Advanced diagnostic features for 10BASE-T1S automotive Ethernet PHYs

TC14 – advanced PHY features



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Introduction

This specification describes advanced features of a 10BASE-T1S automotive Ethernet PHY (often also called transceiver), e.g. for diagnostic purposes for automotive Ethernet PHYs.

Abbreviation/Symbols

AWG noise	Added White Gaussian noise
BCNBFTO	PLCA Beacon Received before Transmit Opportunity
BER	Bit Error Rate
CRC	Cyclic Redundancy Check
DCQ	Dynamic Channel Quality
ED	Energy Detect
HDD	Harness defect detection
MDI	Medium Dependent Interface
OSD	OPEN/SHORT detection
PHY	PHY is a Physical layer interface device, often called transceiver
PLCAD	Physical Layer Collision Avoidance Diagnostic
RXINTO	Packet Received in in Assigned Transmit Opportunity
SNR	Signal Noise Ratio
SQI	Signal Quality Index
TOID	Transmit Opportunity ID
UNEXPB	PLCA Unexpected Beacon received

1 Scope

The objective of this document is to provide a standard set of Advanced PHY features for 10BASE-T1S implementations.

2 Normative references

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

- [1] IEEE 802.3cg Task Force, "IEEE P802.3cg[™] 2019, Draft Standard for Ethernet Amendment 5: Physical Layer Specifications and Management Parameters for 10 Mb/s Operation and Associated Power Delivery over a Single Balanced Pair of Conductors.
- [2] IEEE Std 802.3[™] 2018, IEEE Standard for Ethernet.
- [3] OPEN Alliance 10BASE-T1S Transceiver Interface.

3 Terms and Definitions

For the purposes of this document, the terms and definitions given in [1], [2], and [3] apply.

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

- ISO Online browsing platform: available at https://www.iso.org/obp
- IEC Electropedia: available at <u>http://www.electropedia.org/</u>
- 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	
	ontain the 100 Ω 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=1254. 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 segment includes two end nodes, one coordinator and one head node.

4 **Overview**

10BASE-T1S automotive Ethernet transceivers (PHY or every PHY port of a switch) shall offer the information specified below for diagnostic purposes.

group	group name	parameter	parameter name	Description	mandatory /optional	remarks
DCQ	Dynamic channel quality	TOID	SQI Transmit Opportunity ID	The SQI value is determined for only a specific transmitting node as identified by the PLCA transmit opportunity as configured in TOID	m/o	3)
		SQI	Signal Quality Index	A classification of the signal quality at least in 3 stages. (green, yellow, red).	m/o	1), 3)
HDD	Harness defect detection	OS	OPEN/SHORT Detection	Cable-Harness errors (short circuit or open line) shall be detected.	m/o	3), 4)
PLCAD	PLCA diagnostic	BCNBFTO	PLCA Beacon Received Before Transmit Opportunity	The PLCA Beacon Received Before Transmit Opportunity (BCNBFTO) status indicates the possibility of multiple coordinator nodes on the mixing segment, or a coordinator node incorrectly configured with a node count smaller than the number of nodes on the mixing segment.	m	6)
		UNEXPB	PLCA Unexpected Beacon	The Unexpected Beacon (UNEXPB) status indicates the existence of another coordinator on the mixing segment.	m	5)
		RXINTO	PLCA Receive in Assigned Transmit Opportunity	The Receive in Assigned Transmit Opportunity (RXINTO) status bit indicates the existence of another node on the mixing segment assigned with a duplicate ID	m	

Table 1: Overview of required PHY parameters to be stored and provided via Register Fields.

Remarks to Table 1:

- 1) The SQI levels, at least 3, should correlate to according SNR values at the PHY input and may represent corresponding bit error rates (in the case of an interference model with white Gaussian noise).
- 2) All of the above registers can be reset.
- 3) Mandatory for head node, optional for other nodes.
- 4) Diagnostic function is only available in special "diagnostic" mode, not on the fly.
- 5) Only for PLCA Coordinator
- 6) Only for PLCA Follower

5 Advanced PHY features

5.1 Dynamic Channel Quality

Dynamic channel quality includes the SQI value.

