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Information technology — Telecommunications and information exchange between systems — Local and metropolitan area networks — Specific requirements —

Part 3: Standard for Ethernet

AMENDMENT 9: Physical layer specifications and management parameters for 1000 Mb/s operation over plastic optical fiber

Technologies de l'information — Télécommunications et échange d'information entre systèmes — Réseaux locaux et métropolitains — Prescriptions spécifiques —

Partie 3: Norme pour Ethernet

AMENDEMENT 9

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IEEE Std 802.3bv™-2017
(Amendment to
IEEE Std 802.3™-2015
as amended by
IEEE Std 802.3bw™-2015,
IEEE Std 802.3by™-2016,
IEEE Std 802.3bq™-2016,
IEEE Std 802.3bp™-2016,
IEEE Std 802.3br™-2016,
IEEE Std 802.3bn™-2016,
IEEE Std 802.3bz™-2016, and
IEEE Std 802.3bu™-2016)

IEEE Standard for Ethernet

Amendment 9: Physical Layer Specifications and Management Parameters for 1000 Mb/s Operation Over Plastic Optical Fiber

LAN/MAN Standards Committee
of the
IEEE Computer Society

Approved 14 February 2017
IEEE-SA Standards Board

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Abstract: A family of three point-to-point physical layers (PHYs) for 1000 Mb/s operation over duplex plastic optical fiber (POF) and related management parameters are specified by this amendment to IEEE Std 802.3-2015.

Keywords: 1000BASE-H, 1000BASE-RHA, 1000BASE-RHB, 1000BASE-RXC, amendment, BASE-H, EEE, Energy Efficient Ethernet, IEEE 802.3™, IEEE 802.3bv™, PCS, Physical Coding Sublayer, Physical Medium Attachment sublayer, Physical Medium Dependent sublayer, plastic optical fiber, PMA, PMD, POF

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Introduction

This introduction is not part of IEEE Std 802.3bv-2017, IEEE Standard for Ethernet—Amendment 9: Physical Layer Specifications and Management Parameters for 1000 Mb/s Operation Over Plastic Optical Fiber

IEEE Std 802.3™ was first published in 1985. Since the initial publication, many projects have added functionality or provided maintenance updates to the specifications and text included in the standard. Each IEEE 802.3 project/amendment is identified with a suffix (e.g., IEEE Std 802.3ba™-2010).

The half duplex Media Access Control (MAC) protocol specified in IEEE Std 802.3-1985 is Carrier Sense Multiple Access with Collision Detection (CSMA/CD). This MAC protocol was key to the experimental Ethernet developed at Xerox Palo Alto Research Center, which had a 2.94 Mb/s data rate. Ethernet at 10 Mb/s was jointly released as a public specification by Digital Equipment Corporation (DEC), Intel and Xerox in 1980. Ethernet at 10 Mb/s was approved as an IEEE standard by the IEEE Standards Board in 1983 and subsequently published in 1985 as IEEE Std 802.3-1985. Since 1985, new media options, new speeds of operation, and new capabilities have been added to IEEE Std 802.3. A full duplex MAC protocol was added in 1997.

Some of the major additions to IEEE Std 802.3 are identified in the marketplace with their project number. This is most common for projects adding higher speeds of operation or new protocols. For example, IEEE Std 802.3u™ added 100 Mb/s operation (also called Fast Ethernet), IEEE Std 802.3z added 1000 Mb/s operation (also called Gigabit Ethernet), IEEE Std 802.3ae added 10 Gb/s operation (also called 10 Gigabit Ethernet), IEEE Std 802.3ah™ specified access network Ethernet (also called Ethernet in the First Mile) and IEEE Std 802.3ba added 40 Gb/s operation (also called 40 Gigabit Ethernet) and 100 Gb/s operation (also called 100 Gigabit Ethernet). These major additions are all now included in and are superseded by IEEE Std 802.3-2015 and are not maintained as separate documents.

At the date of IEEE Std 802.3bv-2017 publication, IEEE Std 802.3 is composed of the following documents:

IEEE Std 802.3-2015

Section One—Includes Clause 1 through Clause 20 and Annex A through Annex H and Annex 4A. Section One includes the specifications for 10 Mb/s operation and the MAC, frame formats and service interfaces used for all speeds of operation.

Section Two—Includes Clause 21 through Clause 33 and Annex 22A through Annex 33E. Section Two includes management attributes for multiple protocols and speed of operation as well as specifications for providing power over twisted pair cabling for multiple operational speeds. It also includes general information on 100 Mb/s operation as well as most of the 100 Mb/s Physical Layer specifications.

Section Three—Includes Clause 34 through Clause 43 and Annex 36A through Annex 43C. Section Three includes general information on 1000 Mb/s operation as well as most of the 1000 Mb/s Physical Layer specifications.

