation of harness failures and diagnostic condition BCNBFTO.	OPEN Members Only	2023-03-27
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1.0	Change the sequence of test cases so that test cases where a disturbance node is required are at the end of each chapter in order to create a clean version 1.0 for IPR without test cases where the disturbance node were used in order to have a released version to help deploy the qualification	Public	2024-02-07

VERSION	DESCRIPTION	RESTRICTION LEVEL	DATE
1.1	Version including test cases where a disturbance node is required to continue discussions on the 1.1 draft.	OPEN Members Only	2024-02-07
1.2	Consider the latest CanovaTech feedback regarding TD test cases to improve some wording for better clarity. Redefinition of test cases *9.1.7-Group N7 – Normal communication, mixed operation of PLCA and non-PLCA nodes,* former definition covers a scenario where physical collisions will most likely happen, and JAM sent by the CSMA/CD node will likely run into the frame data from the PLCA node. This means the packages counter verification could not be considered reliable in the PASS criteria. New scenario covers CSMA/CD – fallback operation in automotive. The Coordinator is sent to CSMA/CD, the entire network goes to CSMA/CD – fallback operation and then the Coordinator recovers (PLCA enable) and starts sending BEACONs again, normal PLCA operation resumes. Package counters are verified once PLCA resumes.	OPEN Members Only	2024-03-22
1.3	Further corrections in test cases having mixed operation of PLCA and non-PLCA nodes. Corrections in the test cases with “Bus failure” and “Termination variation”. Removing former message transfer M2, having frames with a random number of data bytes for a better packet transmission queue synchronization Update of HDD test cases following the last definitions agreed in the Advanced diagnostic features for 10BASE-T1S automotive Ethernet PHYs specification Static GND shift added for HDD test cases	OPEN Members Only	2024-12-11
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1.5	Last editorial changes in S3 test case. Preparing the final clean version for IPR and publishing	Public	2025-09-09

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INTRODUCTION

The goal of this document is to define a set of tests that on one hand ensure interoperability between multiple devices that use 10BASE-T1S capable PHYs under normal and stress conditions in a 10BASE-T1S automotive Ethernet system.

Such stress includes, for example: illegal/non-valid transmissions, collisions, babbling idiots as well as dynamic ground shifts, clock drifts, wire harness failures.

Tests are meant as system tests. The major goal is to ensure that disturbances do not lead to a hang-up or dead-lock state of the communication system. Thus, the Pass-Fail-criteria of a test case might not include all observed signals. The disturbances are applied on the wire harness, while the status registers of MAC and PHY shall be observed, as well as in some test cases the digital signals ED and RX at the PMD transceiver interface.

All 10BASE-T1S PHYs can operate using half-duplex point-to-point communications on a link segment using a single balanced pair of conductors, supporting up to four in-line connectors and up to at least 25 meters in reach. Half-duplex communications on a mixing segment (multidrop bus system) using a single balanced pair of conductors, interconnecting up to at least 8 PHYs to a trunk up to at least 25 m, is an optional mode and interoperability for this mode is also covered in this document. PHYs in this optional mode may be attached in-line with the trunk or at the end of stubs with a length of up to 10 cm. An overall effective rate of 10 Mb/s is shared among the nodes.

This document also includes a set of test cases that verify the reliability of important supported features of automotive Ethernet PHYs (often also called transceiver), e.g. signal quality index (SQI) and harness defects detection, for diagnostic purposes for automotive Ethernet PHYs.

Topology discovery and robustness of remote wake-up is in scope of this test specification, even though the support of these features might be optional.

Note: The tests do not solely cover the respective PHYs/Switches but also consider PHY/Switches configuration and an external filter, if applicable. The results of the Interoperability Test Suite will not only depend on the PHY/switches, but also on the general configuration of Implementation Under Test, the Link partner, the MDI circuitry and the communication channel condition.

ABBREVIATION/SYMBOLS

Table 1: List of abbreviations

BI_DA-	Negative MDI pin or cable connected to a PHY's negative MDI pin.
BI_DA+	Positive MDI pin or cable connected to a PHY's positive MDI pin.
BIN	Bus Interface Network
CIDM	Characteristic Impedance Differential mode
CRC	Cyclic Redundancy Check
dPLCA	Dynamic Physical Layer Collision Avoidance: It is an optional PLCA Node ID allocation method. This should allow all node IDs (including node 0) to be assigned dynamically and to change during operation. The coordinator node shall also be able to vary the node count depending on how many active nodes are detected. dPLCA is fully backward compatible to the normal PLCA defined in 802.3cg, so that dPLCA enabled nodes can join a network with normal PLCA nodes without disturbing the operation.
DUT	Device under test: Combination of uC, PHY/Switch component, PHY/Switch configuration and filter that is being tested.
ET	End Termination
GND	Ground connection in electrical circuits
IL	Insertion Loss
ISO/OSI	Layer model of communication systems
IUT	Implementation under test: The PHYs entirety in a network environment are considered as the IUT
LP	Link partner: Device that is connected to a DUT to perform the interoperability tests. A link partner must use a well-known PHY, PHY configuration and external PHY filter (if necessary).
LT	Lower Tester: 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.
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.
MCU	Micro Controller Unit
MDI	Media dependent interface
MDIO	Management Data Input / Output
MII	Medium Independent Interface
P2P	Point-to-point
PCS	Physical Coding Sublayer

PHY	Interface semiconductor circuit for implementation of the functions of the Ethernet 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.
PLCA	Physical Layer Collision Avoidance: A method for generating transmit opportunities for 10BASE-T1S operating on mixing segments. (See IEEE Std 802.3, Clause 148.)
PMA	Physical Medium Attachment
RL	Return Loss
RT	Room Temperature
SCC	Standalone Communication Channel
S-Parameter	Scattering Parameter
SPI	Serial Peripheral Interface
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. See further details at [5].
SV	Supervisor: According to [11], the Supervisor controls the test procedures.
TDR	Time domain reflection
TO	Transmit opportunity: Each node on the network get assigned at least one transmit opportunity in each transmission cycle.
UT	Upper Tester: According to [11], the control and observation of the upper service boundary of the IUT is provided by the UT
n.a.	Not applicable

GLOSSARY TERMS

Table 2: List of definitions

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.
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 (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]).
Alignment Errors	are the number of alignment errors for the packets received by the network interface. An alignment error is caused when an incoming packet does not end on a byte boundary and the CRC does not match at the last byte boundary. When a collision occurs, either a CRC

Glossary term	Glossary definition
	error or an Alignment error almost always results. In the case of an Alignment error, if the collision occurs during a transmission after the preamble, the position of the resulting signal with respect to the phase of the wave is incorrect.
CRC Errors	Each packet is sent on an Ethernet network has a calculated cyclic redundancy check (CRC) appended to it. When the packet is received, this CRC is compared with the calculated CRC. If the calculated CRC is different from the CRC, the packet was corrupted, most likely by line noise or by a collision.
Single Collisions[1]	These counters indicate how many times the port has experienced a single collision when attempting to transmit a given frame. A collision being a case of a half-duplex interface detecting an incoming packet at the time it was trying to transmit a packet.
Multiple Collisions	These counters indicate how many times the port has experienced multiple collisions while attempting to deliver a given frame.
Excessive Collisions	Each time a port experiences a collision when attempting to transmit, it will pause and then try again. If the port has 16 attempts to transmit a packet and each result in a collision, then the port increments the Excessive Collisions counter, and gives up attempting to deliver the packet. It is possible for the port operating in half duplex to experience cases of excessive collisions.

[1] There are two types of collisions in 10BASE-T1S with PLCA. The first is a real, true collision in which two PHYs will transmit at the same time onto the line. This is the traditional collision and will be reported to the MAC. When PLCA is enabled, then logical collisions may be asserted by the PLCA RS to the MAC as a normal part of the PLCA algorithm. When a logical collision is asserted to the MAC, there is NOT a true collision of multiple PHYs transmitting on the line. The MAC cannot determine the difference between the two types of collisions reported by the PHY.

NORMATIVE REFERENCES

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

[1] IEEE P802.3cg™ : Physical Layer Specifications and Management Parameters for 10 Mb/s Operation and Associated Power Delivery over a Single Balanced Pair of Conductors
[2] OPEN ALLIANCE: 10BASE-T1S Physical Media Attachment Test Suite – Revision 1.0
[3] OPEN ALLIANCE: 10BASE-T1S Physical Coding Sublayer Test Suite – Revision 0.3
[4] OPEN ALLIANCE: 10BASE-T1S PLCA Conformance Test Suite – Revision 1.0
[5] OPEN ALLIANCE: 10BASE-T1 Advanced diagnostic features for 10BASE-T1S automotive Ethernet PHYs – Revision 1.1
[6] OPEN ALLIANCE: 10BASE-T1S System Implementation Specification – Revision 1.0
[7] OPEN ALLIANCE: 10BASE-T1S Sleep/Wake-up Specification – Revision 1.0
[8] OPEN ALLIANCE: 10BASE-T1S PLCA Management Registers – Revision 1.3
[9] OPEN ALLIANCE: 10BASE-T1S PMD Transceiver Interface – Revision 1.5
[10] OPEN ALLIANCE: 10BASE-T1S Topology Discovery – Revision 1.3
[11] ISO/IEC 9646 — Information technology — Open Systems Interconnection — Conformance testing methodology and framework
[12] OPEN ALLIANCE: 10BASE-T1x MAC-PHY Serial Interface – Revision 1.1

TERMS AND DEFINITIONS

For the purposes of this document, the terms and definitions given in [1] - [10] apply.

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

[1] ISO Online browsing platform: available at https://www.iso.org/obp

[2] IEC Electropedia: available at http://www.electropedia.org/

Node term definition:

End Node	A node that is at either end of a mixing segment. There are no other nodes between the End Node and the 100Ω edge termination. The End Node may contain the 100Ω edge termination.
Drop Node	Any node that is located between the two end nodes
Coordinator	This is the node configured as aPLCALocalNodeID=0 that is responsible for the periodic transmission of the BEACON and configuring the number of transmit opportunities between each BEACON.
Follower	Followers are any nodes configured as aPLCALocalNodeID=1..254. They synchronize their transmit opportunity counter with the reception of the periodic BEACON transmitted by the coordinator
Head Node	This is the highest-level application node on the mixing segment. It typically implements a switch or gateway access to the core network beyond the bus segment.

Note: It is expected that each mixing segment includes one Coordinator Node, one Head Node, and two End Nodes. The Coordinator and Head Node functions may be implemented in any physical node (including End Nodes) and may be combined into a single physical node or separate physical nodes.

Mixing Segment States:

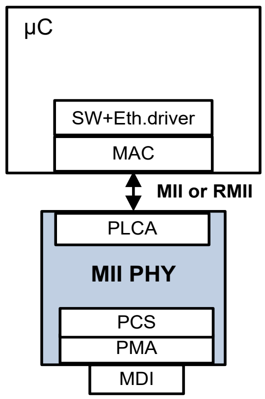
Quiet Link Segment	A 10BASE-T1S network segment in which there is no activity on the physical medium.
Partial Link Segment	A 10BASE-T1S network segment with at least one node transmitting on the physical medium. (Including PLCA beacons)

a. Wake-up/Sleep : In the context of this specification the term “Sleep” indicates entry to low power state and the term “Wake-up” indicates the exit from a low power state.
b. State diagrams follow the conventions outlined in section 147.1.3.1 of [1].

Different 10BASE-T1S PHYs implementations

Following table describes an overview of the different possible 10BASE-T1S PHYs implementations that are covered by this test specification.

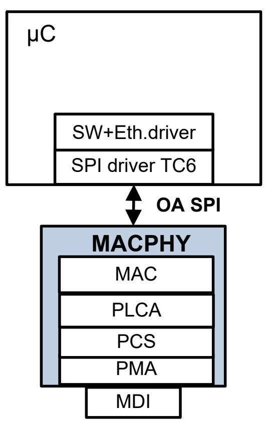
PHY with MII



PLCA integrated in PHY: transparent for every uC

Compatible with every MAC controller supporting Half-duplex

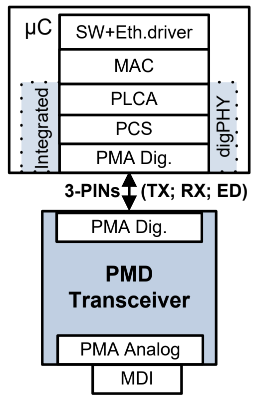
PHY with SPI (MACPHY)



Low-cost ECU without MAC and smaller interface

Requires Ethernet frame processing over SPI interface as defined in [12].

PMD Transceiver



The 10BASE-T1S PMD Transceiver is a simple and cost effective solution with 3-pin clock-less interface between the host controller and the PMD transceiver chip suited for embedded systems where the digital portion of the PHY is fully integrated into an MCU, an Ethernet switch core, or any other suitable host where only the analog portion is left into a separate chip (i.e., the PMD transceiver).

See [9] for interface definitions.

7 ORGANIZATION OF TESTS

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

7.1 Elementary test structure

The main structure description of a test case is shown in Table 1. A brief description about the meaning of each field is provided.

Table 3: Main test structure

Purpose	A short description of the purpose of the test case is given here.
Reference	
Prerequisites	A list of requirements and capabilities needed for a proper test conduction
DUT set-up	The respective test environment setup is specified (e. g. if different test case sequences will require different test system configuration)
Test description	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.
Notes	When necessary, a note will be added complementing the information of the test case.

7.2 Test case instance structure

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

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.

Table 4: Test case instance structure

Instance Test Case #	Description	Parameter	Condition
AX.XX	Description of the test cases belonging to this subgroup	α	conditions under which the variables are applied either in different configurations or stress conditions.
AX.XX		β	

8 LAYER 1 INTEROPERABILITY TEST DEFINITIONS

8.1 General requirements

ID: 10BASET1S_L1_IOP_1

Type: Information

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

ID: 10BASET1S_L1_IOP_2

Type: Requirement

The PCB layout of 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: 10BASET1S_L1_IOP_3

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 status, to enter in SLEEP mode, to send wake-up requests or to detect the wake-up source.

ID: 10BASET1S_L1_IOP_4

Type: Requirement

All monitoring activities shall be done by 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: 10BASET1S_L1_IOP_ 5

Type: Requirement

For all Layer 1 Interoperability test cases, 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 DUT. If multiple qualified link partners are available, the test against multiple link partners is mandatory.

ID: 10BASET1S_L1_IOP_6

Type: Requirement

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

ID: 10BASET1S_L1_IOP_7

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: 10BASET1S_L1_IOP_8

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: 10BASET1_L1_IOP_9

Type: Requirement

A test instance of a test case shall be considered as passed, if no test iteration failed.

ID: 10BASET1_L1_IOP_10

Type: Requirement

Unless differently indicated the tests shall be conducted at ambient temperature (RT) (23 ±2°C).

8.2 Tester definition

As mentioned below the implementation follows the local test method.

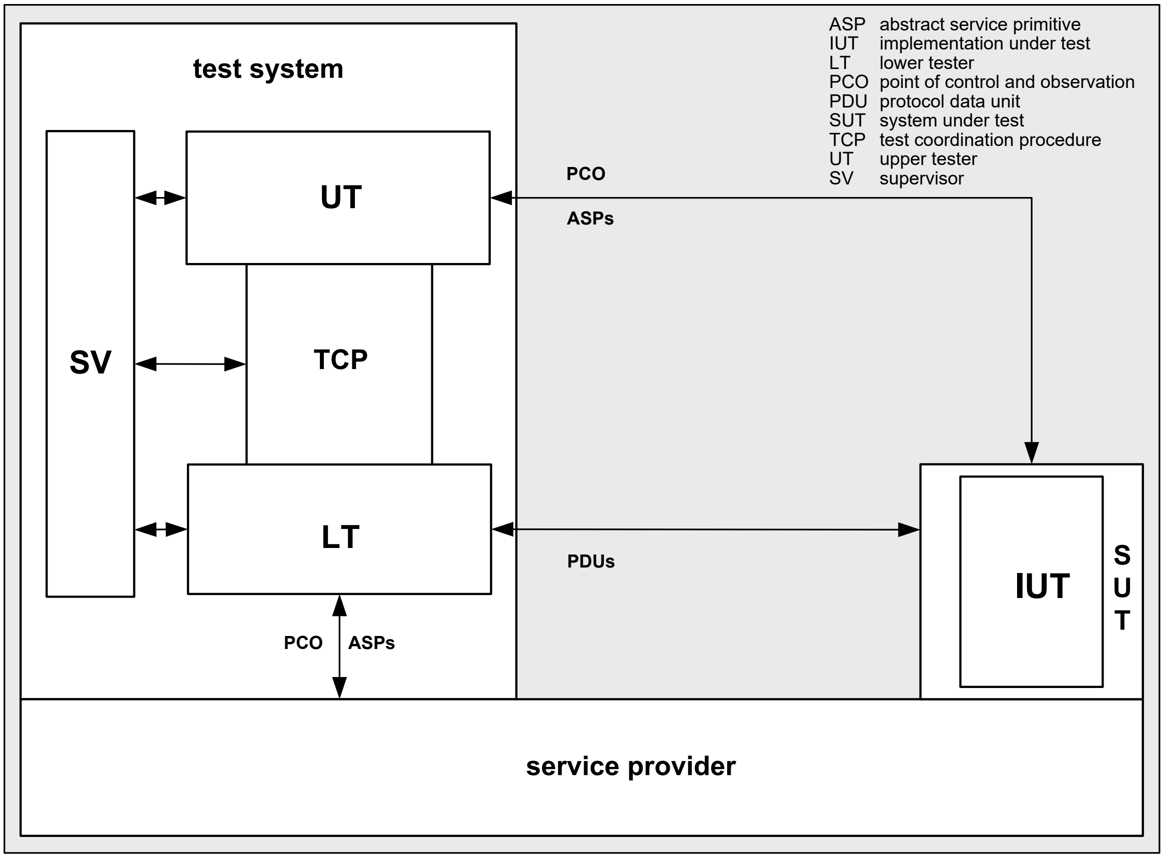


Figure 8-1: Sequential behavior tests with standard network environment

In the following sections are defined the components of the tester architecture.

8.2.1 Upper tester

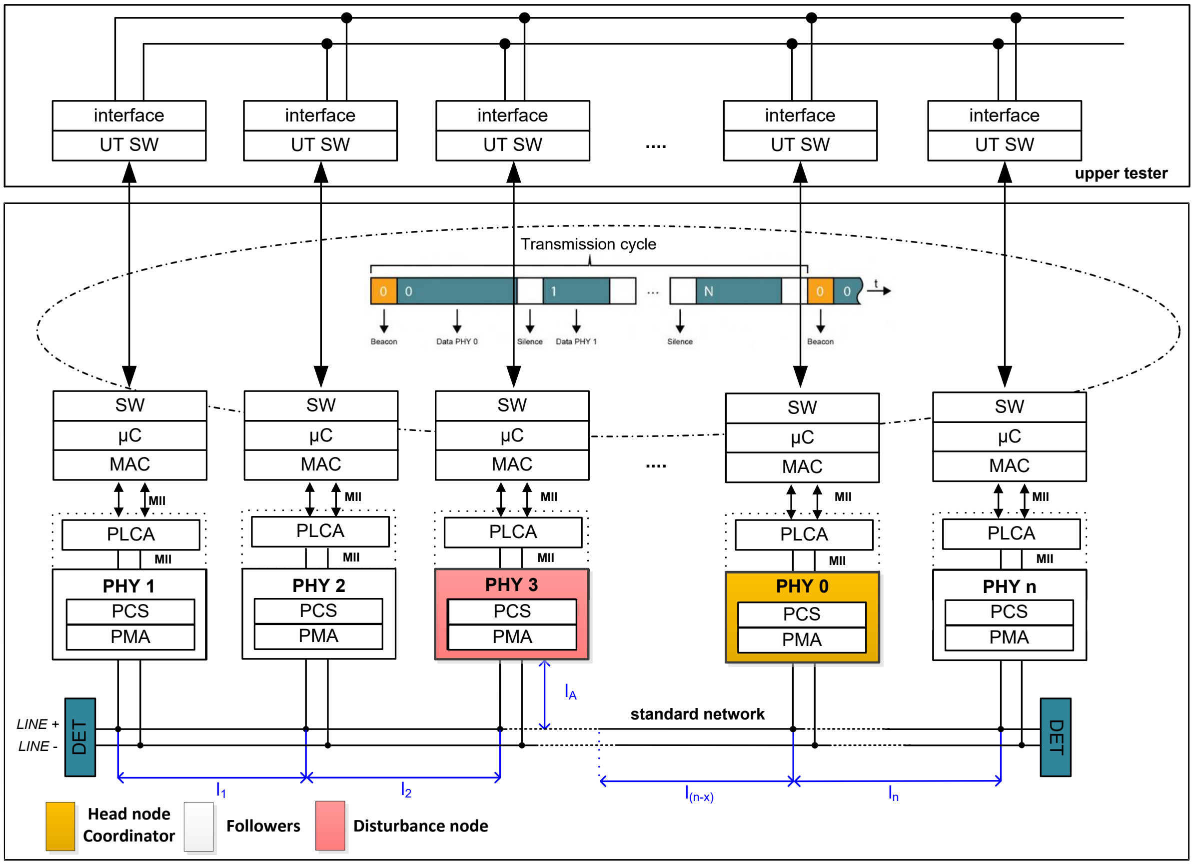


Figure 8-2: Upper tester – Example with nodes populated with PHYs with MII

Control and observation of the upper service boundary of the IUT is provided by the UT.

a. enable PLCA functionality.
b. transmit Ethernet frames.
c. revert to CSMA/CD operation by disabling PLCA functionality.
d. receiving transmitted cycles to check proper reception of communication.
e. check PHY Status and diagnostic features.