5.1.1 SQI Transmit Opportunity ID (DCQ.TOID) Mandatory for head node, optional for other nodes

The SQI value (at least 3 levels), specified in 5.1.2 is determined for only a specific PLCA transmit opportunity as configured in DCQ.TOID. Multidrop mixing segments operating with PLCA enabled allow for the determination of a SQI value for each PHY transmit opportunity. Point-to-point segments need not have PLCA enabled, in which case the SQI may be computed over all received packets.

Register Field	DCQ.TOID
Name	Signal Quality Index Transmit Opportunity ID
size[bits]	8

Field value	Explanation
0x00	Compute SQI over packets received in PLCA transmit opportunity 0
0x01	Compute SQI over packets received in PLCA transmit opportunity 1
0x02	Compute SQI over packets received in PLCA transmit opportunity 2
0xFF	Compute SQI over all received packets. (Used for point-to-point or non-PLCA
	segments.)

Table 2: Definition of DCQ.TOID.

5.1.2 SQI Estimate Value (DCQ.SQI)

Mandatory for head node, optional for other nodes

The SQI value of at least three levels shall be stored in a register. For implementations with less than 8 levels, the levels shall be equally spaced within the 3-bit SQI value field.

Register Field	DCQ.SQI
Name	Signal Quality Index (current SQI value)
size[bits]	3

Field value	Explanation	Explanation
0x0	SQI=0 (red, worst value, not acceptable)	SQI=0 (worst value)
0x1		SQI=1
0x2		SQI=2
0x3	SQI=3 (yellow, still acceptable working)	SQI=3
0x4		SQI=4
0x5		SQI=5
0x6		SQI=6
0x7	SQI=7 (green, best value, normal working)	SQI=7 (best value)

Table 3: Definition of DCQ.SQI (mandatory at least 3 levels)

The following features of the SQI value are mandatory:

- The indicated signal quality should monotonically increase /decrease with noise level.
- The datasheet shall indicate at which level a BER $< 10^{-10}$ (better than 10^{-10}) is achieved.

The bit error rates to be expected in the case of white noise as interference signal are shown in the tables as well for information purposes.

some a cossing.			
SQI with 3	*) noise margin @MDI - AWG noise,	recommended BER for AWG noise model	
levels.SQI	30MHz (informative)	(informative)	
value			
(3 levels)			
SQI=0	noise margin < ED threshold	BER>10 ⁻¹⁰	
(red)			
SQI=1	noise margin < ED threshold	10 ⁻¹² <ber<10<sup>-10</ber<10<sup>	
(yellow)			
SQI=2	noise margin ≥ ED threshold	BER<10 ⁻¹²	
(green)			

Correlation SQI to RX/ED threshold crossing:

Table 4: Recommended correlation from SQI (3 levels) to SNR under AWG assumption.

*) TX, RX, and ED. Further details are specified in [3].

• ED is an Energy Detect that is asserted when MDI input is between a crossing threshold

• RX is output from bit comparator



Figure 1: Illustration of the diagnostic principle.

Correlation SQI to SNR for SQI > 3 levels (open to the implementer) Example: SQI with 8 levels

SQI value	SNR value @MDI - AWG noise, 80MHz	recommended BER for AWG noise model
(8 levels)	(informative)	(informative)
SQI=0	<12dB	
SQI=1	12dB= <snr<14db< td=""><td>BER>10⁻¹⁰</td></snr<14db<>	BER>10 ⁻¹⁰
SQI=2	14dB= <snr<16db< td=""><td></td></snr<16db<>	
SQI=3	16dB= <snr<17db< td=""><td></td></snr<17db<>	
SQI=4	17dB= <snr<18db< td=""><td> 10</td></snr<18db<>	10
SQI=5	19dB= <snr<21db< td=""><td>BER<10-10</td></snr<21db<>	BER<10-10
SQI=6	21dB= <snr<23db< td=""><td></td></snr<23db<>	
SQI=7	23dB= <snr< td=""><td></td></snr<>	

Table 5: Recommended correlation from SQI (8 levels) to SNR under AWG assumption.