Section Four—Includes Clause 44 through Clause 55 and Annex 44A through Annex 55B. Section Four includes general information on 10 Gb/s operation as well as most of the 10 Gb/s Physical Layer specifications.

Section Five—Includes Clause 56 through Clause 77 and Annex 57A through Annex 76A. Clause 56 through Clause 67 and Clause 75 through Clause 77, as well as associated annexes, specify subscriber

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access and other Physical Layers and sublayers for operation from 512 kb/s to 10 Gb/s, and defines services and protocol elements that enable the exchange of IEEE Std 802.3 format frames between stations in a subscriber access network. Clause 68 specifies a 10 Gb/s Physical Layer specification. Clause 69 through Clause 74 and associated annexes specify Ethernet operation over electrical backplanes at speeds of 1000 Mb/s and 10 Gb/s.

Section Six—Includes Clause 78 through Clause 95 and Annex 83A through Annex 93C. Clause 78 specifies Energy-Efficient Ethernet. Clause 79 specifies IEEE 802.3 Organizationally Specific Link Layer Discovery Protocol (LLDP) type, length, and value (TLV) information elements. Clause 80 through Clause 95 and associated annexes includes general information on 40 Gb/s and 100 Gb/s operation as well the 40 Gb/s and 100 Gb/s Physical Layer specifications. Clause 90 specifies Ethernet support for time synchronization protocols.

IEEE Std 802.3bw™-2015

Amendment 1—This amendment includes changes to IEEE Std 802.3-2015 and adds Clause 96. This amendment adds 100 Mb/s Physical Layer (PHY) specifications and management parameters for operation on a single balanced twisted-pair copper cable.

IEEE Std 802.3by™-2016

Amendment 2—This amendment includes changes to IEEE Std 802.3-2015 and adds Clause 105 through Clause 112, Annex 109A, Annex 109B, Annex 110A, Annex 110B, and Annex 110C. This amendment adds MAC parameters, Physical Layers, and management parameters for the transfer of IEEE 802.3 format frames at 25 Gb/s.

IEEE Std 802.3bq™-2016

Amendment 3—This amendment includes changes to IEEE Std 802.3-2015 and adds Clause 113 and Annex 113A. This amendment adds new Physical Layers for 25 Gb/s and 40 Gb/s operation over balanced twisted-pair structured cabling systems.

IEEE Std 802.3bp™-2016

Amendment 4—This amendment includes changes to IEEE Std 802.3-2015 and adds Clause 97 and Clause 98. This amendment adds point-to-point 1 Gb/s Physical Layer (PHY) specifications and management parameters for operation on a single balanced twisted-pair copper cable in automotive and other applications not utilizing the structured wiring plant.

IEEE Std 802.3br™-2016

Amendment 5—This amendment includes changes to IEEE Std 802.3-2015 and adds Clause 99. This amendment adds a MAC Merge sublayer and a MAC Merge Service Interface to support for Interspersing Express Traffic over a single link.

IEEE Std 802.3bn™-2016

Amendment 6—This amendment adds the Physical Layer specifications and management parameters for symmetric and/or asymmetric operation of up to 10 Gb/s on point-to-multipoint Radio Frequency (RF) distribution plants comprising either amplified or passive coaxial media. It also extends the operation of Ethernet Passive Optical Networks (EPON) protocols, such as Multipoint Control Protocol (MPCP) and Operation Administration and Management (OAM).

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IEEE Std 802.3bz™-2016

Amendment 7—This amendment includes changes to IEEE Std 802.3-2015 and adds Clause 125 and Clause 126. This amendment adds new rates of 2.5 Gb/s and 5 Gb/s and new Physical Layers for operation at 2.5 Gb/s and 5 Gb/s over balanced twisted-pair structured cabling systems.

IEEE Std 802.3bu™-2016

Amendment 8—This amendment includes changes to IEEE Std 802.3-2015 to define a methodology for the provision of power via a single twisted pair to connected Data Terminal Equipment (DTE) with IEEE 802.3 single twisted-pair interfaces.

IEEE Std 802.3bv-2017

Amendment 9—This amendment includes changes to IEEE Std 802.3-2015 and adds Clause 115 and Annex 115A. This amendment adds point-to-point 1000 Mb/s Physical Layer (PHY) specifications and management parameters for operation on duplex plastic optical fiber (POF) targeting use in automotive, industrial, home-network, and other applications.

A companion document IEEE Std 802.3.1 describes Ethernet management information base (MIB) modules for use with the Simple Network Management Protocol (SNMP). IEEE Std 802.3.1 is updated to add management capability for enhancements to IEEE Std 802.3 after approval of the enhancements.

IEEE Std 802.3 will continue to evolve. New Ethernet capabilities are anticipated to be added within the next few years as amendments to this standard.