8.2.2 Lower tester

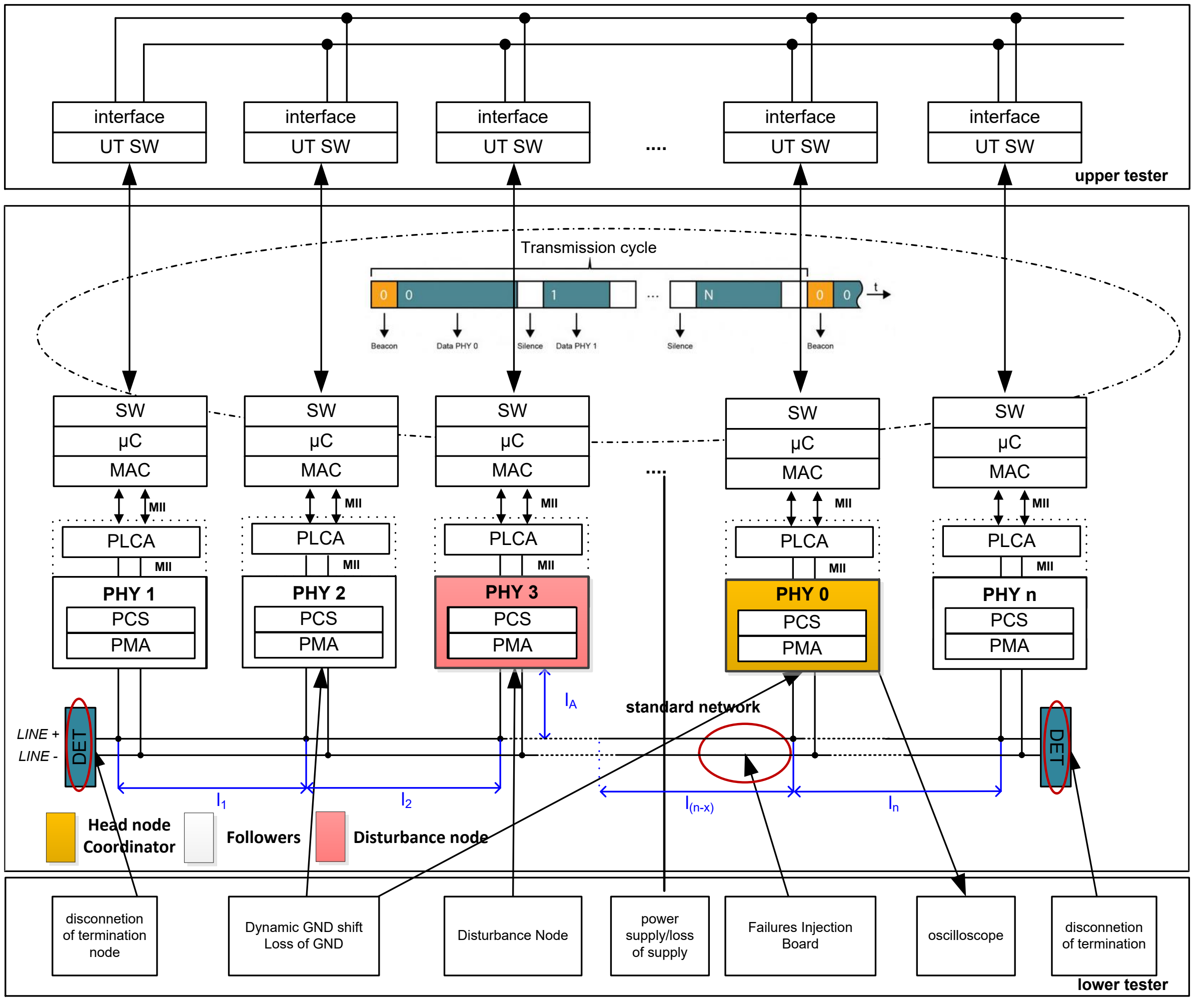


Figure 8-3: Lower tester - Example with nodes populated with PHYs with MII

Indirect control and observation of the lower service boundary of the IUT is provided by the LT via the underlying service provider. The generators/recorders of the LT have several functions:

a. generating and controlling failure injections on the bus.
b. generating and controlling termination failures.
c. generating loss of supply.
d. generating loss of GND.
e. generating GND shift.
f. generating distortion patterns.
g. measurements to check signal integrity (e.g. eye diagrams or masks).

8.2.3 Supervisor

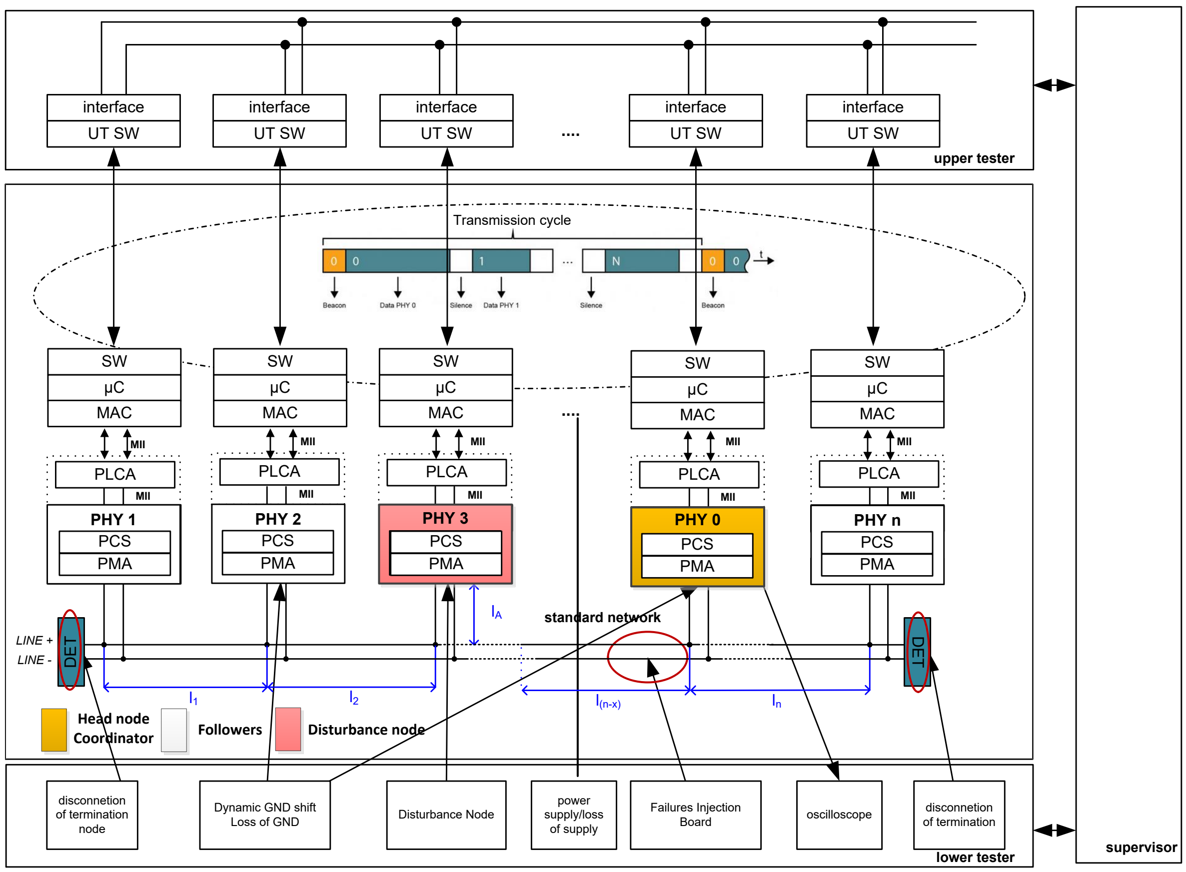


Figure 8-4: Supervisor

To coordinate the test procedures the SV offers several services:

a. SV sets IUT to a defined initial state according to specification of test case TestCaseNumber by using dedicated services of UT and LT
b. SV starts execution of test case TestCaseNumber according to specification by using dedicated services of UT and LT
c. SV records behavior of IUT while executing test
d. SV uploads the information from the recorders and comparison of recorded behavior with the expected response according to specification of test case TestCaseNumber
e. SV generates a test report with relevant information and test verdict.

8.3 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. 802.3cg, [4] and [6].

8.3.1 Channel type 1 (P2P link segment) [H1]

ID: 10BASET1S_L1_IOP_11

Type: Requirement

The parameters of the Type 1 channel (25m link segment with 4 filter boards - without stubs) are derived from the limit definition for a communication channel according to IEEE P802.3cgTM [1] and OPEN Alliance TC9 definitions for 10BASE-T1S communications channel.

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 7.2 of [6].

8.3.2 Channel type 2 (mixing segment) [H2]

ID: 10BASET1S_L1_IOP_12

Type: Requirement

The Type 2 channel (25m mixing segment with 8 stubs) are derived from the limit definition for a communication channel according to IEEE P802.3cgTM [1] and OPEN Alliance TC9 definitions for 10BASE-T1S communications channel

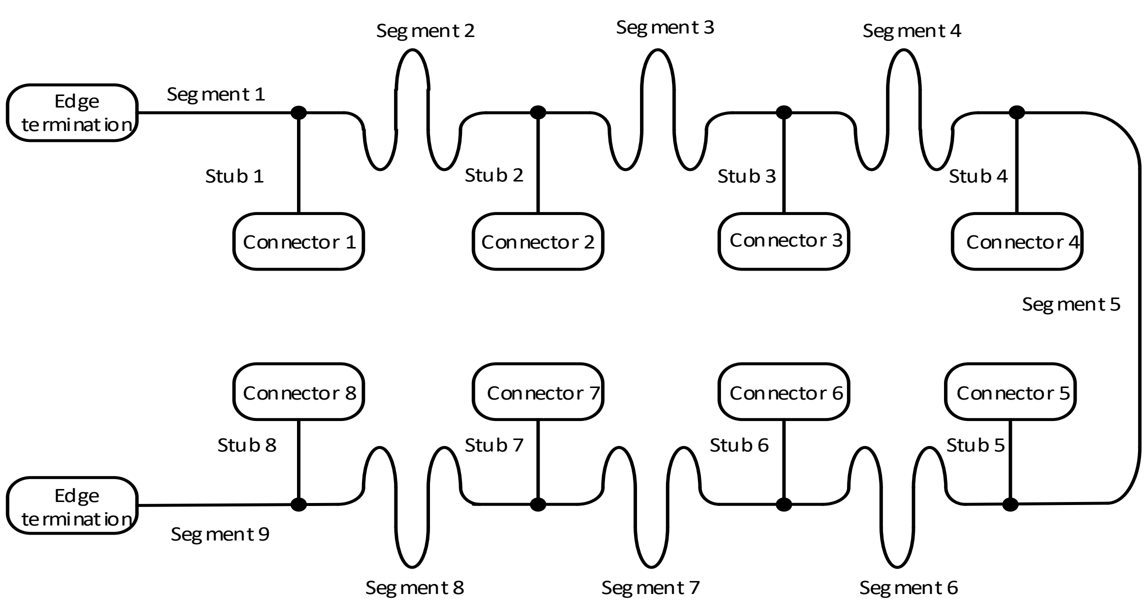


Figure 8-5: Example for channel type 2 implementation – Topology

Table 5: Example for channel type 2 implementation – Parts

Part	Reference	Description	Type
Termination	DET	Differential end termination (100Ohm±1%)	
Segment 1; 9	lDET	<0.3 m cable	FLR9Y 2*0.35 QMM-SN SL13 KroSchu 64996567 or equivalent
Segment 2	l12	4 m cable	same as segment 1
Segment 3	l23	2 m cable	same as segment 1
Segment 4	L34	4 m cable	same as segment 1
Segment 5	l45	0.5 m cable	same as segment 1
Segment 6	l50	0.5 m cable	same as segment 1
Segment 7	l06	13.5 m cable	same as segment 1
Segment 8	l67	0.5 m cable	same as segment 1
Stub1-8	lSTUB	0.1 cable	same as segment 1
Connector 1- 8		Connector	MQS or equivalent

The parameters in Table 5 follow the example channel defined in [6].

8.4 Standard networks - Topologies of wire harness

ID: 10BASET1S_L1_IOP_13

Type: Requirement

10BASE-T1S PHYs shall operate using half-duplex communications on a mixing segment using a single balanced pair of conductors, interconnecting 8 nodes to a trunk up to at least 25 m. Nodes shall be attached to the trunk at the end of stubs with a length of 10 cm.

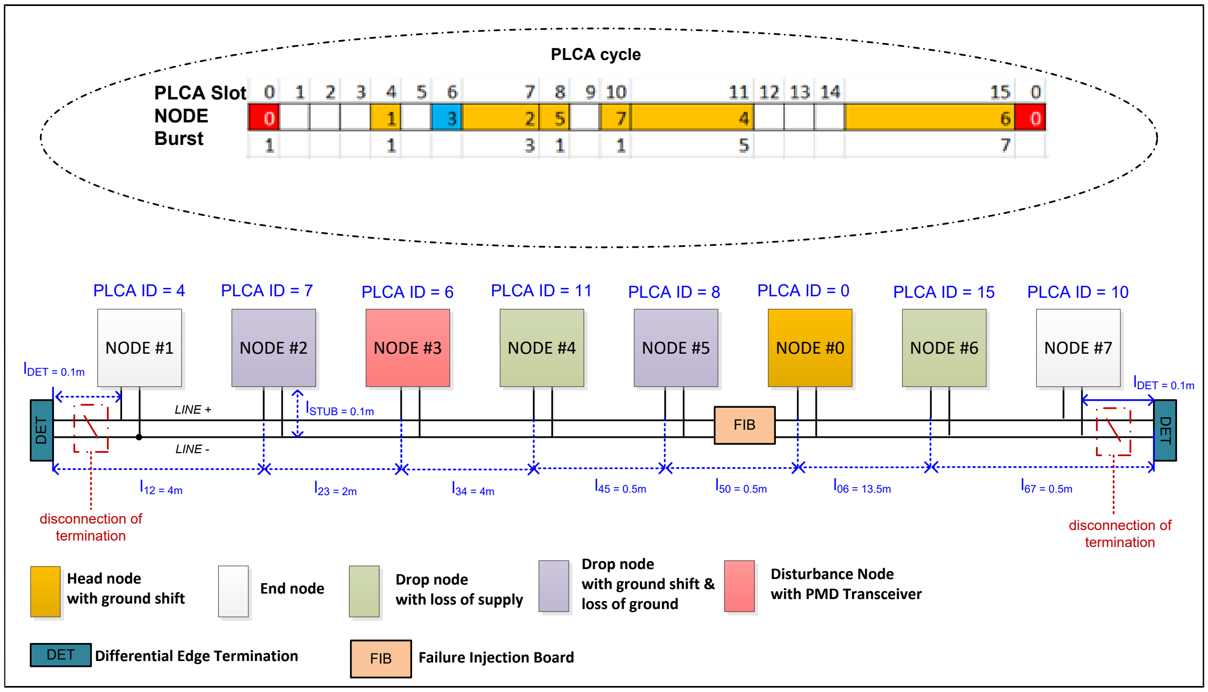


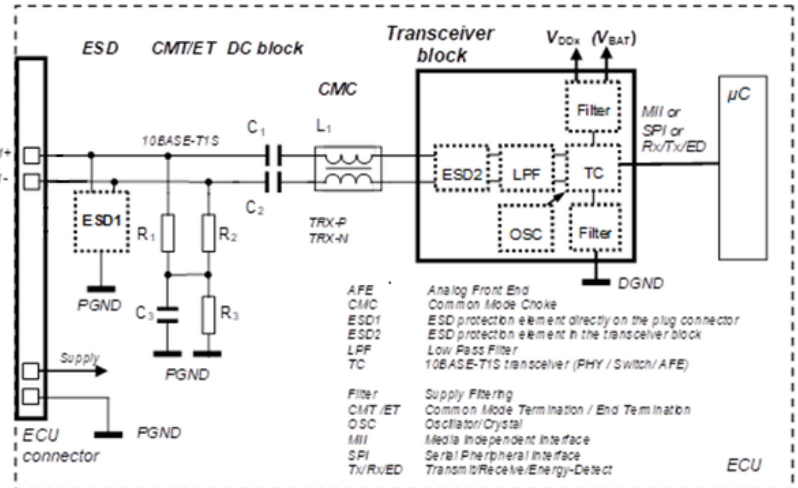
Figure 8-6: Interoperability Topology

Unless it is differently indicated, the head node is configured as coordinator node and drop, and end nodes are configured as follower nodes. The total wire length of the trunk bus between both differential end terminations is 25 m, each node is connected to the trunk with a 10cm stub. A Failure Injection Board shall be mounted between nodes 0 and 5.

Table 6: Standard networks configurations

	Mixing segment multidrop topology	P2P link segment
Reference environment	Interoperability Topology	Diagnostic Topology
Number of nodes (#n)	8	2
Definition of µC / board	Supporting either MII, SPI (MACPHY) or 3-pin clock-less interface (PMD Transceiver)	
Termination	Differential edge termination separated	Node termination
Stubs length (lA) [m]	0.1	n.a.
Splice distances (lx) [m]	As defined in Section 7.3 of [12].	As defined in Section 7.2 of [12].
Channel	Automotive grade unshielded twisted pair (UTP) cable for 10BASE-T1S as defined in [4]	

<table>
<tr>
<td>Node coupling</td>
<td>
As defined in Section 5.3 of [6].



R_1, R_2

CM: Common mode termination (optional) only for Drop Nodes.

ET: Differential end termination. R1, R2 shall not be populated in End Nodes since the electrical termination in H1 and H2 is included in a single stand-alone termination unit at the mixed segment ends in the harness.
</td>
</tr>
<tr>
<td>Location of failures</td>
<td>
disturbing node #3

disconnection of differential end terminations located close to nodes #1 and #7

failure injection board is mounted between nodes #0 and #5

dynamic ground shift and loss of ground located in nodes #0, #2 and #5

loss off supply located in nodes #4 and #6
</td>
</tr>
<tr>
<td>Location of DUTs in Heterogeneous configuration</td>
<td>
DUTs: Nodes #0; #2; #6

LP1: Node(s) #1; (#5)[2]

LP2: Node(s) #4; (#7)[3]

LP3: Node #5

LP4: Node #7
</td>
</tr>
</table>

[2] if there are less than 3 LPs available.
[3] if there are less than 4 LPs available.