5.2 Harness Defect Detection (HDD)

5.2.1 OPEN and SHORT detection (OS)

Mandatory for head node, optional for other nodes

There shall be a possibility to detect harness defects. This can either be done during normal operation (as long as possible) or in a specific host-triggered diagnostic mode. With this functionality a PHY shall reliably detect the following error situations as long as the channel is properly terminated:

- OPEN of one bus wire
- OPEN of both bus wires
- SHORT of both conductors (to ground or supply line)
- SHORT between both bus wires
- (OPTIONAL) SHORT of one conductor (to ground or supply line)*

(OPEN = open circuit, SHORT = short circuit)

It is not necessary to distinguish all of the above error situations individually.

Overview of failure types



Figure 2: Overview of mandatory harness defects to be detected.

It is mandatory to detect all these failures from the head-node when all the other drop-nodes are not transmitting any signal. Optionally these failures may also detected from each drop-node.

It could be easier to apply this harness failures detection in a kind of diagnostic mode. The system implementer should design the system to ensure that the other nodes on the segment also enter a kind of passive mode to avoid disturbing the testing signals to be transmitted by the node performing the diagnostic.

*REMARK: The condition of a short circuit of one bus wire to GND or V_{bat} is not reliably detectable with today's technology. The detection of a short circuit of one wire to GND or V_{bat} is therefore an optional feature. If communication is occurring, this may only be identified by higher application software layers due to decreased signal quality. An indication for such a failure may be a reduced SQI or increased sporadic errors.

one bus wire connected to GND or V_{bat}



Figure 3: Overview of optional harness defect to be detected.

Table is showing the Bus Failure Matrix, indicating which combinations of failures and environmental conditions are mandatory to detect and which combinations are optional.

Bus Failure Matrix	Head-Node	Drop-Node
cable OK	mandatory	optional
Both bus wires OPEN	mandatory	optional
Bus wires SHORT	mandatory	optional
One bus wire OPEN	mandatory	optional
both bus wires SHORT to GND/V _{bat}	mandatory	optional
one bus wires SHORT to GND/V _{bat}	optional	optional

Table 6: Bus failure matrix.

5.3 PLCA diagnostic (PLCAD)

5.3.1 PLCA Beacon Received Before Transmit Opportunity (PLCAD.BCNBFTO) Mandatory only for PLCA Follower

Register Field	PLCAD.BCNBFTO
Name	PLCA Beacon Received Before Transmit Opportunity
size[bits]	1

Field Value	Description
0x0	No Error
0x1	PLCA Follower Received a Beacon before its assigned transmit opportunity
Table 7: Definition of	f PLCA Diagnostic Beacon Received Before Transmit Opportunity (PLCAD.BCNBFTO) Register Field

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 occurred. This condition indicates the possibility of multiple coordinator nodes on the mixing segment, or a coordinator node incorrectly configured with a node count smaller than the number of nodes on the mixing segment.

The Beacon Received before Transmit Opportunity status bit shall be cleared by an intentional write action of the host.

5.3.2 PLCA Unexpected Beacon (PLCAD.UNEXPB) Mandatory only for PLCA Coordinator

Register Field	PLCAD.UNEXPB
Name	PLCA Unexpected Beacon
size[bits]	1

Field Value	Description
0x0	No error
0x1	PLCA Controller received a Beacon it did not send

Table 8: Definition of PLCA Diagnostic Unexpected Beacon (PLCAD.UNEXP) Register Field

The Unexpected Beacon (UNEXPB) status bit reads as a '1' when the controller node received a Beacon it did not transmit. This condition indicates the existence of another coordinator on the mixing segment.

The Unexpected Beacon status bit shall be cleared by an intentional action of the host.

5.3.3 PLCA Receive in Assigned Transmit Opportunity (PLCAD.RXINTO) Mandatory for PLCA Coordinator and for PLCA Follower

Register Field	PLCAD.RXINTO
Name	PLCA Receive in Assigned Transmit Opportunity
size[bits]	1

Field Value	Explanation
0x0	No error
0x1	PHY detected the beginning of a packet in its assigned transmit opportunity

Table 9: Definition of PLCA Diagnostic Receive in Assigned Transmit Opportunity (PLCAD.RXINTO) Register Field

The Receive in Assigned Transmit Opportunity (RXINTO) status bit reads as a '1'when the PHY asserts RXDV at the beginning of a packet in its assigned transmit opportunity. This condition indicates the existence of another node on the mixing segment assigned with a duplicate node ID.

The Receive in Assigned Transmit Opportunity status bit shall be cleared by an intentional write action of the host.