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IEEE Standard for Ethernet

Amendment 9: Physical Layer Specifications and Management Parameters for 1000 Mb/s Operation Over Plastic Optical Fiber

1. Introduction

1.3 Normative references

Insert the following references in alphanumeric order:

IEC 60793-1-41:2010, Optical fibres—Part 1-41: Measurement methods and test procedures—Bandwidth.

IEC 60793-2-40:2009, Optical fibres—Part 2-40: Product specifications—Sectional specification for category A4 multimode fibres.

IEC 61300-2-4, Fibre optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-4: Tests—Fibre/cable retention.

IEC 61300-3-53, Fibre optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-53: Examinations and measurements—Encircled angular flux (EAF) measurement method based on two-dimensional far field data from step index multimode waveguide (including fibre).

ISO/IEC 14763-3:2014, Information technology—Implementation and operation of customer premises cabling—Part 3: Testing of optical fibre cabling.

1.4 Definitions

Insert the following new definition after 1.4.22 "1000BASE-CX":

1.4.22a 1000BASE-H: IEEE 802.3 PCS and PMA sublayers for 1000 Mb/s Ethernet that support PMDs using duplex plastic optical fiber. (See IEEE Std 802.3, Clause 115.)

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Insert the following new definitions after 1.4.26 "1000BASE-PX":

1.4.26a 1000BASE-RHA: IEEE 802.3 Physical Layer specification for 1000 Mb/s Ethernet using 1000BASE-H encoding and red light (approximately 650 nm) PMD tailored for home-network and other consumer application requirements. (See IEEE Std 802.3, Clause 115.)

1.4.26b 1000BASE-RHB: IEEE 802.3 Physical Layer specification for 1000 Mb/s Ethernet using 1000BASE-H encoding and red light (approximately 650 nm) PMD tailored for industrial application requirements. (See IEEE Std 802.3, Clause 115.)

1.4.26c 1000BASE-RHC: IEEE 802.3 Physical Layer specification for 1000 Mb/s Ethernet using 1000BASE-H encoding and red light (approximately 650 nm) PMD tailored for automotive application requirements. (See IEEE Std 802.3, Clause 115.)

1.4.26d 1000BASE-RHx: IEEE 802.3 specification for 1000 Mb/s Ethernet using duplex plastic optical fiber and red light (approximately 650 nm) with unspecified optical power budget (optical power budget is defined by the specific PMD type). (See IEEE Std 802.3, Clause 115.)

Change the definition 1.4.91 as follows:

1.4.91 64B/65B transmission code: A block oriented encoding where 64-bit blocks are prepended with a single bit to indicate whether the block contains only data or a mix of data and control information. The details of each 64B/65B encoding are specific to the PCS. (See IEEE Std 802.3, Clause 55, and Clause 115.)

Insert the following new definition after 1.4.245 "jumper cable assembly":

1.4.245a Kojiri-safe: A property of the mechanical design for receptacles and mated plugs to protect sensitive functional elements, especially fiber optic ferrules and receptacles. Also called scoop-proof.

Insert the following new definition after 1.4.277a "MultiGBASE-T" (inserted by IEEE Std 802.3bq-2016):

1.4.277b multi-level coset code (MLCC): A forward error correcting technique consisting of splitting the information bit stream among several levels, for each one a binary component code (possibly none) is employed with an error correction capability according to the reliability of each level in data transmission over noisy channels. (See IEEE Std 802.3, Clause 115.)

Insert the following new definitions after 1.4.326 "Physical Coding Sublayer":

1.4.326a physical data block (PDB): The minimum data unit of 65 bits used to encode the GMII data stream. (See IEEE Std 802.3, Clause 115.)

1.4.326b physical header data (PHD): Side information block embedded inside a Transmit Block that is used to exchange control and for negotiation of PCS and PMA parameters between two link partners. (See IEEE Std 802.3, Clause 115.)

1.4.326c physical header subframe (PHS): Block of symbols that are the result of adding error detection and error correction parities plus modulation to PHD (See IEEE Std 802.3, Clause 115.)

Change the definition of 1.4.401 as follows:

1.4.401 Tomlinson-Harashima precoder (THP): A precoding technique for intersymbol interference mitigation. (See IEEE Std 802.3, Clause 55, and Clause 115.)