8.5 PLCA configuration

PLCA parameters not mentioned here shall be set to “default” according to [8] and [1]. dPLCA is outside the scope of this document.

The TO_TIMER is to be set at 32-bit times.

8.5.1 PLCA configuration standard mixing segment network [H2]

The nodes are numbered from 0 to 7. Node 0 is configured to be the beacon master. Node number 3 is not a complete node. It is used to drive distortions on the bus via a PMD transceiver that is driven from a signal generator. Nodes with odd numbers get a PLCA ID that is equal to the number plus three (i.e., node 5 has PLCA ID 8), else twice the number plus three (node 2 gets PLCA ID 7). Node zero gets PLCA ID zero.

Each node with an even number is sending a burst of messages, where the number of messages in the assigned PLCA slot equals the node number plus one (i.e., node number 6 sends a burst of 7 messages). Odd numbered nodes and node 0 only send one message. So, in total a maximum of 20 messages will be sent in one PLCA cycle[4].

The maximum slot number (TO) is 15, so that the beacon follows immediately after the message burst sent from node 6.

Depending on the use case nodes may also not send at all within one PLCA cycle, they are either active or inactive. Depending on the test case node 3 may or may not send in PLCA slot 6. Node 3 may also send in other slots to cause disturbance on purpose.

The amount of data per message and the data itself that is to be sent in each message is defined in the section 8.6.

PLCA Slot	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	0
Node	0				1		3	2	5		7	4				6	0
Burst	1				1			3	1		1	5				7	1

Figure 8-7: PLCA cycle in standard mixing segment network [H2]

[4] The PLCA cycle duration is predictable in the following examples with a TO_TIMER of 32 bits:
= BEACON_TIMER + (MAX_ID + 1) * (8 octets <preamble + SFD> + 1522 octets <header, payload, CRC> + at least 12 octets <IPG> = 20 bits + **n** * (8*(8+1522+12)) + m * TO_TIMER
If **n** = 19 and **m** = 9 (empty TOs) :
considering longest Ethernet frame: 1518-byte packets will result in 246,740 + 9 *32= 247,028 bits for 10Mbit/s ~ 24.7 ms
considering shortest Ethernet frame: 64-byte packets will result in 14,100 + 9 *32 = 14,388 bits for 10Mbit/s ~ 1.44 ms
ShorterPLCACycle following above configuration:
= (MAX_ID + 1) * TO_TIMER + BEACON_TIMER = 16 * 32 bits + 20 bits = 532 bits for 10 Mbit/s ~ 53.2 us

8.5.2 PLCA configuration in point-to-point link segment [H1]

The nodes are numbered from 0 to 1. Node 0 is configured to be the beacon master. The maximum slot number (TO) is 1, so that the beacon follows immediately after the message send from node 1.

The amount of data per message and the data itself that is to be sent in each message is defined in the section 8.6.

PLCA Slot	0	1	0
Node	0	1	0
Burst	1	1	1

Figure 8-8: PLCA cycle in point-to-point link segment [H1]

8.5.3 PLCA configuration used in some test cases with mixed operation of PLCA and non-PLCA nodes

To rely on message counters, used in the test approach, the PLCA communication cycle should be defined to avoid physical collisions, that will occur if a CSMA/CD node starts transmitting at the same time as a PLCA-enabled node, for that the number of consecutive empty TOs slots should be higher than IPG length. For example, if the TO_timer is defined with 32-bit times, then 3 consecutive empty TOs slots shall be avoided, as 3.2us * 3 = 9.6us = IPG length.

IEEE clause 4 (4.2.3.2.1) governs MAC behavior including half-duplex deference behavior.

IPG1 = idle count time; IPG2 = IPG - IPG1 = delay time

→ IPG at MAC is IPG1+IPG2 = 96-bit times

For MII xmit[5] , IPG1 time (re)starts when CRC goes low

For RMII xmit, deference time starts when TXEN goes low (i.e. earlier)

Some MACs might use IPG1 < 64-bit times, e.g. 32-bit times. Consequently 32-bit times of idle might be sufficient to launch a packet which will emerge 64-bit times later. Therefore, gaps with one or two empty TOs slots shall also be avoided.

For gaps of 4, 5, 6 empty TOs, it is also important to prevent more than one packet in queue at any point in time. The following recommendations should be considered to avoid collisions.

c. Ensure that the transmit buffer is empty by stopping transmission early on the node that will switch to CSMA/CD.
d. Wait for a settling time before using the CSMA transmitter.
e. Conditionally queue packets, i.e., delay queuing after successful transmission by a time slightly less than a typical PLCA cycle.
f. CSMA/CD node should always start data transmission after all PLCA nodes start data transmission and stop data transmission always before other PLCA nodes stop data transmission

[5] The variable xmit in Ethernet refers to the transmit function or process.

PLCA Slot	0	1	2	3	4	5	6	7	8	9	10	11	0
Node	0				1		3	2	5	6	7	4	0
Burst	1				1			3	1	7	1	5	1

PD1:Node in CSMA/CD

Figure 8-9: PLCA cycle in some test cases with mixed operation of PLCA and non-PLCA nodes

8.6 Message transfer

There shall be three message transfer modes.

When messages are sent, then PLCA is active on all nodes.

M1: all frames have **maximum length** (1500 bytes in the data field)

M2: this message transfer is having all TO slots without transmission, i.e., **empty spots**.

The addresses in a frame shall be:

Destination address DA = Broadcast, so all nodes can check counters and report an error (within their frames)

Source address SA = Unique in each node

Each node shall maintain and transmit the following parameters:

CycleCounter (CC) (16 bit) increases when the message sent by the PLCA beacon master has been received; this message can be identified by the source address (SA).

SequenceNumber (SC) (8 bit), recent number of messages in a burst. The sequence number indicates the last received frame of a burst. The node sending the burst increments the sequence number by 1 after each successfully sent frame until the maximum number of burst frames for the node is reached.

MessageCounter (MC) (32 bit), increases, with each message sent by this node

StatusInformation (SI) (16 bit), to be defined:

- state of health (PLCA Status, SQI if supported, local/remote jabber indication),
- information to synchronize stress conditions applied alternating and cyclically in a decentralized manner like for example loss of power or variable terminations.
- dedicated *Request commands* (for example, node 0 can request other nodes to reset counters or to stop communication and enter low power mode).

aPLCALocalNodeID (PLCA ID) (8 bit), static value

(10 bytes data field up to here, remaining 1490 bytes for padding)

Data field layout: [CC, SC, MC, SI, PLCA ID, Padding]

Padding pattern in M1 (fixed length 1490 bytes):

[0xFF, 0xFE, ...0x01, 0x00] 256 bytes, decreasing

64 x [0x00]	64 bytes constant 0x00

[0x00, 0x01, ... 0xFE, 0xFF]	256 bytes, increasing

64x [0xFF]	64 bytes constant 0xFF

[0x0F, 0x0E, ...0xF1, 0xF0]	256 bytes, decreasing, XORed with 0xF0

64x [0xAA]	64 bytes constant 0xAA

[0xF0, 0xF1, ... 0x0E, 0x0F]	256 bytes, increasing, XORed with 0xF0

64x [0x5A]	64 bytes constant 0x5A

Followed by

210 x [0x3C]	210 bytes constant 0x3C

8.7 Power and Stress conditions

8.7.1 Nominal Battery Voltage

Unless differently indicated the nominal battery voltage used in this specification is 14V ± 0.1V.

8.7.2 Static and Dynamic ground shift

The ground shift is located between the chassis and the predefined system ground connection of the used DUTs.

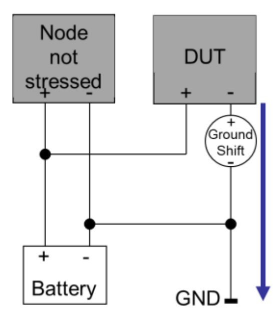


Figure 8-10: Example of ground shift connection

If no dynamic ground shift is applied, there shall also be no static offset between the nodes.

If a dynamic ground shift is applied, then the parameters shall be as follows:

Waveform:	sinus

Amplitude:	3 V (peak-peak)

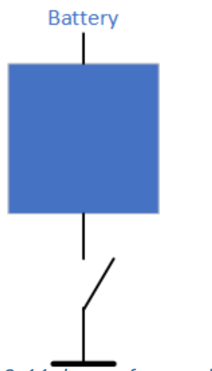
Frequency:	100 Hz to 500 KHz

Frequency sweep time: 0.7 seconds (node 0) [GS0]
1.1 seconds (node 2) [GS2]
1.3 seconds (node 5) [GS5]

If ground shift is applied at more than one node concurrently, then it is denoted as e.g. [GS25]. In this case the frequency sweep of the node with the higher ID will be applied.

If a static ground shift is applied, then 2 V ± 0.1V static offset between the nodes is applied. [GSS].

8.7.3 Loss of ground



While the supply voltage shall be a constant to its nominal level, the ground may be disconnected causing the entire node to assume the battery voltage. Disconnection can be realized by a relay contact. The supply on the disconnected board shall not be shortened. This shall be possible to be tested with nodes 2 and 5 denoted as [LG2] | [LG5] | [LG25]; the latter one in case both nodes lose ground concurrently.

In case loss of ground is applied, nodes 2 and 5 do not need to communicate at all. The node needs to return to normal operation after ground has been re-connected.

Figure 8-11: Loss of ground

8.7.4 Loss of power

On nodes 4 and 6 the supply of the DUT can be short-circuited, so that a fast decline from nominal supply condition to power off is realized. This shall also be possible to happen while a frame is transmitted. The cases are denoted as [LP4] | [LP6] | [LP46]; the latter one in case both nodes lose power concurrently.

In case loss of power is applied, nodes 4 and 6 do not need to communicate at all. The node needs to return to normal operation after power has been re-connected.

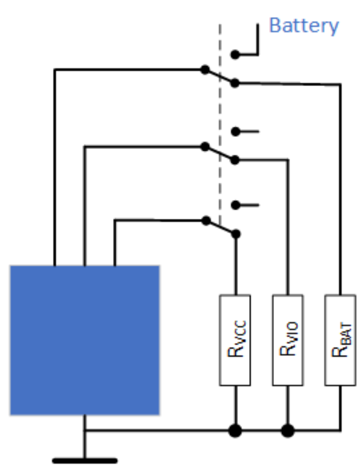


Figure 8-12: Loss of power

If the battery input is disconnected from the battery supply voltage, then all supplies shall be discharged (mind that the resistor to discharge on battery voltage can only take effect if mounted on the cathode side of polarity protection diode).

8.7.5 Failure injector board

Wire harness failures [15]:

[FIB1]: CHxBATw - Eth P short to battery weak (via 62Ω)

[FIB2]: CHxBATh - Eth P short to battery hard (0Ω)

[FIB3]: CLxBATw - Eth N short to battery weak (via 62Ω)

[FIB4]: CLxBATh - Eth N short to battery hard (0Ω)

[FIB5]: CHxGNDw - Eth P short to ground weak (via 62Ω)

[FIB6]: CHxGNDh - Eth P short to ground hard (0 Ω)

[FIB7]: CLxGNDw - Eth N short to ground weak (via 62Ω)

[FIB8]: CLxGNDh - Eth N short to ground hard (0Ω)

[FIB9]: CHxCLw - Eth P short to Eth N weak (via 1KΩ)

[FIB10]:CHxCLh - Eth P short to Eth N hard (0Ω)

[FIB11]: CH_pass_w - Eth P bus line "weak open" (via 1KΩ)

[FIB12]: CH_pass_h - Eth P bus line open

[FIB13]:CL_pass_w - Eth N bus line "weak open" (via 1KΩ)

[FIB14]:CL_pass_h - Eth N bus line open

[FIB15]:CHxCLt - 3rd Termination (via 100Ω)

8.7.6 Termination mismatch

The termination may be missing or even a third termination resistor may be present. After correcting the termination, the communication system shall resume operation.

[T1]: Differential End Termination close to node 1 is missing

[TFIB]: Additional Termination on Failure Injection Board (FIB - [FIB15]) is present

[T7]: Differential End Termination close to node 7 is missing

[T17]: Both differential end terminations are missing

Nominal termination is 100 Ω. All parameters for differential edge termination are defined in section 6.4 of [6].

8.7.7 PLCA reconciliation sublayer functionality disabled

The system may also be stressed by one or more nodes that have PLCA disabled and thus access the bus with CSMA/CD method.

[PD0] node 0 has PLCA disabled

CSMA/CD – fallback operation in automotive. The Coordinator is sent to CSMA/CD, the entire network goes to CSMA/CD – fallback operation and then the Coordinator recovers (PLCA enable) and starts sending BEACONs again, normal PLCA operation resumes.

[PD1] node 1 has PLCA disabled

A node not using PLCA shall send its frame or burst cyclically every 14[6] ms approximately (in case of using PLCA H2 and M1,). *(Make sure that this time is slightly shorter than a typical PLCA cycle).*

Note: When devices are configured as a PLCA Follower, the PLCA Status (PST) bit in the PLCA Status (PLCA_STS) register will be set as long as BEACONs are regularly being received from a Coordinator. If BEACONs are not received by the device, it will continue incrementing its transmit opportunity counter. When the transmit opportunity counter reaches the maximum count of 255, it will then stop incrementing and timer started. If no BEACON is received after the timer expires, the PLCA Status bit will be cleared. When the PLCA Status bit is zero, the device will revert to CSMA/CD operation with PLCA deactivated. Once a BEACON is received the device will set the PLCA Status bit and return to normal PLCA operation. Refer to Clause 148 of [1] for additional details.

8.7.8 Artificial degradation of channel quality - Gaussian noise

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 14.1 an example for practical implementation can be found.

8.7.9 Distortion pattern occurring on the bus wires

"Node 3" is driving the distortion patterns onto the bus.

The following distortion patterns are denoted with a resolution of 20 ns per data point, a "x": means "no drive" on the bus. (Implementation needs to be in LVDS, PMD transceivers or discrete transistors – to be decided).

Patterns are either applied "free-running", with no phase relation to the PLCA, or have a defined phase relation (skew) to the start of the PLCA cycle to allow sweeping the distortion over the entire PLCA cycle.

---

[6] To avoid physical collisions, no data is sent from Node #6 in the mixed CSMA/CD and PLCA node test cases to have enough consecutive empty TOs (longer than the IPG length), then the PLCA cycle duration is:
= 20 bits + n * (8*(8+1522+12)) + m * TO_TIMER =14.837 ms
where n = 12 (number of longest Ethernet frame: 1518-byte packets in the PLCA cycle) and m = 10 (empty TOs)

Collisions may or may not cause re-transmissions and/or switch a node from PLCA active to CSMA/CD behavior.

Defined distortion patterns are:

[DP1]: xx11 11xx

[DP2]: xx00 00xx

[DP3]: xx11 00xx

[DP4]: xx00 11xx

[DP5]: xx10 10xx with this, pulses twice as short as normal occur

[DP6]: xx01 01xx with this, pulses twice as short as normal occur

[DP10]: xxxx 1111 0011 0000 1111 xxxx this is "almost" a beacon

[DP11]: xxxx 0000 1100 1111 0000 xxxx this is "almost" an inverse beacon

[DP12]: xx11 1100 0011 0011 1100 00xx this is "SSD"

[DP13]: xx00 0011 1100 1100 0011 11xx this is inverse "SSD"

[DP14]: xxxx 0000 1100 1100 1111 0011 xxxx this is SUSPEND

[DP15]: xxxx false SUSPEND signal, e.g. 2 SUSPEND symbols followed by a 5B symbol which is not a SUSPEND symbol, it should not lead to a SUSPEND signal being detected

[DP30]: <Beacon> the collision of beacons shall be enforced

[DP31]: <WUP> Wake-up pulse (incl SUSPEND, WUT, COMMIT, ESD and ESDOK)

[DP40]: xxxx 1010 1010 1010 1010 1010 1010 1010 1010 xxxx "noise"

[DP50]: this is a part of a frame, emulating a transmission that suddenly aborts in the data-section.

[DP51]: this is in principle a frame but has 1550 bytes (>1500) in the data-section.

8.8 Summary of variables

8.8.1 Setup

Wire harness (topology):	(2)	H1 | H2
Message transfer:	(2)	M1 | M2

8.8.2 Stress factors

Ground shift:	(8)	GS0 | GS2 | GS5 | GS05 | GS02 | GS25 | GS025 | GSS
Loss of ground:	(3)	LG2 | LG5 | LG25
Loss of power:	(3)	LP4 | LP6 | LP46

Failure injector board	(14)	FIB1 | … | FIB14
Variable Termination	(4)	T1 | TFIB | T7 | T17
Distortions Pattern	(16)	DP1 | DP2 | … | DP51
PLCA disabled	(2)	PD0 | PD1

8.9 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: 10BASET1S_L1_IOP_14

Type: Requirement

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

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

a) Conformance Tests
   1. OA- 10BASE-T1S Physical Media Attachment Conformance Test Suite
   2. OA- 10BASE-T1S Physical Coding Sub-Layer Conformance Test Suite
   3. OA- 10BASE-T1S Physical Layer Collision Avoidance Conformance Test Suite

b) Interoperability Tests
   1. OA- 10BASE-T1S Interoperability Test Suite

ID: 10BASET1S_L1_IOP_15

Type: Requirement

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

ID: 10BASET1S_L1_IOP_16

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: 10BASET1S_L1_IOP_17

Type: Requirement

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

9 TEST SCENARIOS

Within this chapter the test cases related to homogeneous or heterogeneous network tests are described. The test cases are gathered within 4 main sub-groups of test cases as disclosed below:

Group 1 – Interoperability

- [N] Normal communication of transmission cycles in presence of different physical stress conditions
  g. All nodes are powered and in normal mode.
  h. Communication is established, no stress is applied.
  i. After 1 second stress factors according to test instance are applied.
    a) Normal communication, undisturbed
    b) Loss of Ground; Dynamic Ground-shift → behavior to the rest system -> no influence on the communication
    c) Loss of power→ "partial networking" i.e. switching more than 1 node off / on (DUT should have a passive behavior on the bus) → no influence on the rest communication.
    d) Bus failure → Influence on the rest communication
    e) Revert to CSMA/CD operation by disabling PLCA functionality at some nodes → Influence on the rest communication.
    f) Termination variation → Influence on the rest communication
    g) Frames with a random number of data bytes for stressing of clock synchronization and PLCA state machine
    h) Distortion pattern → Collisions may or may not cause re-transmissions and/or switch a node from PLCA active to CSMA/CD behavior.
- [S] Start-up cycles in presence of different physical stress conditions
  j. All nodes are powered and in normal mode, but no communication started.
  k. Stress factors according to test instance are applied.
  l. Communication shall start-up, communication of all nodes is started concurrently triggered by the test system.
    a) Startup with Ground-shift
    b) Startup after bus failure
    c) Startup of multiple nodes at the same time

Group 2 – PHY Diagnostic features set

- [DCQ] Signal Quality
    a) SQI Estimate Value (DCQ.SQI)
      - Indicated signal quality for channel with decreasing quality.
      - Indicated signal quality for channel with increasing quality
- [HDD] Cable Diagnosis
    a) Harness Defect Detection
      - cable OK
      - One bus wire OPEN
      - Both bus wires OPEN
      - Bus wires SHORT
      - both bus wires SHORT to GND and VBAT
- [PLCAD] PLCA diagnostic
    a) Beacon Received Before Transmit Opportunity (BCNBFTO)
    b) Unexpected Beacon (UNEXPB)

c) Duplicated node ID. Receive in Assigned Transmit Opportunity (RXINTO)

Group 3 – Wake-up/Sleep

- [W] Wake-up (optional, if supported)
  m. Communication is established while no stress is applied.
  n. Stress factors according to test instance are applied.
  o. Nodes shall be woken via the bus and communication shall start-up, node 0 to send the WUP triggered by the test system
    a) Wake-up from low power mode (Sleep/Standby), all nodes PLCA
    b) Wake-up from low power mode (Sleep/Standby), mixed PLCA and non-PLCA nodes
- [NW] No wake-up on distortions (optional, if remote Wake-up supported)
  i. All nodes are in low power mode
  p. After 1s stress factors according to test instance are applied. None of the nodes shall wake-up.
  ii. A group of nodes is in low power mode
    a. (Group 1 comprises nodes [2, 4, 6],
    b. Group 2 comprises nodes [1, 5, 7])

    Communication is started on the nodes not being in low-power mode, stress factors are applied, none of the nodes in low-power mode shall wake-up.
  iii. No wake-up by mixing PLCA and non-PLCA nodes

    The node in low-power mode shall not wake-up.
- [G] goto Sleep (optional, if Sleep supported)
    a) goto Sleep with ground shift, unless WUP
    b) goto Sleep with ground shift and mixed PLCA and non-PLCA operation
- [WF] Wakeup-forwarding (optional, if Sleep supported)
    a) Wakeup-forwarding with ground shift

Group 4 – Topology Discovery

- [T] Topology discovery detects the correct distance between nodes
  All nodes are powered, but no communication started.
  Stress factors according to test instance are applied.
  Topology discovery shall be performed, triggered by the test system.

    a) Topology discovery, controlled by higher layers
    b) Topology discovery, automatic mode

9.1 Test evaluation

For the evaluation of the tests the following shall be observed:

q. Status-register of the MAC
r. PHY Register (STATUS [local/remote jabber indication]; PLCA Diagnostic)
s. Interrupt pin of the PHY
t. For [TP] Test pattern test cases, applicable for PMD Transceiver: ED and RX signal at 3-wire-interface
u. SQI" values, if available

When message transfer is active the main evaluation criteria shall be

v. Loss of messages
w. Appearance of "ghost messages" (unexpected increase in message counter)

When bit patterns are sent in the PMA test modes the evaluation criteria shall be

x. Matching of received signal (RX, ED) to the signals that have been sent

9.2 PASS criteria

ISO16750-1; Class A: "All functions of the device/system perform as designed during and after the test." Cannot be expected to be fulfilled for all kind of distortions.