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1.5 Abbreviations

Insert the following new abbreviations into the list, in alphanumeric order:

BCH	Bose, Ray-Chaudhuri, Hocquenghem
LED	light emitting diode
MLCC	multi-level coset code
PDB	physical data block
PHD	physical header data
PHS	physical header subframe
POF	plastic optical fiber
SI-POF	step index plastic optical fiber

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30. Management

30.3.2.1.2 aPhyType

Insert the following after 1000BASE-X in APPROPRIATE SYNTAX:

APPROPRIATE SYNTAX:

...
1000BASE-H Clause 115 1000 Mb/s PAM16-THP

30.3.2.1.3 aPhyTypeList

Insert the following after 1000BASE-X in APPROPRIATE SYNTAX:

APPROPRIATE SYNTAX:

...
1000BASE-H Clause 115 1000 Mb/s PAM16-THP

30.5.1.1.2 aMAUType

Insert the following enumerations after 1000BASE-KX in APPROPRIATE SYNTAX:

APPROPRIATE SYNTAX:

...
1000BASE-RHA Plastic optical fiber PHY as specified in Clause 115.
1000BASE-RHB Plastic optical fiber PHY as specified in Clause 115.
1000BASE-RHC Plastic optical fiber PHY as specified in Clause 115.

30.5.1.1.4 aMediaAvailable

Insert into the third paragraph in BEHAVIOUR DEFINED AS section of 30.5.1.1.4 after the second sentence (and before the sentences inserted by IEEE Std 802.3bw-2015 and IEEE Std 802.3bp-2016) the following:

BEHAVIOUR DEFINED AS:

...
For 1000BASE-RHx, a link_status (see 115.3.5.4 and 45.2.3.47d.3) of OK maps to the enumeration “available” and a link_status of FAIL maps to the enumeration “not available”

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45. Management Data Input/Output (MDIO) Interface

45.2 MDIO Interface Registers

45.2.1 PMA/PMD registers

Change the 1.22 through 1.29 Reserved row (as modified by IEEE Std 802.3bz-2016) and insert a new row above as follows:

Table 45–3—PMA/PMD registers

Register address	Register name	Subclause
1.22	BASE-H PMA/PMD extended ability	45.2.1.14d
~~1.22~~1.23 through 1.29	Reserved	

Change the 1.740 through 1.1099 Reserved row of Table 45-3 and insert new rows as follows (unchanged rows not shown):

Table 45–3—PMA/PMD registers

Register address	Register name	Subclause
1.740 through ~~1.1099~~1.899	Reserved	
1.900	BASE-H PMA/PMD control	45.2.1.117a
1.901 through 1.1099	Reserved	

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45.2.1.6 PMA/PMD control 2 register (Register 1.7)

Change the below 1 1 0 1 0 x = reserved line in the Description of bits 1.7.5:0 of Table 45–7 to be two lines, including new footnote c (footnote b inserted by IEEE Std 802.3bp-2016) as follows:

Table 45–7—PMA/PMD control 2 register bit definitions

Bit(s)	Name	Description	R/W[a]
1.7.5:0	PMA/PMD type selection	5 4 3 2 1 0 ~~1 1 0 1 0 x = reserved~~ 1 1 0 1 0 1 = reserved 1 1 0 1 0 0 = BASE-H PMA/PMD[c]	R/W

[a]R/W = Read/Write, RO = Read only
[b]If BASE-T1 is selected, bits 1.2100.3:0 are used to differentiate which BASE-T1 PMA/PMD is selected.
[c]If BASE-H PMA/PMD is selected, register 1.900 is used to differentiate which BASE-H PMA/PMD is selected.

45.2.1.10 PMA/PMD extended ability register (Register 1.11)

Change Bit 1.11.15 of Table 45-14 (as modified by IEEE Std 802.3bz-2016), as follows (unchanged rows not shown):

Table 45–14—PMA/PMD extended ability register bit definitions

Bit(s)	Name	Description	R/W[a]
1.11.15	~~Reserved~~ BASE-H extended abilities	~~Value always zero~~1 = PMA/PMD has BASE-H extended abilities listed in register 1.22. 0 = PMA/PMD does not have BASE-H extended abilities	RO

[a]RO = Read Only

Insert new subclause 45.2.1.10.aaaa before 45.2.10.aaa (inserted by IEEE Std 802.3bz-2016) as follows (unchanged rows not shown):

45.2.1.10.aaaa BASE-H extended abilities (1.11.15)

When read as one, bit 1.11.15 indicates that the PMA/PMD has BASE-H extended abilities listed in register 1.22. When read as zero, bit 1.11.15 indicates that the PMA/PMD does not have BASE-H extended abilities.

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Insert new subclause 45.2.1.14d and Table 45-17d after 45.2.1.14c (as inserted by IEEE Std 802.3bz-2016) as follows:

45.2.1.14d BASE-H PMA/PMD extended ability register (Register 1.22)

The assignment of bits in the BASE-H PMA/PMD extended ability register is shown in Table 45–17d. All of the bits in the BASE-H PMA/PMD extended ability register are read only; a write to the BASE-H PMA/PMD extended ability register shall have no effect.

Table 45–17d—BASE-H PMA/PMD extended ability register bit definitions

Bit(s)	Name	Description	R/W[a]
1.22.15:3	Reserved	Value always 0	RO
1.22.2	1000BASE-RHC ability	1 = PMA/PMD is able to perform 1000BASE-RHC 0 = PMA/PMD is not able to perform 1000BASE-RHC	RO
1.22.1	1000BASE-RHB ability	1 = PMA/PMD is able to perform 1000BASE-RHB 0 = PMA/PMD is not able to perform 1000BASE-RHB	RO
1.22.0	1000BASE-RHA ability	1 = PMA/PMD is able to perform 1000BASE-RHA 0 = PMA/PMD is not able to perform 1000BASE-RHA	RO

[a]RO = Read Only

Insert new subclause 45.2.1.117a and Table 45-90a after 45.2.1.117 as follows:

45.2.1.117a BASE-H PMA/PMD control register (Register 1.900)

The assignment of bits in the BASE-H PMA/PMD control register is shown in Table 45–90a.

Table 45–90a—BASE-H PMA/PMD control register bit definitions

Bit(s)	Name	Description	R/W[a]
1.900.15:4	Reserved	Value always 0	RO
1.900.3:0	Type selection	3 2 1 0 1 x x x = Reserved 0 1 x x = Reserved 0 0 1 1 = Reserved 0 0 1 0 = 1000BASE-RHC 0 0 0 1 = 1000BASE-RHB 0 0 0 0 = 1000BASE-RHA	R/W

[a]RO = Read Only, R/W = Read Write

45.2.1.117a.1 Type selection (1.900.3:0)

Bits 1.900.3:0 are used to set the mode of operation. When these bits are set to 0000, the mode of operation is 1000BASE-RHA. When these bits are set to 0001, the mode of operation is 1000BASE-RHB. When these bits are set to 0010, the mode of operation is 1000BASE-RHC. Any attempt to configure a different value or a mode of operation not supported per register 1.22 shall have no effect.

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45.2.3 PCS registers

Change the 3.420 through 3.1799 reserved row of Table 45-119 and insert new 1000BASE-H rows as follows (unchanged rows and footnotes not shown):

Table 45–119—PCS registers

Register address	Register name	Subclause
3.420 through ~~3.1799~~3.499	Reserved	
3.500	1000BASE-H OAM transmit control	45.2.3.47a
3.501 through 3.508	1000BASE-H OAM transmit message	45.2.3.47a
3.509	1000BASE-H OAM receive control	45.2.3.47b
3.510 through 3.517	1000BASE-H OAM receive message	45.2.3.47b
3.518	1000BASE-H PCS control	45.2.3.47c
3.519	1000BASE-H PCS status 1	45.2.3.47d
3.520	1000BASE-H PCS status 2	45.2.3.47e
3.521	1000BASE-H PCS status 3	45.2.3.47f
3.522	1000BASE-H PCS status 4	45.2.3.47g
3.523 through 3.1799	Reserved	

Insert 45.2.3.47a after 45.2.3.47 as follows:

45.2.3.47a 1000BASE-H OAM transmit registers (Registers 3.500 through 3.508)

Registers 3.500 through 3.508 are used to transmit messages over the 1000BASE-H OAM channel established between two link partners (see 115.9.1). The 1000BASE-H OAM message is part of the physical header data (PHD) defined for 1000BASE-H (see Table 115–6).

The transmit registers are used to compose a 1000BASE-H OAM message and to control its transmission to the link partner. Register 3.500 contains control, status, identification, and the beginning of a 1000BASE-H OAM message. Eight additional registers (3.501 through 3.508) hold the remainder of the 1000BASE-H OAM message.

The assignment of bits in the 1000BASE-H OAM transmit registers is shown in Table 45–160a.

45.2.3.47a.1 TXO_REQ (3.500.15)

Bit 3.500.15 set to one requests the 1000BASE-H based PHY to transmit the 1000BASE-H OAM message written to registers 3.500 through 3.508. Bit 3.500.15 is set to zero by the 1000BASE-H based PHY to indicate that the 1000BASE-H OAM message has been accepted for transmission, and that the 1000BASE-H OAM transmit message registers are free to accept a new 1000BASE-H OAM message.

Bit 3.500.15, together with bits 3.500.14 (TXO_PHYT), 3.500.13 (TXO_MERT), and 3.500.12 (TXO_MSGT), indicates the status of the 1000BASE-H OAM transmission channel (see 115.9.2).