However, when the distortion is removed/switched-off, then the communication system shall resume operation.

ISO16750-1; Class C: "One or more functions of a device/system do not perform as designed during the test, but return automatically to normal operation after the test"

All data patterns [DP1, ... , DP51] send by the misbehaving node must not lead to more than the loss of one single frame, when no other failure condition is applied concurrently.

Details of the Pass criteria are given in each test description.

9.3 Test scenarios and combinations overview

Table 7: Test scenarios and combinations overview

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
N1	Normal com.	H2	M1	no	no	no	no	no	no	no	no
N2	Normal com.	H2	M1	no	yes	no	no	no	no	no	no
N3	Normal com.	H2	M1	no	no	yes	no	no	no	no	no
N4	Normal com.	H2	M1	no	no	no	yes	no	no	no	no
N5	Normal com.	H2	M1	yes	no	no	no	no	no	no	no
N6	Normal com.	H2	M1	no	no	no	no	no	yes	no	no
N7	Normal com.	H2	M1	no	no	no	no	yes	no	no	no
N8	Normal com.	H2	M1	no	no	no	no	yes	no	no	no
N9	Normal com.	H2	M1	no	no	no	no	no	no	no	yes
S1	Start-up	H2	M1	yes	no	no	no	no	no	no	no
S2	Start-up	H2	M1	no	no	no	yes	no	no	no	no
S3	Start-up	H2	M1	no	no	no	no	no	no	no	no
DCQ1	SQI	H1-ho[7]	M1m[8][1]	no	no	no	no	no	no	yes	no

[7] H1-ho / H2-ho: test conducted only in homogeneous configuration.
[8][1] M1m = M1 modified, the message transfer follows the M1 schema, but modifications are applied in eh PLCA configuration, for example lower amount of node participating in the PLCA cycle. Details of the corresponding modification are given in the respective test description.

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
HDD1	Error Free/No Fault	H1-ho[7]	n.a.	yes	no	no	yes	no	no	no	no
HDD2	FAULT reported	H1-ho[7]	n.a.	yes	no	no	yes	no	no	no	no
PLCAD1	BCNBFTO	H2-ho[7]	M1m[8]	no	no	no	no	no	no	no	no
PLCAD2	UNEXPB	H2-ho[7]	M2	no	no	no	no	no	no	no	no
PLCAD3	RXINTO	H2-ho[7]	M1m[8]	no	no	no	no	no	no	no	no
W1	Wake-up	H2	M1	yes	no	no	no	no	no	no	no
W2	Wake-up	H2	M1	no	no	no	no	yes	no	no	no
NW1	No wake-up	H2	M1	no	no	no	no	yes	no	no	no
NW2	No wake-up	H2	M1	yes	no	no	no	no	no	no	yes
NW3	No wake-up	H2	M1	yes	no	no	no	no	no	no	yes
NW4	No wake-up	H2	M1	yes	no	no	no	no	no	no	yes
G1	Goto sleep	H2	M1	no	no	no	no	yes	no	no	no
G2	Goto sleep	H2	M1	yes	no	no	no	no	no	no	yes
WF1	Wakeup-forwarding	H2	M1	yes	no	no	no	no	no	no	no
T1	Topology discovery	H2	n.a.	yes	no	no	no	no	no	no	no
T2	Topology discovery	H2	n.a.	yes	no	no	no	no	no	no	no

10 GROUP 1 – INTEROPERABILITY TEST CASES

ID: 10BASET1S_L1_IOP_18

Type: Requirement

The test cases defined in this section are mandatory for all 10BASE-T1S PHYs implementation, including DigPHYs and PMD Transceivers.

10.1 [N] Normal communication of transmission cycles in presence of different physical stress conditions

ID: 10BASET1S_L1_IOP_19

Type: Information

The test cases defined in this section shall ensure that the PHY is able to communicate with other PHYs from different vendor under diverse stress conditions. This scenario can be used for homogenous and also heterogenous (in that different PHYs are used) test configurations.

10.1.1 Group N1 – Normal communication, undisturbed

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
N1	Normal com.	H2	M1	no	no	no	no	no	no	no	no

Table 8: Main test structure of Group N1

Purpose	Purpose of the test is to check that communication between the nodes works as expected under nominal conditions.
Reference	[2] [6] [5]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations.

	7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount* = 16 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.

Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1.
	2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node.
	3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (Node #0) to start communication.
	4. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.
	    a. Messages are sent as broadcast, so all nodes can check counters and report an error.
	    b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message.
	    c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register.
	    d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register.
	5. Keep transmitting *MessageTransfer_M1* for at least 60 seconds.
	6. Read and record counters included in each received frame.
	7. Power-off all nodes.

Pass criteria	The test case shall be considered as passed, if all of the following condition(s) are fulfilled. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • The length of the PLCA cycle may be for information only. Beacons shall occur periodically with a constant period *of 23.5 ms ± 1 ms.* • For information purposes the number CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 9: Test case instances definition for Group N1 - Test case N1

Instance Test Case #	Description	Parameter	Condition
N1.1	Normal communication undisturbed	n.a.	n.a.

10.1.2 Group N2 – Normal communication with loss of ground

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
N2	Normal com.	H2	M1	No	yes	no	no	no	no	no	no

Table 10: Main test structure of Group N2

Purpose	Purpose of the test is to check that communication does not break down when nodes are losing the connection to ground.
Reference	[2] [6] [5]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount = 16* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section PLCA configuration standard mixing segment network [H2] 8.5.1. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (node #0) to start communication.

	4. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6. a. Messages are sent as broadcast, so all nodes can check counters and report an error. b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. 5. Keep transmitting *MessageTransfer_M1* for at least 90 seconds. 6. Loss of ground conditions at nodes #2 and #5, LG2 | LG5 | LG25, are applied following the conditions defined in Table 11. a. The counters [CC, SC, MC] at nodes that lose ground shall be reset or storage in a "new phase" each time when ground is connected, i.e. re-integrated in the communication. 7. Read and record counters included in each received frame. 8. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. There shall be no loss of messages except those from the nodes that lose ground connection. Nodes shall re-integrate when the ground is connected. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node, except those from the nodes that lose ground connection, should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored at nodes that lose ground should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes, except those from the nodes that lose ground connection, should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	Amount of test repetitions: n.a.
Notes	PHYs may spit out unwanted pulses when losing ground during reception or send non-nominal bus levels while facing brownout during transmission. The entire node set on battery voltage level, thus a common mode pulse on the bus can be expected.

Table 11 - Test case instances definition for Group N2 - Test cases N2.1 to N2.3

Instance Test Case #	Description	Parameter	Condition
N2.1	Normal communication with loss of ground of selected nodes	LG2 | LG5 | LG25	– Applied alternating and cyclically – One event per 1 second; condition remains for 0.1 seconds. – No timing relation to PLCA slots.
N2.2	Normal communication with chattering ground node 2	LG2	– Applied 8 times for 0.1 seconds with 0.1 seconds pause to simulate chattering contact and this is done repeatedly every 3 seconds. – No timing relation to PLCA slots.
N2.3	Normal communication with chattering ground node 5	LG5	

10.1.3 Group N3 – Normal communication with loss of power

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
N3	Normal com.	H2	M1	no	no	yes	no	no	no	no	no

Table 12: Main test structure of Group N3

Purpose	Purpose of the test is to check that communication does not break down when nodes are losing the connection to battery.
Reference	[2] [6] [5]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount = 16* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (node #0) to start communication. 4. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.

	a. Messages are sent as broadcast, so all nodes can check counters and report an error. b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. 5. Keep transmitting *MessageTransfer_M1* for at least 90 seconds for N3.1 or until each node has lost power at least 10 times for N3.2; see **Fehler! Verweisquelle konnte nicht gefunden werden.**. 6. After at least 1s of starting communication, loss of power conditions at nodes #4 and #6, LP4 | LP6 | LP46, are applied following the conditions defined in **Fehler! Verweisquelle konnte nicht gefunden werden.**. a. The counters [CC, SC, MC] at nodes that lose power shall be reset or storage in a "new phase" each time when power is re-connected, i.e. re-integrated in the communication. 7. Read and record counters included in each received frame. 8. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. There shall be no loss of messages except those from the nodes that lose power. Nodes shall re-integrate when power is re-connected. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node, except those from the nodes that lose power, should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored at nodes that lose power should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes, except those from the nodes that lose power, should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	Amount of test repetitions: n.a.
Notes	PHYs may spit out unwanted pulses when losing power during reception or send non-nominal bus levels while facing brownout during transmission.

Table 13: Test case instances definition for Group N3 - Test cases N3.1 to N3.2

Instance Test Case #	Description	Parameter	Condition
N3.1	Normal communication with uncorrelated loss of power	LP4 | LP6 | LP46	– Applied alternating and cyclically – One event per 1 second; Condition remains for 0.1 seconds. PHY supply to be discharged in this time span. – No timing relation to PLCA slots.
N3.2	Normal communication with correlated loss of power	LP4 | LP6	– Applied alternating and cyclically – Condition remains for 0.1 seconds – Loss of power shall happen during active message transmission of the node9[1]. – Wait for 1s before loss of power is applied again. Nodes need to recover before they can lose power again. – Test shall run until each node (LP4 | LP6) has lost power at least 10 times

9[1] The intention is that the message will not be completed on the bus

10.1.4 Group N4 – Normal communication with bus failures

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
N4	Normal com.	H2	M1	no	no	no	yes	no	no	no	no

Table 14: Main test structure of Group N4

Purpose	Purpose of the test is to check that communication recovers after bus failures have been applied and removed.
Reference	[2] [6] [5]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount = 16* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (node #0) to start communication. 4. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.

	a. Messages are sent as broadcast, so all nodes can check counters and report an error. b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. e. *LocalStatusInformation* at all nodes shall be reset or storage in a "new phase" each time when failure condition has been removed, i.e. re-integrated in the communication. 5. Keep transmitting *MessageTransfer_M1* for at least 3 seconds[10]. 6. Bus failure conditions are applied following the conditions defined in Table 15. a. When the bus failure has been removed and the physical integrity of the link has been fully restored (considering any bounce caused during the physical reconnection, e.g. contact settling time of the relay). The counters [CC, SC, MC] at all nodes shall be reset or storage in a "new phase" each time when failure condition has been removed, i.e. re-integrated in the communication. b. If supported, the nodes should apply MAC TX buffer rest short before the bus failure has been removed. 7. Read and record counters included in each received frame. 8. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. Message transfer must automatically re-start within 1 PLCA cycle after bus failure has been removed. However, due to backoff timer a node might need up to ~ 370 ms to transmit in the assigned TO in the PLCA cycle, see "Notes" below, however it shall not affect the reception, so no message shall be lost. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.

[10] Communication is started and after a random time in between 1 s and 1 s + length of one PLCA cycle a bus failure condition is applied. Condition remains for 1 s. Test shall run for at least 2 PLCA cycles after condition has been removed. This means, duration time should be at least 1s + ~25 ms + 1s + 50 ms = 2.075 s; i.e. 3 s meets the requirements.

Test iterations	Amount of test repetitions: each bus failure condition shall be applied at least 20 times with no timing relation to the PLCA cycle
Notes	During bus failure the nodes may enter in CSMA/CD mode, then physical collisions will most likely happen, this will affect the time needed for the PLCA cycle to be resynchronized. IEEE specification (4.2.3.2.5 Collision backoff and retransmission (half duplex mode only)) defines the maximum backoff timer should be ~52.4 ms. In normal PLCA operation, PHY transmits only in its assigned transmit opportunity (TO), keeping CRS high until its TO and then MAC can transmit successfully immediately. But if there was a transmission attempt before (during the bus failure condition) MAC may not be able to transmit right after PHY dessert CRS (due to the backoff timer) and therefore will not use its TO, this can be repeated multiple times. IEEE specifies a maximum of 16 transmission attempts, taking that into account, it can take up to 366.89 ms for the PLCA cycle to be resynchronized.

Table 15 - Test case instances definition for Group N4 - Test cases N4.1 to N4.14

Instance Test Case #	Description	Parameter	Condition
N4.1	Normal communication with bus failures	FIB1	– Communication is started and after a random time in between 1 second and 1 second + length of one PLCA cycle a bus failure condition is applied – No timing relation to PLCA slots. – Condition remains for 1 second. – Test shall run for at least 2 PLCA cycles after condition has been removed – Each bus failure condition shall be applied at least 20 times with no timing relation to the PLCA cycle
N4.2		FIB2	
N4.3		FIB3	
N4.4		FIB4	
N4.5		FIB5	
N4.6		FIB6	
N4.7		FIB7	
N4.8		FIB8	
N4.9		FIB9	
N4.10		FIB10	
N4.11		FIB11	
N4.12		FIB12	
N4.13		FIB13	
N4.14		FIB14	

10.1.5 Group N5 – Normal communication with ground shifts

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
N5	Normal com.	H2	M1	yes	no	no	No	no	no	no	no

Table 16: Main test structure of Group N5

Purpose	Purpose of the test is to check that communication robustness against dynamic ground shift in a network with nominal termination.
Reference	[2] [6] [5]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount = 16* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with H2 topology using the configuration cycle as defined in section 8.5.1. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (Node #0) to start communication. 4. Initiate data transmission with the respective PLCA Cycle and Message transfer. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.

	a. Messages are sent as broadcast, so all nodes can check counters and report an error. b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. c. If PLCA functionality becomes disabled, aPLCAStatus = FALSE at any node, an interrupt shall be signaled, and the event stored in an internal LocalStatusInformation register. d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal LocalStatusInformation register. 5. Keep transmitting MessageTransfer_M1 for at least 1s + ground shift frequency sweep time as defined in Table 17. 6. Dynamic ground shifts at nodes #0, #2 and #5, GS0 | GS2| GS5, are applied following the conditions defined in Table 17. 7. Read and record counters included in each received frame. 8. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. There shall be no loss of messages. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 17: Test case instances definition for Group N5 - Test cases N5.1 to N5.7

Instance Test Case #	Description	Parameter	Condition

N5.1	Normal communication with ground shift	GS0	– Communication is started and after at least 1 second ground shift condition is applied
			– No timing relation to PLCA slots.
			– Condition remains for frequency sweep time:
			  – 0.7 seconds (node 0) [GS0]
			  – 1.1 seconds (node 2) [GS2]
			  – 1.3 seconds (node 5) [GS5]
			– If ground shift is applied at more than one node concurrently, then the frequency sweep time of the node with the higher ID will be applied.

N5.2		GS2	
N5.3		GS5	
N5.4		GS02	
N5.5		GS05	
N5.6		GS25	
N5.7		GS025	

10.1.6 Group N6 – Normal communication with termination mismatch

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
N6	Normal com.	H2	M1	no	No	no	no	no	yes	no	no

Table 18: Main test structure of Group N6

Purpose	Purpose of the test is to check that communication robustness against termination mismatches.
Reference	[2] [6] [5]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. aPLCANodeCount = 16 2. The DUTs' positions are defined in Table 6 3. used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (Node #0) to start communication. 4. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.

	a. Messages are sent as broadcast, so all nodes can check counters and report an error. b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. e. *LocalStatusInformation* at all nodes shall be reset or storage in a “new phase” each time when termination is switched from “non-nominal” back to nominal, i.e. re-integrated in the communication. 5. Keep transmitting *MessageTransfer_M1* for at least 3 seconds. 6. Termination mismatch at nodes #1, #7 and #FIB, T1 | T7 | TFIB, are applied following the conditions defined in Table 19. a. The counters [CC, SC, MC] at all nodes shall be reset or storage in a “new phase” each time when termination is switched from “non-nominal” back to nominal, i.e. re-integrated in the communication 7. Read and record counters included in each received frame. 8. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. Communication must resume in case it has stopped while the termination mismatch was present. Message transfer must automatically re-start within 1 PLCA cycle after bus failure has been removed. However, due to backoff timer a node might need up to ~ 370 ms to transmit in the assigned TO in the PLCA cycle, see “Notes” below, however it shall not affect the reception, so no message shall be lost. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	Amount of test repetitions: n.a.
Notes	During the termination mismatch the nodes may enter in CSMA/CD mode, then physical collisions will most likely happen, this will affect the time needed for the PLCA cycle to be resynchronized. IEEE specification (4.2.3.2.5 Collision backoff and retransmission (half duplex mode only)) defines the maximum backoff timer should be ~52.4 ms. In normal PLCA operation, PHY transmits only in its assigned transmit opportunity (TO), keeping CRS high until its TO and then MAC can transmit successfully immediately. But if there was a transmission attempt before (during the bus failure

	condition) MAC may not be able to transmit right after PHY dessert CRS (due to the backoff timer) and therefore will not use its TO, this can be repeated multiple times. IEEE specifies a maximum of 16 transmission attempts, taking into account, it can take up to 366.89 ms for the PLCA cycle to be resynchronized.

Table 19 - Test case instances definition for Group N6 - Test cases N6.1 to N6.4

Instance Test Case #	Description	Parameter	Condition
N6.1	Normal communication with termination mismatch	T1	– Communication is started and after at least 1 second termination shall be switched to "non-nominal" for 1 second and then back to nominal – No timing relation to PLCA slots. – Test shall run for at least 1s after condition has been removed
N6.2		TFIB	
N6.3		T7	
N6.4		T17	

10.1.7 Group N7 – Normal communication, CSMA/CD – fallback operation in automotive.

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
N7	Normal com.	H2	M1	no	no	no	No	yes	no	no	no

Table 20: Main test structure of Group N7

Purpose	Purpose of the test is to check that all nodes on the mixing segment fall back to CSMA/CD when there is no BEACON, and then normal PLCA operation resumes when the Head Node starts sending BEACONs again.
Reference	[2] [6] [5]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount = 16* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (Node #0) to start communication. 4. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.

	a. Messages are sent as broadcast, so all nodes can check counters and report an error. 5. Keep transmitting *MessageTransfer_M1* for at least 60 seconds. 6. After at least 1 second data transmission has been initiated, revert to CSMA/CD operation by disabling PLCA functionality at Coordinator / Head Node (Node #0). PLCA Control register is reset. 7. As there is no BEACON, all nodes on the mixing segment fall back to CSMA/CD. 8. After at least 10 seconds data transmission has been initiated, enable the PLCA reconciliation sublayer functionality at the Head Node (Node #0). Head Node (Node #0) starts sending BEACONs again, normal PLCA operation resumes. a. Messages are sent as broadcast, so all nodes can check counters and report an error. 9. Once normal PLCA operation resumes, read and record counters included in each received frame. a. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. b. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. c. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. 10. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. Communication needs to run without any loss of messages once normal PLCA operation resumes. Reading the PLCA status seems to be sufficient. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 21: Test case instances definition for Group N7 - Test case N7.1

Instance Test Case #	Description	Parameter	Condition
N7.1	Normal communication, CSMA/CD – fallback operation in automotive.	PD0	– Communication is started and after at least 1 second revert to CSMA/CD operation by disabling PLCA functionality at the respective node. – The transmission buffer of the node in CSMA/CD operation shall be filled with its frame or burst cyclically approximately every 25 ms (slightly shorter than a typical PLCA cycle) and not immediately once emptied. – All nodes on the mixing segment fall back to CSMA/CD. – After at least 10 seconds enable the PLCA functionality at the Head Node (Node #0). – Head Node (Node #0) starts sending BEACONs again, normal PLCA operation resumes.

10.1.8 Group N8 – Normal communication, mixed operation of PLCA and non-PLCA nodes

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
N8	Normal com.	H2	M1	no	no	no	no	yes	no	no	no

Table 22: Main test structure of Group N8

Purpose	Purpose of the test is to check that communication between the nodes works as expected when one node is not using PLCA.
Reference	[2] [6] [5]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.3. a. *aPLCANodeCount = 12* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.3. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (Node #0) to start communication. 4. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.

	a. Messages are sent as broadcast, so all nodes can check counters and report an error. b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. c. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. 5. Keep transmitting *MessageTransfer_M1* for at least 60 seconds. 6. Revert to CSMA/CD operation by disabling PLCA functionality at nodes #1. PLCA Control register is reset, PD1, following the conditions defined in Table 23. 7. Read and record counters included in each received frame. 8. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all of the following condition(s) are fulfilled. Communication needs to run without any loss of messages for at least 60 s. Reading the PLCA status seems to be sufficient. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	As Node #1 is defined as link partner in Heterogeneous configuration, see Table 6, in this configuration these test cases shall be repeated having the DUT populated in Node #1.
Notes	To rely on message counters the PLCA communication cycle should be defined to avoid physical collisions, that will occur if a CSMA/CD node starts transmitting at the same time as a PLCA-enabled node, for that the number of consecutive empty TOs slots should be higher or lower than IPG length. For example, if the TO_timer is defined with 32-bit times, then 3 consecutive empty TOs slots shall be avoided, as 3.2us * 3 = 9.6us = IPG length.

Table 23 - Test case instances definition for Group N8 - Test case N8.1

Instance Test Case #	Description	Parameter	Condition
N8.1	Normal communication, mixed operation of PLCA and non-PLCA nodes	PD1 As Node #1 is defined as link partner in Heterogeneous configuration, see Table 6, in this configuration this test case shall be repeated having the DUT populated in Node #1.	– Communication is started and after at least 500 ms stop queuing in the transmit buffer of the node that will switch to CSMA/CD. 500 ms later revert to CSMA/CD operation by disabling PLCA functionality at the respective node. This ensures that the transmit buffer is empty at the point in time the node goes in CSMA/CD. – Wait for a settling time of about 23.39 ms before using the CSMA/CD transmitter. – Conditionally queue packets on the node in CSMA/CD: The transmission buffer of the node in CSMA/CD operation shall be filled with its packet cyclically approximately every 23.39 ms (slightly shorter than a typical PLCA cycle) and not immediately once emptied. – No timing relation to PLCA slots.

10.1.9 Group N9 – Normal communication with distortion patterns

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
N9	Normal com.	H2	M1	no	no	no	no	no	no	no	yes

Table 24: Main test structure of Group N9

Purpose	Purpose of the test is to check that communication recovers after distortions (invalid frames or signals) on the bus wires have been applied.
Reference	[2] [6] [5]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount = 16* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (Node #0) to start communication. 4. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6. a. Messages are sent as broadcast, so all nodes can check counters and report an error.

	b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. **For tests cases N5.1 to N5.6 and N5.10 to N5.13 - With short distortion patterns** 5. Keep transmitting *MessageTransfer_M1* for at least 100 PLCA Cycles. **For tests cases N5.30 to N5.31 - With distortion patterns similar to symbols** 6. Keep transmitting *MessageTransfer_M1* for 100 PLCA Cycles. **For tests cases N5.40, N5.50 and N5.51- With long distortion patterns** 7. Keep transmitting *MessageTransfer_M1* for 100 PLCA Cycles. 8. Distortion patterns are applied following the conditions defined in Table 25, Table 26 and Table 27 respectively. 9. Read and record counters included in each received frame. 10. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all of the following condition(s) are fulfilled. **For tests cases N5.1 to N5.6 and N5.10 to N5.13 - With short distortion patterns** In these tests only “short distortions” are sent, so the assumption is that no more than one message is hit. There shall be no loss of more than one message per distortion pattern sent. **For tests cases N5.30 to N5.31 - With distortion patterns similar to symbols** Here Beacon or WUT is sent and thus the PLCA cycle may start over. Since a cycle may be aborted messages of a certain cycle can be skipped. If a message is skipped, then all messages that were scheduled for the remainder of the PLCA cycle shall also be skipped. **For tests cases N5.40, N5.50 and N5.51- With long distortion patterns** Here “long distortions” are sent, so the assumption is that at most two messages are hit. There shall be no loss of more than two messages per distortion pattern sent. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	Amount of test repetitions: each distortion pattern shall be sent at least 100 times.
Notes	

Table 25 - Test case instances definition for Group N9 - Test cases N9.1 to N9.6 and N9.10 to N9.13

Instance Test Case #	Description	Parameter	Condition
N9.1	Normal communication with short distortion patterns	DP1	– Each distortion pattern shall be sent at least 100 times. – The distortion pattern is sent after the beacon with a delay that is increased by a fixed time (1/100 of the nominal time between two beacons when all nodes are sending and no stress factor is active) on each transmission, so that the position of the distortion is shifted in 100 steps over the entire PLCA cycle. – There is no need to have a timing that exactly matches a certain bit position of a certain frame. Jitter in the occurrence of the frames is accepted. Shifting the distortion pattern over the entire PLCA cycle in steps that are approximately 1/100 of the average PLCA cycle length is sufficient. – Starting the transmission of the distortion pattern does not need to be tight to the beacon itself.
N9.2		DP2	
N9.3		DP3	
N9.4		DP4	
N9.5		DP5	
N9.6		DP6	
N9.10		DP10	
N9.11		DP11	
N9.12		DP12	
N9.13		DP13	
N9.14		DP14	

Table 26 - Test case instances definition for Group N9 - Test cases N9.30 to N9.31

Instance Test Case #	Description	Parameter	Condition
N9.30	Normal communication with distortion patterns similar to symbols	DP30	Idem Table 25.
N9.31		DP31	

Table 27 - Test case instances definition for Group N9 - Test cases N9.40, N9.50 and N9.51

Instance Test Case #	Description	Parameter	Condition
N9.40	Normal communication with long distortion patterns	DP40	Idem Table 25.
N9.50		DP50	
N9.51		DP51	

10.2 Startup cycles in the presence of different physical stress conditions

ID: 10BASET1S_L1_IOP_20

Type: Information

The test cases defined in this section shall ensure that the PHY is able to starts up communication with other PHYs from different vendor under diverse stress conditions. This scenario can be used for homogenous and also heterogenous (in that different PHYs are used) test configurations.

10.2.1 Group S1 – Startup with ground shifts

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
S1	Start-up	H2	M1	yes	no	no	no	no	no	no	no

Table 28: Main test structure of Group S1

Purpose	Purpose of the test is to ensure that communication starts up, when dynamic ground shift is present before.
Reference	[2] [6] [5]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount = 16* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.

Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1.
	2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node.
	3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes.
	4. Dynamic ground shifts at nodes #0, #2 and #5, GS0 | GS2| GS5, are applied following the conditions defined in Table 29.
	5. Subsequently, after at least 0.5 seconds the respective ground shift condition has been applied, enable the PLCA reconciliation sublayer functionality at the Head Node (Node #0) to start communication.
	6. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.
	    a. Messages are sent as broadcast, so all nodes can check counters and report an error.
	    b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message.
	    c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register.
	    d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register.
	7. Keep transmitting *MessageTransfer_M1* for at least 1.7 seconds.
	8. Read and record counters included in each received frame.
	9. Power-off all nodes.

Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. Communication starts up immediately. Communication runs failure free from the beginning. There shall be no loss of messages. No unexpected interrupts signaled by the DUTs. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 29 - Test case instances definition for Group S1 - Test cases S1.1 to S1.7

Instance Test Case #	Description	Parameter	Condition

S1.1	Start up with ground shift	GS0	– All nodes are powered and in normal mode. All nodes have a transmission pending.
			– Ground shift condition is applied and after at least half of the frequency sweep time communication is started
			  – 0.7 seconds (node 0) [GS0]
			  – 1.1 seconds (node 2) [GS2]
			  – 1.3 seconds (node 5) [GS5]
			– If ground shift is applied at more than one node concurrently, then the frequency sweep time of the node with the higher ID will be applied.
			– Communication shall run for at least 1s after condition has been removed

S1.2		GS2	
S1.3		GS5	
S1.4		GS02	
S1.5		GS05	
S1.6		GS25	
S1.7		GS025	

10.2.2 Group S2 – Startup after bus failure

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
S2	Start-up	H2	M1	no	no	no	yes	no	no	no	no

Table 30: Main test structure of Group S2

Purpose	Purpose of the test is to ensure that communication starts up, when bus failures have been present temporarily before and while the communication is started.
Reference	[2] [6] [5]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount = 16* 2. The DUTs' positions are defined in Table 6. 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes. 4. Bus failure conditions are applied following the conditions defined in Table 31. 5. Subsequently, after at least 0.5 seconds bus failure condition has been applied, enable the PLCA reconciliation sublayer functionality at the Head Node (Node #0) to start communication.

	6. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6. a. Messages are sent as broadcast, so all nodes can check counters and report an error. b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. c. The counters [CC, SC, MC] at all nodes shall be reset or storage in a “new phase” each time when failure condition has been removed. d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. e. *LocalStatusInformation* at all nodes shall be reset or storage in a “new phase” each time when failure condition has been removed, i.e. re-integrated in the communication. f. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. 7. Keep transmitting *MessageTransfer_M1* for at least 1.7 seconds. 8. Read and record counters included in each received frame. 9. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. Communication starts up and runs failure free after the bus failure has been removed and the physical integrity of the link has been fully restored (taking into account any bounce caused during the physical reconnection, e.g. contact settling time of the relay). From this point in time there shall be neither loss of messages nor unexpected interrupts signaled by the DUTs. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 31 – Test case instances definition for Group S2 – Test cases S2.1 to S2.14

Instance Test Case #	Description	Parameter	Condition
S2.1	Start up with bus failures	FIB1	– All nodes are powered and in normal mode. All nodes have a transmission pending. – Bus failure condition is applied and remains for 1 second. – Communication is started after at least 0.5 seconds bus failure condition has been applied. – No timing relation to PLCA slots. – Communication shall run for at least 1 second after condition has been removed. – Each bus failure condition shall be applied at least 20 times with no timing relation to the PLCA cycle
S2.2		FIB2	
S2.3		FIB3	
S2.4		FIB4	
S2.5		FIB5	
S2.6		FIB6	
S2.7		FIB7	
S2.8		FIB8	
S2.9		FIB9	
S2.10		FIB10	
S2.11		FIB11	
S2.12		FIB12	
S2.13		FIB13	
S2.14		FIB14	

10.2.3 Group S3 – Startup after WUP sent by multiple nodes at the same time

Only applicable if supplementary service primitive that makes use of WUP command is supported. This supplementary service primitive is defined in [7].

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
S3	Start-up	H2	M1	no	no	no	no	no	no	no	no

Table 32: Main test structure of Group S3

Purpose	Purpose of the test is to ensure that communication starts up, when more than one node gets the command from application layer to start sending WUP commands (SUSPEND, WUT, COMMIT, ESD and ESDOK) at (almost) the same time.
Reference	[2] [6] [5]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network, either DUTs or link partners, shall be able to receive all frames sent by the other nodes. 9. DUT and link partners shall support supplementary service primitive that makes use of WUP command as defined in [7].
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. aPLCANodeCount = 16 2. The DUTs' positions are defined in Table 6. 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node.

	3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes. 4. Subsequently, enable the PLCA reconciliation sublayer functionality at the Head Node (Node #0) to start communication. 5. Some nodes shall get the command to start sending WUP commands (SUSPEND, WUT, COMMIT, ESD and ESDOK) at (almost) the same time as defined in Table 33. This one-time command sent by the application could be either a multicast event or triggered independently by the upper tester software in the respective nodes if there is some timing synchronization between them. 6. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6. a. Messages are sent as broadcast, so all nodes can check counters and report an error. b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. 7. Keep transmitting *MessageTransfer_M1* for at least 1 second. 8. Read and record counters included in each received frame. 9. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. Communication starts up immediately. Communication runs failure free from the beginning. There shall be no loss of messages. No unexpected interrupts signaled by the DUTs. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 33 - Test case instances definition for Group S3 - Test cases S3.1 to S3.5

Instance Test Case #	Description	Nodes sending WUP	Condition
S3.1	Start up with WUP	0	– All nodes are powered and in normal mode. All nodes have a transmission pending. – Some nodes shall get the command to start sending WUP commands (SUSPEND, WUT, COMMIT, ESD and ESDOK) at (almost) the same time. – No timing relation to PLCA slots. – Communication starts after BEACON. Communication runs failure free from the beginning. No unexpected interrupts signalled by the DUTs. – Communication shall run for at least 1 second.
S3.2		0, 2	
S3.3		0, 2, 4	
S3.4		0, 2, 4, 5	
S3.5		0, 1, 2, 4, 5, 6, 7 (node 3 is left out intentionally)	

11 GROUP 2 – DIAGNOSTIC FEATURES SET TEST CASES

ID: 10BASET1S_L1_IOP_21

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.

11.1 [DCQ] Dynamic Channel Quality

ID: 10BASET1S_L1_IOP_22

Type: Information

The test cases defined in this chapter shall be mandatory for nodes where SQI values are accessible (diagnostic class 2).

The SQI value is determined either for only a specific transmitting node as identified by the PLCA transmit opportunity as configured in TOID or computed over all received packets.

11.1.1 Group DCQ1 – Dynamic Channel Quality – SQI Transmit Opportunity ID (SQI)

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
DCQ1	TOID	H1	M1m	No	no	no	no	no	no	yes	no

Table 34: Main test structure of Group DCQ1

Purpose	Shall ensure the proper indication of the signal quality by the PHY for a channel whose quality is artificially degraded by injected white noise and then increased again until the injected white noise is gradually and completely removed.
Reference	[5] – Section: Dynamic 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 shall be able to monitor the signal quality indicated by the PHY. 3. DUT with the capability to reset and configure its PHY. 4. DUT should be configured as Coordinator node. 5. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 6. DUT shall be able to send frames in the respective transmit opportunity. 7. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed.

	8. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 9. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes
DUT set-up	1. This test case is conducted with *H1* topology (P2P link segment) a. aPLCANodeCount = 2. 2. DUT shall be connected to an active link partner with opposite Follower node configuration (*aPLCALocalNodeID* = 0 and *aPLCALocalNodeID* = 1 respectively) 3. DUT shall be configured to allow the determination of SQI values for PLCA slot (TO) 1 4. The used *MessageTransfer_M1* is defined in section 8.6. The Transmission Cycle is repeated until all artificial noise levels are applied onto communication channel.

Test description	1. DUTs and LPs shall be powered on and configured with *H1* topology using the configuration cycle as defined in section 8.5.2.
	2. Reset CycleCounter (CC); MessageCounter (MC) and StatusInformation (SI) at each node.
	3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (Node #0) to start communication.
	4. Initiate data transmission with the respective PLCA Cycle and Message transfer. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.
	    a. Messages are sent as broadcast, so all nodes can check counters and report an error.
	    b. The counters [CC, MC] are stored at each node and incremented accordingly after every sent message.
	    c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register.
	    d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register.
	    e. The counters [CC, MC] at all nodes shall be storage in a "new phase" if the SQI value at any node is lower than 2.
	5. Read the PHY's SQI value at least 100 times. This means ca. 4 seconds[11]. Determine and store the minimum and maximum read values.
	6. Increase artificial noise level by one step, i.e. by 100mV Gaussian noise generator amplitude[12].
	    a. Keep transmitting *MessageTransfer_M1* continuously.

[11] Each SQI value shall be determined across:
- at least 16 Kbytes of data received at the MAC layer since the last SQI update.
- at least 32 carrier events (frames or bursts of frames) have been detected at the MAC layer since the last update.

Considering for example, the longest Ethernet frame (8 octets <preamble + SFD> + 1522 octets <header, payload, CRC> + at least 12 octets <IPG> = 8*(8+1522), this means for 32 carrier events it will be needed about [32*(20 bits + (8*(8+1522+12))] = 395,392 bits. This corresponds to a refresh rate of approx. 40 ms. This means 100 readings correspond to approx. 4 seconds.
12 Note that directional coupler has an attenuation factor of about 20dB, so the injected noise is done in steps whose amplitude is about 10 times lower.

	7. Go back to previous step 5 until the SQI value at any node has achieved a SQI value lower than 1 for three artificial noise levels. 8. Read the PHY's SQI value at least 100 times. This means ca. 4 seconds. Determine and store the minimum and maximum read values. 9. Draw minimum and maximum curves with the values obtained in each artificial noise step. This corresponds to the curve where SQI values steadily decreases. 10. Decrease artificial noise level by one step, i.e. by 100mV Gaussian noise generator amplitude. a. Keep transmitting *MessageTransfer_M1* continuously. 11. Go back to previous step 8 until the artificial noise has been fully removed. 12. Stop data transmission. 13. Draw minimum and maximum curves with the values obtained in each artificial noise step in a second graph. This corresponds to the curve where SQI values steadily increase. 14. Measure the jitter in the eye diagram at the MDI of the receiver DUT at the highest artificial noise level, corresponding to an SQI value of 3.

Pass criteria	Each test iteration shall be classified as passed, if all the following condition(s) are fulfilled.
	○ SQI values
	    ○ Steadily and monotonically increase/decrease step by step.
	○ The jitter measured in the eye diagram at the MDI of the receiver DUT at the highest artificial noise level, corresponding to an SQI value of 3, shall be ≤ 15ns.
	○ For SQI values ≥ 3
	    ○ *CycleCounter (CC);* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1.

Test iterations	Amount of test repetitions: n.a.
Notes	

Table 35 - Test case instances definition for Group DCQ1- Test cases DCQ1.1

Instance Test Case #	Description	Parameter	Condition
DCQ1.1	SQI Transmit Opportunity ID (TOID)	n.a.	n.a.

11.2 [HDD] – Harness Defect Detection

ID: 10BASET1S_L1_IOP_23

Type: Information

The test cases defined in this chapter are mandatory for nodes where cable diagnostics functionality is supported.