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Table 45–160a—1000BASE-H OAM transmit register bit definitions

Bit(s)	Name	Description	R/W[a]
3.500.15	TXO_REQ	1 = Transmission of a 1000BASE-H OAM message is pending; write as 1 to request transmission 0 = 1000BASE-H transmit registers are available for a new 1000BASE-H OAM message	R/W, SC
3.500.14	TXO_PHYT	The identifier of the last 1000BASE-H OAM message received by the remote PHY	RO
3.500.13	TXO_MERT	The identifier of the last 1000BASE-H OAM message read by the STA attached to the remote PHY	RO
3.500.12	TXO_MSGT	1000BASE-H OAM message identifier; its value change with each new transmitted message	RO
3.500.11:0	TXO_DATA0	Transmit 1000BASE-H OAM message first 12 bits	R/W
3.501.15:0	TXO_DATA1	Transmit 1000BASE-H OAM message 16-bit data word 1	R/W
3.502.15:0	TXO_DATA2	Transmit 1000BASE-H OAM message 16-bit data word 2	R/W
3.503.15:0	TXO_DATA3	Transmit 1000BASE-H OAM message 16-bit data word 3	R/W
3.504.15:0	TXO_DATA4	Transmit 1000BASE-H OAM message 16-bit data word 4	R/W
3.505.15:0	TXO_DATA5	Transmit 1000BASE-H OAM message 16-bit data word 5	R/W
3.506.15:0	TXO_DATA6	Transmit 1000BASE-H OAM message 16-bit data word 6	R/W
3.507.15:0	TXO_DATA7	Transmit 1000BASE-H OAM message 16-bit data word 7	R/W
3.508.15:0	TXO_DATA8	Transmit 1000BASE-H OAM message 16-bit data word 8	R/W

[a]R/W = Read/Write, RO = Read only, SC = Self-clearing

45.2.3.47a.2 TXO_PHYT (3.500.14)

Bit 3.500.14 reflects the value of the bit TXO_MSGT in the last 1000BASE-H OAM message received by the remote 1000BASE-H based PHY.

45.2.3.47a.3 TXO_MERT (3.500.13)

Bit 3.500.13 reflects the value of the bit TXO_MSGT in the last 1000BASE-H OAM message read by the STA attached to the remote 1000BASE-H based PHY.

45.2.3.47a.4 TXO_MSGT (3.500.12)

Bit 3.500.12 is used for 1000BASE-H OAM message identification. Bit 3.500.12 is changed by the 1000BASE-H based PHY when it accepts a new 1000BASE-H OAM message for transmission (simultaneously setting bit 3.500.15 to zero), acting as a 1-bit sequence number.

45.2.3.47a.5 TXO_DATAx (Bits 3.500.11:0 and Registers 3.501 through 3.508)

Bits 3.500.11:0 (TXO_DATA0) contains the first 12 bits of a 1000BASE-H OAM message and registers 3.501 through 3.508 (TXO_DATA1 through TXO_DATA8) the remaining 128 bits of that 1000BASE-H OAM message.

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TXO_DATA0 and TXO_DATA1 shall be a 28-bit 1000BASE-H OAM protocol identifier composed of a 24-bit Organizationally Unique Identifier (OUI) or Company ID (CID) followed by a 4-bit protocol number; where TXO_DATA0[10:0] = OUI[23:12], TXO_DATA1[15:3] = OUI[11:0], and TXO_DATA1[3:0] = protocol number. The content of TXO_DATA2 to TXO_DATA8 is vendor specific to the assignee of the OUI or CID.

45.2.3.47b 1000BASE-H OAM receive registers (Registers 3.509 through 3.517)

Registers 3.509 through 3.517 store messages received over the 1000BASE-H OAM channel established between two link partners (see 115.9.3). Register 3.509 contains status information, identification, and the first 12 bits of a 1000BASE-H OAM message, and registers 3.510 through 3.517 the following 128 bits of the received 1000BASE-H OAM message.

The assignment of bits in the 1000BASE-H OAM receive registers is shown in Table 45–160b.

Table 45–160b—1000BASE-H OAM receive register bit definitions

Bit(s)	Name	Description	R/W[a]
3.509.15	RXO_VAL	1 = A new 1000BASE-H OAM message has arrived 0 = No new 1000BASE-H OAM message arrived since either last message was read or PMA reset	RO
3.509.14:13	Reserved	Value always 0	RO
3.509.12	RXO_MSGT	Identifier of the received 1000BASE-H OAM message	RO
3.509.11:0	RXO_DATA0	Receive 1000BASE-H OAM message first 12 bits	RO
3.510.15:0	RXO_DATA1	Receive 1000BASE-H OAM message 16-bit data word 1	RO
3.511.15:0	RXO_DATA2	Receive 1000BASE-H OAM message 16-bit data word 2	RO
3.512.15:0	RXO_DATA3	Receive 1000BASE-H OAM message 16-bit data word 3	RO
3.513.15:0	RXO_DATA4	Receive 1000BASE-H OAM message 16-bit data word 4	RO
3.514.15:0	RXO_DATA5	Receive 1000BASE-H OAM message 16-bit data word 5	RO
3.515.15:0	RXO_DATA6	Receive 1000BASE-H OAM message 16-bit data word 6	RO
3.516.15:0	RXO_DATA7	Receive 1000BASE-H OAM message 16-bit data word 7	RO
3.517.15:0	RXO_DATA8	Receive 1000BASE-H OAM message 16-bit data word 8	RO

[a]RO = Read only

45.2.3.47b.1 RXO_VAL (3.509.15)

The 1000BASE-H based PHY sets bit 3.509.15 to one to indicate the reception of a new 1000BASE-H OAM message. The 1000BASE-H based PHY sets bit 3.509.15 to zero when the last register (3.517) containing the 1000BASE-H OAM message is read (see Figure 115–43). The 1000BASE-H based PHY does not update the receive message registers until the message is read by STA as indicated by a read of register 3.517.