11.2.1 Group HDD1 – Harness Defect Detection – Error Free Channel and conditions where NO FAULT should be reported

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
HDD1	Error Free/No Fault	H1	n.a.	yes	no	no	yes	no	no	no	no

Table 36: Main test structure of Group HDD1

Purpose	Shall ensure that the PHY's cable diagnostic does not report a harness fault in an error-free channel or under harness conditions where no fault should be reported .
Reference	[5] – Section: Harness Defect Detection
Prerequisites	1. DUT shall be able to trigger the PHY's cable diagnostic feature. 2. The link partner shall terminate the channel properly. 3. The link partner should be inactive and configured in high impedance (Hi-Z) mode.
DUT set-up	1. This test case is conducted with *H1* topology (P2P link segment) a. PLCANodeCount = 2 2. This test case is conducted with 2 nodes mixing segment multidrop (P2P link segment) topology pattern. a. PLCANodeCount = 2. 3. DUT shall be connected to properly terminated link partner with opposite Coordinator/Follower node configuration (*aPLCALocalNodeID* = 0 and *aPLCALocalNodeID* = 1 respectively)
Test description	1. DUT shall soft reset and reconfigure its PHY. 2. DUT shall start cable diagnostic of its PHY. Ensure that the other nodes on the segment are in transmitter high impedance mode as defined [6] to avoid disturbing the testing signals transmitted by the node performing diagnostic functions. 3. Apply each of the harness failures sequentially in separate test iterations according to the HDD class supported by the DUT as shown in Table 37. 4. DUT shall wait until the PHY finished cable diagnostics. 5. 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.
Test iterations	The test shall be repeated for both harness failure condition, a near end (close to the DUT) and a far end (close to the other end of the main bus connector), for which the roles of DUT and LP could be reversed.
Notes	

Table 37 - Test case instances definition for Group HDD1- Test cases HDD1.1 – HDD1.20

Instance Test Case #	Failure Case Description	Condition			
		HDD Class 1 Open / Short	HDD Class 2 SW Open / Short	HDD Class 3 SW Open / Short	HDD Class 4 SW Open / SW Short
		HARD		WEAK	
	Reporting:	NO FAULT	NO FAULT	NO FAULT	NO FAULT
HDD1.1	Error Free Channel	-	-	-	-
HDD1.2	Open of both Wires	$R_{OC} \leq 2.5\Omega$	$R_{OC} \leq 2.5\ \Omega$	$R_{OC} \leq 20\ \Omega$	$R_{OC} \leq 20\ \Omega$
HDD1.3	Short of both Wires to GND	$R_{SC} \geq 100\ K\Omega$	$R_{SC} \geq 100\ K\Omega$	$R_{SC} \geq 10\ K\Omega$	$R_{SC} \geq 10\ K\Omega$
HDD1.4	Short of both Wires to VBAT	$R_{SC} \geq 100\ K\Omega$	$R_{SC} \geq 100\ K\Omega$	$R_{SC} \geq 10\ K\Omega$	$R_{SC} \geq 10\ K\Omega$
HDD1.5	Short of both Wires	$R_{SC} \geq 100\ K\Omega$	$R_{SC} \geq 100\ K\Omega$	$R_{SC} \geq 1\ k\ \Omega$	$R_{SC} \geq 1\ K\Omega$
HDD1.6	Open of single Wire or Single Termination lost	Not req.	$R_{OC} \leq 2.5\ \Omega$	$R_{OC} \leq 20\ \Omega$	$R_{OC} \leq 20\ \Omega$
HDD1.7	Third Termination	Not req.	Not req.	$R_{SC} \geq 1\ K\Omega$	$R_{SC} \geq 1\ K\Omega$
HDD1.8	No Termination	Not req.	Not req.	Not req.	$R_{OC} \leq 20\ \Omega$
HDD1.9	Short of single Wire to GND	Not req.	Not req.	Not req.	$R_{SC} \geq 10\ K\Omega$
HDD1.10	Short of single Wire to VBAT	Not req.	Not req.	Not req.	$R_{SC} \geq 10\ K\Omega$
HDD1.11... HDD1.20	All failure cases above	The same resistance values considered in HDD1.1 to HDD1.10 should be considered, and each test case shall be repeated with a ground static offset of 2 V ± 0.1V [GSS] applied at the DUT.			

11.2.2 Group HDD2 – Harness Defect Detection – Harness conditions where FAULTS should be reported

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
HDD2	FAULT reported	H1	n.a.	yes	no	no	yes	no	no	no	no

Table 38: Main test structure of Group HDD2

Purpose	Shall ensure that the PHY's cable diagnostic reports a harness fault under harness conditions where fault should be reported.
Reference	[5] – Section: Harness Defect Detection
Prerequisites	1. DUT shall be able to trigger the PHY's cable diagnostic feature. 2. The link partner shall terminate the channel properly. 3. The link partner should be inactive and configured in high impedance (Hi-Z) mode.
DUT set-up	1. This test case is conducted with *H1* topology (P2P link segment) a. aPLCANodeCount = 2. 2. This test case is conducted with 2 nodes mixing segment multidrop (P2P link segment) topology pattern. a. aPLCANodeCount = 2. 3. DUT shall be connected to properly terminated link partner with opposite Coordinator/Follower node configuration (*aPLCALocalNodeID* = 0 and *aPLCALocalNodeID* = 1 respectively)
Test description	1. DUT shall soft reset and reconfigure its PHY. 2. DUT shall start cable diagnostic of its PHY. Ensure that the other nodes on the segment are in transmitter high impedance mode as defined [6] to avoid disturbing the testing signals transmitted by the node performing diagnostic functions. 3. Apply each of the harness failures sequentially in separate test iterations according to the HDD class supported by the DUT as shown in Table 39. 4. DUT shall wait until the PHY finished cable diagnostics. 5. DUT shall read out the indicated result.
Pass criteria	Each test iteration shall be classified as passed, if all the following condition(s) are fulfilled. ○ Cable diagnostic reports a harness fault in each case.
Test iterations	The test shall be repeated for both harness failure condition, a near end (close to the DUT) and a far end (close to the other end of the main bus connector), for which the roles of DUT and LP could be reversed.
Notes	

Table 39 - Test case instances definition for Group HDD2- Test cases HDD2.1 - HDD2.18

Instance Test Case #	Failure Case Description	Condition			
		HDD Class 1 Open / Short	HDD Class 2 SW Open / Short	HDD Class 3 SW Open / Short	HDD Class 4 SW Open / SW Short
		HARD		WEAK	
	Reporting:	FAULT	FAULT	FAULT	FAULT
HDD2.1	Open of both Wires	$R_{OC} \geq 100$ KΩ	$R_{OC} \geq 100$ KΩ	$R_{OC} \geq 100$ Ω	$R_{OC} \geq 100$ Ω
HDD2.2	Short of both Wires to GND	$R_{SC} \leq 10$ Ω *	$R_{SC} \leq 10$ Ω *	$R_{SC} \leq 1$ KΩ *	$R_{SC} \leq 1$ KΩ *
HDD2.3	Short of both Wires to VBAT	$R_{SC} \leq 10$ Ω *	$R_{SC} \leq 10$ Ω *	$R_{SC} \leq 1$ KΩ *	$R_{SC} \leq 1$ KΩ *
HDD2.4	Short of both Wires	$R_{SC} \leq 10$ Ω	$R_{SC} \leq 10$ Ω	$R_{SC} \leq 100$ Ω	$R_{SC} \leq 100$ Ω
HDD2.5	Open of single Wire or Single Termination lost	Not req.	$R_{OC} \geq 100$ KΩ	$R_{OC} \geq 100$ Ω	$R_{OC} \geq 100$ Ω
HDD2.6	Third Termination	Not req.	Not req.	$R_{SC} \leq 100$ Ω	$R_{SC} \leq 100$ Ω
HDD2.7	No Termination	Not req.	Not req.	Not req.	$R_{OC} \geq 100$ Ω
HDD2.8	Short of single Wire to GND	Not req.	Not req.	Not req.	$R_{SC} \leq 1$ KΩ
HDD2.9	Short of single Wire to VBAT	Not req.	Not req.	Not req.	$R_{SC} \leq 1$ KΩ
HDD2.10... HDD2.18	All failure cases above	The same resistance values considered in HDD2.1 to HDD2.9 should be considered, and each test case shall be repeated with a ground static offset of 2 V ± 0.1V [GSS] applied at the DUT.			

11.3 [PLCAD] – PLCA diagnostic

11.3.1 Group PLCAD1 – PLCA diagnostic – PLCA Beacon Received Before Transmit Opportunity (BCNBFTO)

ID: 10BASET1S_L1_IOP_24

Type: Information

The test cases defined in this chapter shall be mandatory only for PLCA Follower

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
PLCAD 1	BCNBFTO	H2	M1m	no	no	no	no	no	no	no	no

Table 40: Main test structure of Group PLCAD1

Purpose	The purpose of this test is to ensure that the DUT is able to indicate properly the detection of missing transmit opportunities. The PLCA Beacon Received before Transmit Opportunity (BCNBFTO) status bit reads as a ´1´ when the PLCA cycle is completed before the assigned transmit opportunity occurs. This condition indicates the possibility of multiple coordinator nodes on the mixing segment, or a coordinator node incorrectly configured with a node count *aPLCANodeCount* smaller than the number of nodes on the mixing segment.
Reference	[5] – Section: PLCA diagnostic
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1, with following variations: a. Configure DUT is Node #6 as Follower node; with an assigned *aPLCALocalNodeID = 15;* and *aPLCANodeCount = 16*

	b. Configure all remaining nodes *aPLCANodeCount = 13* and the assigned PLCA Slot as defined in section 8.5.1. 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (Node #0) to start communication. 4. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6. a. Messages are sent as broadcast, so all nodes can check counters and report an error. b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. 5. Keep transmitting *MessageTransfer_M1* for at least 2 PLCA cycles. 6. Read out aPLCAStatus. 7. Keep transmitting MessageTransfer_M1 for at least max *'plca_status_timer'*. 8. Read out the respective BCNBFTO flag on the DUT. 9. Read and record counters included in each received frame. 10. Power-off all nodes.
Pass criteria	Each test iteration shall be classified as passed, if all of the following condition(s) are fulfilled. ○ The *aPLCAStatus = OK* on the Follower DUT Node #6. ○ The respective BCNBFTO flag on the Follower DUT Node #6 shall indicate that a BEACON was received before its assigned transmit opportunity.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 41 - Test case instances definition for Group PLCAD1- Test case PLCAD1.1

Instance Test Case #	Description	Parameter	Condition
PLCAD1.1	PLCA Beacon Received Before Transmit Opportunity (BCNBFTO)	n.a.	n.a.

11.3.2 Group PLCAD2 – PLCA diagnostic – PLCA Unexpected Beacon (UNEXPB)

ID: 10BASET1S_L1_IOP_25

Type: Information

The test cases defined in this chapter shall be mandatory only for PLCA Coordinator

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
PLCAD 2	UNEXPB	H2	M2	no	no	no	no	no	no	no	no

Table 42: Main test structure of Group PLCAD2

Purpose	The purpose of this test is to ensure that the DUT is able to indicate properly the detection of additional BEACON coming from other Coordinator node(s).
Reference	[5] – Section: PLCA diagnostic
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1, with following variations: a. Configure DUT is Node #6 as coordinator node; with an assigned *aPLCALocalNodeID = 0;* and *aPLCANodeCount = 16* b. Configure all remaining nodes *aPLCANodeCount = 13* and the assigned PLCA Slot as defined in section 8.5.1. c. The used *MessageTransfer_M2* has all TO slots without transmission, i.e. with empty spots 2. The DUTs' positions are defined in Table 6

Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined previously. 2. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes, including DUT Coordinator Node #6[13], and subsequently at the Head Node (Node #0) to start communication. 3. Initiate data transmission with the respective *PLCA Cycle and Message Transfer*. 4. Keep transmitting *MessageTransfer_M2* for at least 2 PLCA cycles. 5. Upon the second PLCA cycle is completed read out the respective UNEXPB flag on the DUT. 6. Power-off all nodes.
Pass criteria	Each test iteration shall be classified as passed if all the following condition(s) are fulfilled. ○ The respective UNEXPB flag on the Coordinator DUT Node #6 shall indicate that a BEACON was received before its assigned transmit opportunity.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 43 - Test case instances definition for Group PLCAD2- Test case PLCAD2.1

Instance Test Case #	Description	Parameter	Condition
PLCAD2.1	PLCA Unexpected Beacon (UNEXPB)	n.a.	n.a.

[13] The DUT in Node 6 configured as Coordinator with *aPLCALocalNodeID* = 0, sends the first BEACON before Node 0

11.3.3 Group PLCAD3 – PLCA diagnostic – PLCA Receive in Assigned Transmit Opportunity (RXINTO)

ID: 10BASET1S_L1_IOP_26

Type: Information

The test cases defined in this chapter shall be mandatory for PLCA Coordinator and for PLCA Follower

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
PLCAD 3	RXINTO	H2	M1m	no	no	no	no	no	no	no	no

Table 44: Main test structure of Group PLCAD3

Purpose	The purpose of this test is to ensure that the DUT is able to indicate properly the detection of the existence of another node on the mixing segment assigned with a duplicate node ID.
Reference	[5] – Section: PLCA diagnostic
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network either DUTs or link partners, shall be able to receive all frames sent by the other nodes.
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1, with following variations: a. Configure DUT is Node #6; with the same assigned *aPLCALocalNodeID* = 11*;* as for Node #4, i.e. Node ID duplication as *aPLCALocalNodeID* = 11 is assigned to both nodes #4 and #6. b. Configure all remaining nodes as defined in section 8.5.1. 2. The DUTs' positions are defined in Table 6

	3. The used *MessageTransfer_M1* is defined in section 8.6, apart from Node #6 whose transmission buffer shall be kept empty.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (Node #0) to start communication. 4. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6. a. Messages are sent as broadcast, so all nodes can check counters and report an error. b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. 5. Keep transmitting *MessageTransfer_M1* for at least 2 PLCA cycles. 6. Upon the second PLCA cycle is completed read out the respective RXINTO flag on the DUT Node #6 as well as on Node #4. 7. Read and record counters included in each received frame. 8. Power-off all nodes.
Pass criteria	Each test iteration shall be classified as passed if all the following condition(s) are fulfilled. ○ The respective RXINTO flag on the DUT Node #6 shall indicate the detection of the existence of another node on the mixing segment assigned with a duplicate node ID.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 45 - Test case instances definition for Group PLCAD3- Test case PLCAD3.1

Instance Test Case #	Description	Parameter	Condition
PLCAD3.1	PLCA Receive in Assigned Transmit Opportunity (RXINTO)	n.a.	n.a.

12 GROUP 3 – WAKE-UP/SLEEP

ID: 10BASET1S_L1_IOP_27

Type: Requirement

The test cases defined in this section are mandatory for all 10BASE-T1S PHYs supporting the Wake-up/Sleep functionalities of the supplementary service primitive defined in [13].

ID: 10BASET1S_L1_IOP_28

Type: Information

The test cases defined in this section shall ensure that the PHY is able to wake-up and go to low power modes with other PHYs from different vendor under diverse stress conditions. This scenario can be used for homogenous and heterogenous (in that different PHYs are used) test configurations.

12.1 [W] Wake-up (optional, if supported)

12.1.1 Group W1 – Wake-up from Low Power Mode

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
W1	Wake-up	H2	M1	yes	no	no	no	no	no	no	no

Table 46: Main test structure of Group W1

Purpose	Purpose of the test is to ensure that nodes can be woken in case dynamic ground shifts are present.
Reference	[2] [6] [5] [7]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as

	frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network, either DUTs or link partners, shall be able to receive all frames sent by the other nodes. 9. DUT and link partners shall support supplementary service primitive that makes use of WUP command as defined in [7].
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount = 16* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.

Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1.
	2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node.
	3. Once the configuration in all nodes is completed, set nodes in low-power mode[14] "Sleep" by activating *LowPowerEntryLocal.request* service primitive as defined for the test instances in Table 47.
	4. Enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes among the nodes not being in low power and subsequently at the Head Node (Node #0) to start communication while no stress is applied.
	5. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.
	    a. Messages are sent as broadcast, so all nodes not being in low power can check counters and report an error.
	    b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message.
	    c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register.
	    d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register.
	6. Keep transmitting *MessageTransfer_M1* for at least 1s + ground shift frequency sweep time as defined in Table 47.
	7. Dynamic ground shifts at nodes #0, #2 and #5, GS0 | GS2| GS5, are applied following the conditions defined in Table 47.
	8. After at least 0.25 seconds ground shift condition is applied, Node #0 sends WUP commands via *Wakeup.request* service primitive once.
	9. Read and record counters included in each received frame.
	10. Power-off all nodes.

[14] In the context of this specification the term "Sleep" indicates entry to low power state and the term "Wake-up" indicates the exit from a low power state.

<table>
<tr><td>Pass criteria</td><td>The test case shall be considered as passed, if all the following condition(s) are fulfilled.

There shall be no loss of messages.
All nodes being in low power mode shall wake up within 17 ms and incorporate into the communication after node #0 sends WUP commands once.
CycleCounter (CC); SequenceNumber (SN) and MessageCounter (MC) stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO.
No StatusInformation on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication.
For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.</td></tr>
<tr><td>Test iterations</td><td>Repeat this test case having, in starting conditions, Nodes in low-power mode “Standby” (if applicable) as defined for the test instances in Table 47.</td></tr>
<tr><td>Notes</td><td></td></tr>
</table>

Table 47 - Test case instances definition for Group W1 - Test cases W1.1 to W1.7

<table>
<tr><th>Instance Test Case #</th><th>Nodes in LP (Sleep and Standby)</th><th>Parameter</th><th>Condition</th></tr>
<tr><td>W1.1</td><td>1, 2, 4, 5, 6, 7</td><td>none</td><td rowspan="7">– Nodes are in low-power mode as defined for the test instances
– Communication is started among the nodes not being in low power while no stress is applied and after at least 1 second ground shift condition is applied
– No timing relation to PLCA slots.
– Condition remains for frequency sweep time:
  – 0.7 seconds (node 0) [GS0]
  – 1.1 seconds (node 2) [GS2]
  – 1.3 seconds (node 5) [GS5]
– If ground shift is applied at more than one node concurrently, then the frequency sweep time of the node with the higher ID will be applied.
– After at least 0.25 seconds ground shift condition is applied, Node #0 sends the WUP once.</td></tr>
<tr><td>W1.2</td><td>2, 4, 6</td><td>GS5</td></tr>
<tr><td>W1.3</td><td>1, 5, 7</td><td>GS2</td></tr>
<tr><td>W1.4</td><td>1, 2, 4, 5, 6, 7</td><td>GS0</td></tr>
<tr><td>W1.5</td><td>2, 4, 6</td><td>GS05</td></tr>
<tr><td>W1.6</td><td>1, 5, 7</td><td>GS02</td></tr>
<tr><td>W1.7</td><td>5, 6, 7</td><td>GS2</td></tr>
</table>

12.1.2 Group W2 – Wake-up from Low Power Mode, mixed PLCA and non-PLCA nodes

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
W2	Wake-up	H2	M1	no	no	no	No	yes	no	no	no

Table 48: Main test structure of Group W2

Purpose	Purpose of the test is to ensure that nodes can be woken in case not all nodes are using PLCA.
Reference	[2] [6] [5] [7]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network, either DUTs or link partners, shall be able to receive all frames sent by the other nodes. 9. DUT and link partners shall support supplementary service primitive that makes use of WUP command as defined in [7].
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.3. a. *aPLCANodeCount = 12* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.3. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, set nodes in low-power mode by activating *LowPowerEntryLocal.request* service primitive as defined for the test instances in [7].

	4. Enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes among the nodes not being in low power and subsequently at the Head Node (Node #0) to start communication while no stress is applied.
	5. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.
	    a. Messages are sent as broadcast, so all nodes not being in low power can check counters and report an error.
	    b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message.
	    c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register.
	    d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register.
	6. Keep transmitting *MessageTransfer_M1* for at least 2 seconds[15].
	7. Revert to CSMA/CD operation by disabling PLCA functionality at node #1. PLCA Control register is reset, PD1 , following the conditions defined in Table 49.
	8. After at least 0.25 seconds of disabling PLCA functionality at Node #1, Node #0 sends WUP commands via *Wakeup.request* service primitive once.
	9. All nodes in low power mode are incorporated into the PLCA cycle without actively transmitting data, they must correctly receive the data transmitted by the other nodes after they have woken up.
	10. Read and record counters included in each received frame.
	11. Power-off all nodes.

Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. There shall be no loss of messages. • All nodes in low power mode shall wake up within 17 ms after node #0 sends WUP command and incorporated into the PLCA cycle without actively transmitting data, they must correctly receive the data transmitted by the other nodes after they have woken up. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	As Node #1 is defined as link partner in Heterogeneous configuration, see Table 6, in this configuration these test cases shall be repeated having the DUT populated in Node #1.