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45.2.3.47b.2 RXO_MSGT (3.509.12)

Bit 3.509.12 is used for message identification. Bit 3.509.12 changes with every new received 1000BASE-H OAM message, acting as a 1-bit sequence number.

45.2.3.47b.3 RXO_DATAx (Bits 3.509.11:0 and Registers 3.510 through 3.517)

Bits 3.509.11:0 (RXO_DATA0) contains the first 12 bits of a received 1000BASE-H OAM message, and registers 3.510 through 3.517 (RXO_DATA1 through RXO_DATA8) the remaining 128 bits of that received 1000BASE-H OAM message.

45.2.3.47c 1000BASE-H PCS control register (Register 3.518)

The assignment of bits in the 1000BASE-H PCS control register is shown in Table 45–160c.

Table 45–160c—1000BASE-H PCS control register bit definitions

Bit(s)	Name	Description	R/W[a]
3.518.15:13	Operation mode	15 14 13 0 0 0 = Normal operation 0 0 1 = Test mode 1 0 1 0 = Test mode 2 0 1 1 = Test mode 3 1 0 0 = Test mode 4 1 0 1 = Test mode 5 1 1 0 = Test mode 6 1 1 1 = Reserved	R/W
3.518.12:10	Loopback mode	12 11 10 0 0 0 = No loopback 0 0 1 = GMII level loopback 0 1 0 = PMD interface level loopback 0 1 1 = Line loopback 1 x x = Reserved	R/W
3.518.9:2	Reserved	Value always 0	RO
3.518.1	1000BASE-H OAM enable	1 = Enable 1000BASE-H OAM functionality 0 = Disable 1000BASE-H OAM functionality	R/W
3.518.0	EEE enable	1 = Enable LPI mode 0 = Disable LPI mode	R/W

[a]R/W = Read/Write, RO = Read only

45.2.3.47c.1 Operation mode (3.518.15:13)

Bits 3.518.15:13 shall have a default value of binary 000, selecting normal 1000BASE-H operation. A value of binary 001 through binary 110 in bits 3.518.15:13 shall select the test mode as specified in Table 45–160c with behavior as defined in 115.5.

45.2.3.47c.2 Loopback mode (3.518.12:10)

Bits 3.518.12:10 shall select one of the loopback modes defined in 115.10. Bits 3.518.12:10 shall have a default value of binary 000 (no loopback operation). Loopback modes are only available when a 1000BASE-H based PHY is in the normal operation mode (no test mode is selected in 3.518.15:13).

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45.2.3.47c.3 1000BASE-H OAM enable (3.518.1)

Bit 3.518.1 controls establishing the 1000BASE-H OAM channel with the link partner (115.9). If the 1000BASE-H based PHY does not have 1000BASE-H OAM ability (bit 3.519.1 = 0), setting bit 3.518.1 shall have no effect. Setting bit 3.518.1 to zero shall prevent establishment of a 1000BASE-H OAM channel with the link partner. Changes in a 1000BASE-H OAM enable value shall only take effect after a PMA reset. Bit 3.518.1 has no specified default value.

45.2.3.47c.4 EEE enable (3.518.0)

Setting bit 3.518.0 to one enables 1000BASE-H based PHY EEE capability (see 115.4). Setting bit 3.518.0 to zero shall prevent establishment of EEE operation with the link partner. If the 1000BASE-H based PHY does not have EEE ability (bit 3.519.0 = 0), setting bit 3.518.0 shall have no effect. Changes in EEE enable value shall only take effect after a PMA reset. Bit 3.518.0 has no specified default value.

45.2.3.47d 1000BASE-H PCS status 1 register (Register 3.519)

The assignment of bits in the 1000BASE-H PCS status 1 register is shown in Table 45–160d.