[15] step 6 happens in parallel with subsequent steps 7 to 9

Notes	

Table 49: Test case instances definition for Group W2 - Test case W2.1

Instance Test Case #	Nodes in low power mode (Sleep and Standby)	Parameter	Condition
W2.1	2, 5	PD1 As Node #1 is defined as link partner in Heterogeneous configuration, see Table 6, in this configuration these test cases shall be repeated having the DUT populated in Node #1.	– Nodes are in low-power mode as defined for the test instances – Communication is started among the nodes not being in low power while no stress is applied and after at least 500 ms stop queuing in the transmit buffer of the node that will switch to CSMA/CD. 500 ms later revert to CSMA/CD operation by disabling PLCA functionality at the respective node. This ensures that the transmit buffer is empty at the point in time the node goes in CSMA/CD. – Wait for a settling time of 18.49 ms (slightly shorter than a typical PLCA cycle) before using the CSMA/CD transmitter. – Conditionally queue packets on the node in CSMA/CD: The transmission buffer of the node in CSMA/CD operation shall be filled with its packet cyclically approximately every 18.49 ms (slightly shorter than a typical PLCA cycle) and not immediately once emptied. – No timing relation to PLCA slots. – After at least 0.25 seconds of disabling PLCA functionality at Node #1, Node #0 sends the WUP once. – All nodes in low power mode shall wake up within 17 ms after node #0 sends WUP command and incorporated into the PLCA cycle without actively transmitting data, they must correctly receive the data transmitted by the other nodes after they have woken up. – Test shall run for at least 1 second after PLCA functionality at nodes #1 has been disabled.

12.2 [NW] No wake-up on distortions (optional, if remote Wake-up supported)

12.2.1 Group NW1 – No wake-up, mixed PLCA and non-PLCA nodes

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
NW1	No wake-up	H2	M1	no	no	no	no	yes	no	no	no

Table 50: Main test structure of Group NW1

Purpose	Purpose of the test is to ensure that nodes are not woken by transmissions of non-PLCA nodes on the bus wires, while other nodes are actively communicating.
Reference	[2] [6] [5] [7]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network, either DUTs or link partners, shall be able to receive all frames sent by the other nodes. 9. DUT and link partners shall support supplementary service primitive that makes use of WUP command as defined in [7].
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.3. a. *aPLCANodeCount = 12* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.3. 2. Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node. 3. Once the configuration in all nodes is completed, set all nodes in low-power mode by activating *LowPowerEntryLocal.request* service primitive (sleep, if supported else standby).

	4. Wakeup only nodes #0, #1 and #7 by the *WakeupLocal.request* service primitive. All nodes waking up will be in CSMA/CD due to reset after low power mode. 5. While node #1 remains in CSMA/CD operation (PD1), enable the PLCA reconciliation sublayer functionality only at nodes #7 and subsequently at the Head Node (Node #0) to start communication while no stress is applied. 6. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6. a. Messages are sent as broadcast, so all nodes not being in low power can check counters and report an error. b. The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message. c. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. d. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. 7. The test shall run for at least 60 seconds. 8. Read and record counters included in each received frame. 9. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. • None of the nodes in low power mode shall wake up. Only nodes #0, #1 and #4 shall communicate, while the others remain in low power mode. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO. • No *StatusInformation* on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication. • For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 51: Test case instances definition for Group NW1 - Test case NW1.1

Instance Test Case #	Description	Parameter	Condition
NW1.1	No wake-up, mixed PLCA and non-PLCA nodes	n.a.	– Nodes are in low-power mode as defined for the test instances – Communication is started among the PLCA nodes not being in low power while no transmission is applied at Node #1 in CSMA/CD operation for at least 100 ms. – Wait for a settling time of 3.69 ms (slightly shorter than a typical PLCA cycle) before using the CSMA/CD transmitter. – Conditionally queue packets on the node in CSMA/CD: The transmission buffer of the node in CSMA/CD operation shall be filled with its packet cyclically approximately every 3.69 ms (slightly shorter than a typical PLCA cycle) and not immediately once emptied. – No timing relation to PLCA slots. – Test shall run for at least 60 second.

12.2.2 Group NW2 – No wake-up on distortions, all nodes in low power mode

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
NW2	No wake-up	H2	M1	yes	no	no	no	no	no	no	yes

Table 52: Main test structure of Group NW2

Purpose	Purpose of the test is to ensure that nodes are not woken by distortions patterns on the MDI.
Reference	[2] [6] [5] [7]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network, either DUTs or link partners, shall be able to receive all frames sent by the other nodes. 9. DUT and link partners shall support supplementary service primitive that makes use of WUP command as defined in [7].
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount = 16* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1. 2. Once the configuration in all nodes is completed, set all nodes in low-power mode by activating *LowPowerEntryLocal.request* service primitive, (sleep, if supported else standby). 3. Within 1 second, dynamic ground shift is applied continuously at node #0, GS0 during the test duration with a repeatedly frequency sweep time of 0.7s

	4. After at least 1 s ground shift condition is applied, distortion patterns are sent following the conditions defined in Table 53. The distortion patterns shall be sent cyclically with a rate of 1 per 1 ms. 5. The test shall run for at least 30 seconds, so each pattern is sent more than 2000 times. 6. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. • None of the nodes in low power mode shall wake up.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 53 - Test case instances definition for Group NW2 - Test cases NW2.1 to NW2.51

Instance Test Case #	Description	Parameter	Condition
NW23.1	No wake-up on distortions, all nodes in low-power mode	DP1	– Nodes are in low-power mode as defined for the test instances – Within 1 second ground shift condition at nodes #0, GS0, is applied repeatedly with frequency sweep time of 0.7 seconds. – No timing relation to PLCA slots. – At least 1 second after ground shift condition is applied, distortion patterns shall be sent cyclically with a rate of 1 per 1 ms. – The test shall run for at least 30 seconds, so each pattern sent more than 2000 times.
NW2.2		DP2	
NW2.3		DP3	
NW2.4		DP4	
NW2.5		DP5	
NW2.6		DP6	
NW2.10		DP10	
NW2.11		DP11	
NW2.12		DP12	
NW2.13		DP13	
NW2.14		DP14	
NW2.30		DP30	
NW2.31	WUP – skipped, not included	DP31	
NW2.40		DP40	
NW2.50		DP50	
NW2.51		DP51	

12.2.3 Group NW3 – No wake-up on distortions, group of nodes in low power mode

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
NW3	No wake-up	H2	M1	yes	no	no	no	no	no	no	yes

Table 54: Main test structure of Group NW3

Purpose	Purpose of the test is to ensure that nodes are not woken by distortions patterns on the MDI.
Reference	[2] [6] [5] [7]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network, either DUTs or link partners, shall be able to receive all frames sent by the other nodes. 9. DUT and link partners shall support supplementary service primitive that makes use of WUP command as defined in [7].
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. aPLCANodeCount = 16 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.

Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1.
	2. Once the configuration in all nodes is completed, set nodes in low-power mode by activating *LowPowerEntryLocal.request* service primitive as defined below:
	    a. **Group 1:** only nodes #2, #4 and #6 are in low-power mode (sleep, if supported else standby).
	    b. **Group 2:** only nodes #1, #5 and #7 are in low-power mode (sleep, if supported else standby).

	3. Enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes among the nodes not being in low power and subsequently at the Head Node (Node #0) to start communication while no stress is applied.
	4. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.
	    a. Messages are sent as broadcast, so all nodes not being in low power can check counters and report an error.
	5. After at least 1 second of starting communication, dynamic ground shifts are applied continuously during the test duration with a repeatedly frequency sweep time as defined below:
	    a. **Group 1** nodes #0 and #5, GS05, with a frequency sweep time of 1.3 seconds.
	    b. **Group 2** nodes #0 and #2, GS02, with a frequency sweep time of 1.1 seconds
	6. After at least 1 second ground shift condition is applied, distortion patterns are sent following the conditions defined in Table 55. The distortion patterns shall be sent cyclically with a rate of 1 per 1 ms.
	7. The test shall run for at least 30 seconds.
	8. Power-off all nodes.

Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. • None of the nodes in low power mode shall wake up.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 55 - Test case instances definition for NW3.1 - Group 1 (a) / Group 2 (b) - Test cases NW3.1a/b to NW3.51a/b

Instance Test Case #	Description	Parameter	Condition
NW3.1 a/b	No wake-up on distortions. **Group 1 (a):** – only nodes #2, #4 and #6 are in low-power mode **Group 2 (b):** – only nodes #1, #5 and #7 are in low-power mode	DP1	**Group 1 (a):** – only nodes #2, #4 and #6 are in low-power mode **Group 2 (b):** – only nodes #1, #5 and #7 are in low-power mode – Communication is started among the nodes not being in low power while no stress is applied and after at least 1 second ground shift condition is applied – No timing relation to PLCA slots. – Ground shift condition remains continuously during the test duration with a repeated frequency sweep time of: **Group 1 (a):** – 1.3 seconds (node 0 and 5) [GS05] **Group 2 (b):** – 1.1 seconds (node 0 and 2) [GS02] – After at least 1 second ground shift condition is applied, distortion patterns shall be sent cyclically with a rate of 1 per 1 ms. – The test shall run for at least 30 seconds
NW3.2 a/b		DP2	
NW3.3 a/b		DP3	
NW3.4 a/b		DP4	
NW3.5 a/b		DP5	
NW3.6 a/b		DP6	
NW3.10 a/b		DP10	
NW3.11 a/b		DP11	
NW3.12 a/b		DP12	
NW3.13 a/b		DP13	
NW3.14 a/b		DP14	
NW3.30 a/b		DP30	
NW3.31 a/b	WUP – skipped, not included	DP31	
NW3.40 a/b		DP40	
NW3.50 a/b		DP50	
NW3.51 a/b		DP51	

12.2.4 Group NW4 – No wake-up on distortions having a timing relation to the PLCA cycle, group of nodes in low power mode

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
NW4	No wake-up	H2	M1	yes	no	no	No	no	no	no	yes

Table 56: Main test structure of Group NW4

Purpose	Purpose of the test is to ensure that nodes are not woken by distortions patterns on the MDI.
Reference	[2] [6] [5] [7]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network, either DUTs or link partners, shall be able to receive all frames sent by the other nodes. 9. DUT and link partners shall support supplementary service primitive that makes use of WUP command as defined in [7].
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount = 16* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1. 7. Once the configuration in all nodes is completed, set only nodes #2, #4 and #6 in low-power mode by activating *LowPowerEntryLocal.request* service primitive, (sleep, if supported else standby). 2. Enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes among the nodes not being in low power and subsequently at the Head Node (Node #0) to start communication while no stress is applied.

	3. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6. a. Messages are sent as broadcast, so all nodes not being in low power can check counters and report an error. 4. After at least 1 second of starting communication, dynamic ground shifts are applied at nodes #0, #2 and #5, GS025, continuously during the test duration with a repeatedly frequency sweep time of 1.3 seconds. 5. After at least 1 second ground shift condition is applied, distortion patterns are sent following the conditions defined in Table 57. 6. Each distortion pattern shall be sent at least 100 times. 7. The distortion pattern is sent after a beacon with a delay that is increased by a fixed time (a 1/100 of the nominal time between two beacons when all nodes are sending and no stress factor is active) on each transmission, so that the location is shifted in 100 steps over the entire PLCA cycle. 8. The test shall run for at least 30 seconds. 9. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. • None of the nodes in low power mode shall wake-up.
Test iterations	Amount of test repetitions: n.a.
Notes	

Table 57 - Test case instances definition for NW4.1 - Test cases NW4.1 to NW4.51

Instance Test Case #	Description	Parameter	Condition
NW4.1	No wake-up on distortions, only nodes #2, #4 and #6 are in low-power mode.	DP1	– Only nodes #2, #4 and #6 are in low-power mode – Communication is started among the nodes not being in low power while no stress is applied and after at least 1 second ground shift condition is applied – No timing relation to PLCA slots. – Ground shift condition remains continuously during the test duration with a repeatedly frequency sweep time of: – 1.3 seconds (node 0, 2 and 5) [GS025] – After at least 1 second ground shift condition is applied, each distortion pattern shall be sent at least 100 times. – The distortion pattern is sent after a beacon with a delay that is increased by a fixed time (a 1/100 of the nominal time between two beacons when all nodes are sending and no stress factor is active) on each transmission, so that the location is shifted in 100 steps over the entire PLCA cycle. – There is no need to have a timing that exactly matches a certain bit position of a certain frame. Jitter in the occurrence of the frames is accepted. Shifting the distortion pattern over the entire PLCA cycle in steps that are approximately 1/100 of the average PLCA cycle length is sufficient. – Starting the transmission of the distortion pattern does not need to be tight to the beacon itself. – The test shall run for at least 30 seconds
NW4.2		DP2	
NW4.3		DP3	
NW4.4		DP4	
NW4.5		DP5	
NW4.6		DP6	
NW4.10		DP10	
NW4.11		DP11	
NW4.12		DP12	
NW4.13		DP13	
NW4.14		DP14	
NW4.30		DP30	
NW4.31	WUP – skipped, not included	DP31	
NW4.40		DP40	
NW4.50		DP50	
NW4.51		DP51	

12.3 [G] Goto Sleep (optional, if Sleep supported)

12.3.1 Group G1 – Goto Sleep, mixed PLCA and non-PLCA operation

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
G1	Goto sleep	H2	M1	no	no	no	no	yes	no	no	no

Table 58: Main test structure of Group G1

Purpose	Purpose of the test is to ensure that nodes can enter low power modes even when PLCA and non-PLCA nodes are mixed
Reference	[2] [6] [5] [7]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network, either DUTs or link partners, shall be able to receive all frames sent by the other nodes. 9. DUT and link partners shall support supplementary service primitive that makes use of WUP command as defined in [7].
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.3. a. *aPLCANodeCount = 12* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.3. 2. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (Node #0) to start communication among the nodes while no stress is applied

	3. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6. a. Messages are sent as broadcast, so all nodes can check counters and report an error. b. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. c. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. 4. After at least 1 second of starting communication, revert to CSMA/CD operation by disabling PLCA functionality at node #1. PLCA Control register is reset, PD1 following the conditions defined in Table 59. 5. After at least 1 second PLCA functionality has been disabled at the respective node, commands to stop communication and assert *loc_low_power_req* are sent locally via host interface of the respective nodes following the different orders as defined in Table 59. Unless differently indicated *loc_low_power_req* is sent sequentially to one node about every 100 ms. 6. Read and record counters included in each received frame 7. The test shall run for at least 2 seconds + 7 nodes x 100 ms. 8. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. Messages received by node 0 shall be as expected in each PLCA cycle. No messages shall be received from nodes once *loc_low_power_req* has been asserted locally. PLCA disable should not prevent the nodes to enter in low power mode. • All nodes shall enter low power mode in the intended order. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO.
Test iterations	Amount of test repetitions: n.a.
Notes	To rely on message counters the PLCA communication cycle should be defined to avoid physical collisions, that will occur if a CSMA/CD node starts transmitting at the same time as a PLCA-enabled node, for that the number of consecutive empty TOs slots should be higher or lower than IPG length. For example, if the TO_timer is defined with 32-bit times, then 3 consecutive empty TOs slots shall be avoided, as 3.2us * 3 = 9.6us = IPG length.

Table 59 - Test case instances definition for Group G1 - Test cases G1.1

<table>
<tr><th>Instance Test Case #</th><th>Order</th><th>PLCA disable</th><th>Condition</th></tr>
<tr><td>G1.1</td><td>All nodes with PLCA functionality enable, aPLCAStatus = TRUE shall be requested to enter in low power mode.

2, 5, 6, 7</td><td>PD1

As Node #1 is defined as link partner in Heterogeneous configuration, see Table 6, in this configuration these test cases shall be repeated having the DUT populated in Node #1.</td><td>

Communication is up and running, with all nodes.
After at least 500 ms stop queuing in the transmit buffer of the node that will switch to CSMA/CD. 500 ms later revert to CSMA/CD operation by disabling PLCA functionality at the respective node. This ensures that the transmit buffer is empty at the point in time the node goes in CSMA/CD.
Wait for a settling time of 23.39 ms before using the CSMA/CD transmitter.
Conditionally queue packets on the node in CSMA/CD: The transmission buffer of the node in CSMA/CD operation shall be filled with its packet cyclically approximately every α ms (slightly shorter than a typical PLCA cycle) and not immediately once emptied.

<table>
<tr><th>Nodes in low power</th><th>α = Transmission buffer interval time [ms]</th></tr>
<tr><td>none</td><td>23.39</td></tr>
<tr><td>2</td><td>19.73</td></tr>
<tr><td>2+5</td><td>18.49</td></tr>
<tr><td>2+5+6</td><td>9.86</td></tr>
<tr><td>2+5+6+7</td><td>8.63</td></tr>
</table>

After at least 1 second PLCA functionality has been disabled at the respective node, commands to stop the communication and asserted loc_low_power_req are sent locally via host interface of the respective nodes following the different orders.
All nodes shall enter low power mode in the intended order.
The test shall run for at least 2 seconds + 7 nodes x 100 ms.

</td></tr>
</table>

12.3.2 Group G2 – Goto Sleep with ground shift and WUP

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
G2	Goto sleep	H2	M1	yes	no	no	no	no	no	no	yes

Table 60: Main test structure of Group G2

Purpose	The purpose of this test is to ensure that nodes can enter low power modes even when ground shifts are applied. However, if *loc_low_power_req* is asserted during data transmission, the node should wait for the frame transmission to complete before entering low power mode.
Reference	[2] [6] [5] [7]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network, either DUTs or link partners, shall be able to receive all frames sent by the other nodes. 9. DUT and link partners shall support supplementary service primitive that makes use of WUP command as defined in [7].
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1. a. *aPLCANodeCount = 16* 2. The DUTs' positions are defined in Table 6 3. The used *MessageTransfer_M1* is defined in section 8.6.
Test description	1. DUTs and LPs shall be powered on and configured with *H2* topology using the configuration cycle as defined in section 8.5.1. 2. Once the configuration in all nodes is completed, enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes and subsequently at the Head Node (Node #0) to start communication among the nodes while no stress is applied

	3. Initiate data transmission with the respective *PLCA Cycle and Message transfer*. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6. a. Messages are sent as broadcast, so all nodes can check counters and report an error. b. If PLCA functionality becomes disabled, *aPLCAStatus = FALSE* at any node, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. c. If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal *LocalStatusInformation* register. 4. After at least 1 second of starting communication, dynamic ground shifts are applied continuously during the test duration as defined in Table 61. 5. After at least 1 s ground shift condition is applied, commands to stop the communication and asserted *loc_low_power_req* are sent locally via host interface of the respective nodes following the different orders as defined in Table 61. Unless differently indicated *loc_low_power_req* is sent sequentially to each node (one node per PLCA cycle, but not necessarily in every cycle). 6. When *loc_low_power_req* at node #0 is asserted via its host interface, it shall be asserted after SUSPEND pattern is transmitted from the distortion node prior to transmission of WUP. a. Use an I/O port at node #0 to trigger the transmission of distortion pattern DP14 (SUSPEND) b. Then assert *loc_low_power_req* at node #0 and use this same signal to trigger DP31 (WUP) from the disturbance node before *low_power_timer_done*. Node #0 shall then go back to *WUS_NORMAL* state. 7. Read and record counters included in each received frame 8. The test shall run for at least 2 seconds + 7 nodes x *PLCACycleTime*. 9. Power-off all nodes.
Pass criteria	The test case shall be considered as passed, if all the following condition(s) are fulfilled. Messages received by node #0 shall be as expected in each PLCA cycle. No messages shall be received from nodes once *loc_low_power_req* has been asserted locally, apart from node #0. • All nodes shall enter low power mode in the intended order except for node #0. • *CycleCounter (CC); SequenceNumber (SN)* and *MessageCounter (MC)* stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO.
Test iterations	n.a.
Notes	

Table 61 - Test case instances definition for Group G2 - Test case G2.1

Instance Test Case #	Order	Ground shift	Condition
G2.1	2, 1, 4, 5, 6, 7, 0	GS0	– Communication is up and running, with all nodes. – Within 1 second ground shift condition is applied repeatedly. No timing relation to PLCA slots. – After at least 1 second ground shift condition is applied, commands to stop the communication and asserted *loc_low_power_req* are sent locally via host interface. – All nodes shall enter low power mode in the intended order except for node #0. – After at least 20 ms all nodes except for Node #0 have entered in low power mode, *loc_low_power_req* is asserted on Node #0 via its host interface, the same signal is used to trigger the transmission of distortion pattern DP31 (WUP) from the disturbance node (with a delay of about 1240us to allow Node#0 to complete the transmission of the frame allocated in its TO without causing a physical collision). If *loc_low_power_req* is asserted during data transmission, the node should wait for the frame transmission to complete before entering low power mode. – The test shall run for at least 2 seconds + 7 nodes x *PLCACycleTime*.

12.4 [WF] Wakeup-forwarding (optional, if supported)

ID: 10BASET1S_L1_IOP_29

Type: Requirement

The test cases defined in this section are mandatory for all 10BASE-T1S Multi-PHY devices (e.g. switches) or PHYs that implement WAKE_FWRD or WAKE_IN_OUT pins (most likely Head nodes) supporting the Wake-up/Sleep functionalities of the supplementary service primitive defined in [7].

12.4.1 Group WF1 – Wakeup-forwarding with ground shift

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
WF1	Wakeup-forwarding	H2	M1	yes	no	no	no	No	no	no	no

Table 62: Main test structure of Group WF1

Purpose	Purpose of the test is to ensure that a wakeup from the originating PHY can be forwarded to a target 10BASE-T1S mixing segment. On this target mixing segment the wakeup is sent over MDI (as WUP) and nodes can be woken even in case dynamic ground shifts are present
Reference	[2] [6] [5] [7]
Prerequisites	1. DUT with the capability to reset and configure its PHY. 2. DUT shall be able to be configured either as Coordinator node or as Follower node. 3. DUT shall be able to indicate PLCA status via its status registers (PLCA_STS). 4. DUT shall be able to send frames in the respective transmit opportunity. 5. DUT and link partners shall be able to detect any lost frames by the networking stack or by the application. For example, continually monitoring the number of sent frames from each node transmitting and comparing it to the sequence of frames received to identify if any have been missed. 6. The test system shall be able to monitor the status information, channel quality and PLCA diagnostic of the DUTs and LPs, as well as MAC counters such as frame CRC errors, alignment errors and collision counters during the test iterations. 7. Each node in the network, either DUTs or link partners, shall be able to transmit Ethernet frames as broadcast in its respective TO. 8. Each node in the network, either DUTs or link partners, shall be able to receive all frames sent by the other nodes. 9. DUT and link partners shall support supplementary service primitive that makes use of WUP command as defined in [7].
DUT set-up	1. This test case is conducted with *H2* topology using the configuration cycle as defined in section 8.5.1.

<table>
<tr><td></td><td>
<ol type="a">
aPLCANodeCount = 16
<ol start="2">
The DUTs’ positions are defined in Table 6
The used MessageTransfer_M1 is defined in section 8.6.

</td></tr>
<tr><td>Test description</td><td>

DUTs and LPs shall be powered on and configured with H2 topology using the configuration cycle as defined in section 8.5.1.
Reset CycleCounter (CC); SequenceNumber (SN), MessageCounter (MC) and StatusInformation (SI) at each node.
Once the configuration in all nodes is completed, set nodes in low-power mode “Sleep” by activating LowPowerEntryLocal.request service primitive as defined for the test instances in Table 63.
Enable the PLCA reconciliation sublayer functionality at all End and Drops Nodes among the nodes not being in low power and subsequently at the Head Node (Node #0) to start communication while no stress is applied.
Initiate data transmission with the respective PLCA Cycle and Message transfer. Each data field contains the respective payload [CC, SC, MC, SI, PLCA ID, Padding], as defined in section 8.6.
<ol type="a">
Messages are sent as broadcast, so all nodes not being in low power can check counters and report an error.
The counters [CC, SC, MC] are stored at each node and incremented accordingly after every sent message.
If PLCA functionality becomes disabled, aPLCAStatus = FALSE at any node, an interrupt shall be signaled, and the event stored in an internal LocalStatusInformation register.
If the SQI value at any node is lower than 1, an interrupt shall be signaled, and the event stored in an internal LocalStatusInformation register.

Keep transmitting MessageTransfer_M1 for at least 1s + ground shift frequency sweep time as defined in Table 63.
Dynamic ground shifts at nodes #0, #2 and #5, GS0 | GS2| GS5, are applied following the conditions defined in Table 63.
After at least 0.25 seconds ground shift condition is applied, a Wakeup.request originate:
<ol type="a">
[Source#1] either from an originating PHY of Node #0 (multi-PHY device) not belonging to the 10BASE-T1S mixing segment H2, or
[Source#2] over a physical pin (WAKE, WAKE_IN_OUT), is detected

Node #0 forwards WUP commands via Wakeup.request service primitive to the H2 target mixing segment.
Read and record counters included in each received frame.
Power-off all nodes.

</td></tr>
<tr><td>Pass criteria</td><td>
The test case shall be considered as passed, if all the following condition(s) are fulfilled.

Once the nodes are woken up, there shall be no loss of messages.

All nodes being in low power mode shall wake up within 17 ms and incorporate into the communication after node #0 forwards WUP commands.
CycleCounter (CC); SequenceNumber (SN) and MessageCounter (MC) stored in each node should be equal to value of the counter in the last frame received from the respective node ± 1. For nodes configured to send bursts, the deviation can be up to the number of frames configured to be sent in the respective TO.
No StatusInformation on any of the nodes should include any anomaly such as having signaled, if supported, an SQI value lower than 1 or if the PLCA has become inactive in any circumstance during communication.

</td></tr>
</table>

	• For information purposes the number of CRC errors, alignment errors and collision counters shall be read for each node.
Test iterations	If applicable, repeat test instances defined in Table 63 for Source#1 with Source#2 disclosed in step 8, i.e. *Wakeup.request* originated over a physical pin (WAKE, WAKE_IN_OUT).
Notes	

Table 63 - Test case instances definition for Group WF1 - Test cases WF1.1 to WF1.7

Instance Test Case #	Nodes in LP (Sleep and Standby)	Parameter	Condition

WF1.1	1, 2, 4, 5, 6, 7	none	– Nodes are in low-power mode as defined for the test instances
			– Communication is started among the nodes not being in low power while no stress is applied and after at least 1 second ground shift condition is applied
			– No timing relation to PLCA slots.
			– Condition remains for frequency sweep time:
			  – 0.7 seconds (node 0) [GS0]
			  – 1.1 seconds (node 2) [GS2]
			  – 1.3 seconds (node 5) [GS5]
			– If ground shift is applied at more than one node concurrently, then the frequency sweep time of the node with the higher ID will be applied.
			– After at least 0.25 seconds ground shift condition is applied, an originating PHY out of 10BASE-T1S mixing segment H2 detects a Wakeup.Request and forwards WUP commands via Wakeup.request service primitive to the H2 target mixing segment
			– The test shall run for at least 1 second + ground shift frequency sweep time.

WF1.2	2, 4, 6	GS05	
WF1.3	1, 5, 7	GS2	
WF1.4	1, 2, 4, 5, 6, 7	GS0	
WF1.5	2, 4, 6	GS05	
WF1.6	1, 5, 7	GS02	
WF1.7	5, 6, 7	GS2	

13 GROUP 4 – TOPOLOGY DISCOVERY

ID: 10BASET1S_L1_IOP_30

Type: Requirement

The test cases defined in this section are mandatory for all 10BASE-T1S PHYs supporting Topology Discovery procedure to measure the distance between two 10BASE-T1S nodes connected to the same link defined in [10].

Note that this method allows determining the distance between two nodes. The reference node shall always be an end node, in order to determine the order of the nodes connected to the same link. If the reference node is located somewhere in the middle of the mixing segment, the order of the nodes cannot be determined.

ID: 10BASET1S_L1_IOP_31

Type: Information

The test cases defined in this section shall ensure that the PHY is able to measure the distance between other PHYs from different vendor connected to the same link as defined in [10] under diverse stress conditions. This scenario can be used for homogenous and heterogenous (in that different PHYs are used) test configurations.

13.1 [T] Topology discovery (optional, if supported)

13.1.1 Group T1 – Topology discovery, controlled by higher layers – manual mode.

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
T1	Topology discovery	H2	n.a.	yes	no	no	no	no	no	no	no

Table 64: Main test structure of Group T1

Purpose	Purpose of the test is to ensure that the distance between two nodes connected to the same link can be measure correctly.
Reference	[10]
Prerequisites	The host at the DUT shall be able to enable PHY's topology discovery feature, as defined in [10], in each node.
DUT set-up	1. This test case is conducted with *H2* topology (mixing segment) 2. Disable PLCA functionality, as any transmission could affect the measurement.

	3. DUT shall be configured either as reference or as measured node

Test description	1. All nodes shall be power on.
	2. Reference node requests all nodes on the link to enable topology discovery functionality following the order as defined for the test instances in Table 65. (TD_EN = 1; MTX_DIS MAC transmission disabled = true).
	    a. All nodes shall be set in receive only mode, (set TD_EN at the TD Control register), as any transmission could affect the measurement.
	3. Unless differently indicated, set DM_DUR to 15 for better precision, duration of distance/delay measurement will result in 16ms.
	4. Dynamic ground shifts are applied continuously during the test duration as defined for the test instances in Table 65.
	5. Measured the internal delay. This shall be performed by two nodes at a time:
	    a. Two nodes shall be selected at a time while the rest of the nodes connected to the same mixing segment remain in receive only mode. One node shall be configured as reference node (set REFN at the TD Control register) and the second shall be configured as measured node (clean REFN at the TD Control register) as defined for the test instances in Table 65.
	        i. The node (first the reference node and then the measured node) starts internal delay measurement by setting DLYM_START of TD Control register.
	        ii. Monitor TD Status register at each node separately to confirm whether internal delay measurements finished successfully (DLYM_DONE), in the case proceed with next step otherwise (DLYM_ERR) go back to step a. Each time a measurement is aborted (finished unsuccessfully) a dedicated counter shall be incremented.
	        iii. The result of the internal delay measurement is reported in the TD_DLY_RES register of each node, this result shall be stored.
	        iv. Repeats the procedures from <i> upon the measurement of the internal delay at the measured node is completed.
	6. Measured the distance between two nodes.
	    a. The reference node requests one of the nodes to start a distance measurement procedure as a measured node. Then, the measured node shall start the distance measurement via DM_START bit of TD Control Register and the reference node shall do the same afterwards within 900 ms.
	    b. Monitor TD Status register at the reference node to confirm whether distance measurements finished successfully (DM_DONE), in the case proceed with next step otherwise (DM_ERR) go back to step a. Each time a measurement is aborted (finished unsuccessfully) a dedicated counter shall be incremented.
	    c. The result of the distance measurement is reported in the TD_DIST_RES register, this result shall be stored.
	    d. To increase the precision the average value of both distance results, read from the Reference Node as well as from the Measured Node registers, shall be used.
	7. Return to 5 until each reference – measured node combination as defined for the test instances in Table 65 has measured the distance.
	8. Read all recorded counters and measurement results obtained in each test instance.
	9. Repeat the distance measurement 2 times.
	10. Power-off all nodes.

Pass criteria	Each test iteration shall be classified as passed, if all the following condition(s) are fulfilled.

	○ Assuming a cable propagation delay of 5.5 ns/m, a measurement duration of 16 ms, the accuracy of the calculated distance measurements shall not be worse than ±50 cm[16]. The distance between each node is disclosed in section 8.4. ○ The distance measurement mismatch (number of received pulses) reported in the TD_DIST_RES registers of each of the two nodes, participating in the measurement of the distance, shall not be higher than ±3 pulses. ○ The results of the respective distance measurements obtained during the different repetitions shall be consistent and the number of pulses received shall not differ by more than ±3 pulses between each other.
Test iterations	Amount of test repetitions: each distance shall be determined at least 2 times
Notes	The result of distance measurement is just a number of received pulses within a defined time. For a proper correlation between the calculate distance it is needed to know propagation delay of used cable as well as the propagation delay of used MDI (CMCs, etc.).

Table 65 - Test case instances definition for Group T1 – Test cases T1.1 – T1.3

Instance Test Case #	Reference node	Measured node order	Parameter	Condition
T1.1	1	2, 4, 5, 0, 6, 7	none	– dynamic ground shifts are applied continuously during the test duration
T1.2	7	6, 0, 5, 4, 2, 1	GS25	
T1.3	0	5, 4, 2, 1, 6, 7	GS0	

[16] This accuracy is affected by the MDI components (mainly CMC) and all the parasitic elements in the line. The electrical distance of the MDI should be either given by the silicon vendor or measured and later considered accordingly in the calculated distance between reference and measured nodes.

13.1.2 Group T2 – Topology discovery, automatic mode

Test group	Test scenario	Wire harness	Message transfer	Ground shift	Loss of ground	Loss of power	Bus failure	CSMA/CD nodes	Termination variation	Gaussian noise	Distortion
T2	Topology discovery	H2	n.a.	yes	no	no	no	no	no	no	no

Table 66: Main test structure of Group T2

Purpose	Purpose of the test is to ensure that the distance between two nodes connected to the same link can be measure correctly.
Reference	[10]
Prerequisites	The host at the DUT shall be able to enable PHY's topology discovery feature, as defined in [10], in each node.
DUT set-up	1. This test case is conducted with *H2* topology (P2P link segment) 2. Disable PLCA functionality, as any transmission could affect the measurement. 3. DUT shall be configured either as reference or as measured node
Test description	1. All nodes shall be power on. 2. Reference node requests all nodes to on the link to enable topology discovery functionality (TD_EN = 1; MTX_DIS MAC transmission disabled = true) following the order as defined for the test instances in Table 67. 3. Unless differently indicated, set DM_DUR to 15 for better precision, duration of distance/delay measurement will result in 16ms. 4. Dynamic ground shifts are applied continuously during the test duration as defined for the test instances in Table 67. 5. Afterwards, it requests one of these nodes to enter TopDisc automatic procedure as a measured node. Then, the measured node shall start the automatic mode via AUTO_START bit of TD Control Register and the reference node shall do the same afterwards within 900 ms (i.e. 1s ±10% timer). a. Once the automatic mode is started, the reference node performs the internal delay measurement. The measured node is observing the link and waits until the measurement is done. Then, the measured node starts the measurement of its internal delay. b. The result of the last internal delay measurements in the automatic mode are reported in the TD_MNDLY_RES registers, these results shall be stored. c. After the successfully finished internal delay measurement, the measured node proceeds to the distance measurement and waits for the reference node to start the measurement. d. The result of the distance measurement is reported in the TD_DIST_RES register, this result shall be stored. e. Return to a. until each reference – measured node combination as defined for the test instances in Table 67 has measured the distance.

	6. Read all recorded counters and measurement results obtained in each test instance. 7. Repeat the distance measurement 2 times. 8. Power-off all nodes
Pass criteria	Each test iteration shall be classified as passed, if all the following condition(s) are fulfilled. ○ Assuming a cable propagation delay of 5.5 ns/m, a measurement duration of 16 ms, the accuracy of the obtained distance measurements shall not be worse than ±50 cm. The distance between each node is disclosed in section 8.4. ○ The distance measurement mismatch (number of received pulses) reported in the TD_DIST_RES registers of each of the two nodes, participating in the measurement of the distance, shall not be higher than ±3 pulses. ○ The results of the respective distance measurements obtained during the different repetitions shall be consistent and the number of received pulses shall not differ by more than ±3 pulses between each other.
Test iterations	Amount of test repetitions: each distance shall be determined at least 2 times
Notes	The result of distance measurement is just a number of received pulses within a defined time. For a proper correlation between the calculate distance it is needed to know propagation delay of used cable as well as the propagation delay of used MDI (CMCs, etc.).

Table 67 - Test case instances definition for Group T2 – Test cases T2.1 – T2.3

Instance Test Case #	Reference node	Measured node order	Parameter	Condition
T2.1	1	2, 4, 5, 0, 6, 7	none	– dynamic ground shifts are applied continuously during the test duration
T2.2	7	6, 0, 5, 4, 2, 1	GS25	
T2.3	0	5, 4, 2, 1, 6, 7	GS0	

14 APPENDIX

14.1 Artificial degradation of channel quality

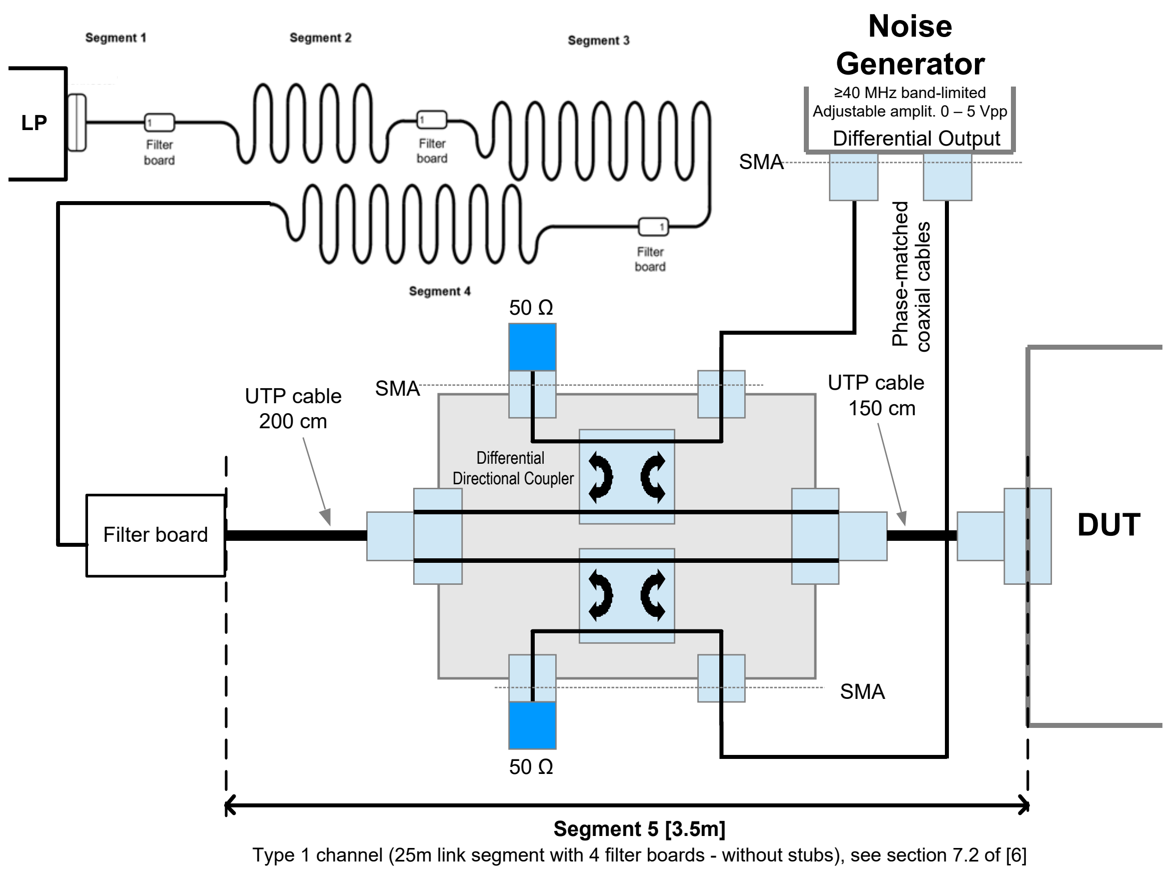


Figure 14-1 shows an example approach to artificially reduce the quality of the communication channel with a differential directional coupler whose parameters are defined in Table 68

Figure 14-1: Example for artificial degradation of channel quality

Table 68: Example for Differential Directional Coupler Parameters

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

14.2 List of tables

14.3 List of figures