Table 45–160d— 1000BASE-H PCS status 1 register bit definitions

Bit(s)	Name	Description	R/W[a]
3.519.15	Local receiver status	1 = The local receive operation is reliable 0 = The local receive operation is unreliable	RO
3.519.14	Remote receiver status	1 = The receive operation of the remote PHY is reliable 0 = The receive operation of the remote PHY is unreliable	RO
3.519.13	Link status	1 = A bidirectional reliable link is established 0 = A bidirectional reliable link is not established	RO, LL
3.519.12	Local PHD reception status	1 = PHD reception is reliable for the local PHY 0 = PHD reception is unreliable for the local PHY	RO
3.519.11	Remote PHD reception status	1 = PHD reception is reliable for the remote PHY 0 = PHD reception is unreliable for the remote PHY	RO
3.519.10	PHD lock status	1 = PHD transmission and reception are reliable 0 = PHD transmission or reception are unreliable	RO, LL
3.519.9	THP lock status	1 = THP is initialized; payload data is received with THP processing 0 = THP is not initialized	RO
3.519.8	Tx Assert LPI received	1 = Tx PCS has received LPI 0 = LPI not received by Tx PCS	RO, LH
3.519.7	Rx Assert LPI generated	1 = Rx PCS has generated LPI 0 = LPI not generated by Rx PCS	RO, LH
3.519.6	Tx LPI indication	1 = Tx PCS is currently transmitting LPI 0 = Tx PCS is not currently transmitting LPI	RO
3.519.5	Rx LPI indication	1 = Rx PCS is currently receiving LPI 0 = Rx PCS is not currently receiving LPI	RO
3.519.4	Reserved	Value always 0	RO

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Table 45–160d— 1000BASE-H PCS status 1 register bit definitions *(continued)*

Bit(s)	Name	Description	R/W[a]
3.519.3	Remote 1000BASE-H OAM ability	1 = The remote PHY has 1000BASE-H OAM ability and it is enabled 0 = The remote PHY does not have 1000BASE-H OAM ability or it is disabled	RO
3.519.2	Remote EEE ability	1 = The remote PHY has EEE ability and it is enabled 0 = The remote PHY does not have EEE ability or it is disabled	RO
3.519.1	1000BASE-H OAM ability	1 = The PHY has 1000BASE-H OAM ability 0 = The PHY does not have 1000BASE-H OAM ability	RO
3.519.0	EEE ability	1 = The PHY has EEE ability 0 = The PHY does not have EEE ability	RO

[a]RO = Read only, LH = Latching high, LL = Latching low

45.2.3.47d.1 Local receiver status (3.519.15)

Bit 3.519.15 reflects the value of the state variable loc_rcvr_status as determined by the PHY quality monitor state diagram (see 115.3.5.1).

45.2.3.47d.2 Remote receiver status (3.519.14)

Bit 3.519.14 reflects the value of the state variable rem_rcvr_status as determined by the link monitor state diagram (see 115.3.5.1).

45.2.3.47d.3 Link status (3.519.13)

Bit 3.519.13 reflects the value of the state variable link_status as determined by the link monitor state diagram (see 115.3.5.1). Bit 3.519.13 shall have latching low behavior. Bit 1.1.2, bit 3.1.2, and bit 3.519.13 are identical for 1000BASE-H; a read to any of these three bits shall release the latch for all the bits.

45.2.3.47d.4 Local PHD reception status (3.519.12)

Bit 3.519.12 reflects the value of the state variable loc_rcvr_hdr_lock as determined by the local PHD reception monitor state diagram (see 115.3.5.1).

45.2.3.47d.5 Remote PHD reception status (3.519.11)

Bit 3.519.11 reflects the value of the state variable rem_rcvr_hdr_lock as determined by the remote PHD reception monitor state diagram (see 115.3.5.1).

45.2.3.47d.6 PHD lock status (3.519.10)

Bit 3.519.10 reflects the value of the state variable rcvr_hdr_lock as determined by the PHD monitor state diagram (see 115.3.5.1). Bit 3.519.10 shall have latching low behavior.

45.2.3.47d.7 THP lock status (3.519.9)

Bit 3.519.9 reflects the value of the state variable rcvr_thp_lock as determined by the adaptive THP REQ state diagram (see 115.3.6.1).

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45.2.3.47d.8 Tx Assert LPI received (3.519.8)

When read as a one, bit 3.519.8 indicates that the transmit 1000BASE-H PCS has received Assert LPI signaling from the TX GMII one or more times since the register was last read. When read as a zero, bit 3.519.8 indicates that the 1000BASE-H PCS transmitter has not received Assert LPI. Bit 3.519.8 shall have latching high behavior. Bit 3.519.8 is a copy of bit 3.1.11; a read of either bit shall release the latch for all the bits.

45.2.3.47d.9 Rx Assert LPI generated (3.519.7)

When read as a one, bit 3.519.7 indicates that the receive 1000BASE-H PCS has generated Assert LPI on the RX GMII one or more times since the register was last read. When read as a zero, bit 3.519.7 indicates that the 1000BASE-H PCS receiver has not generated Assert LPI on the RX GMII. Bit 3.519.7 shall have latching high behavior. Bit 3.519.7 is a copy of bit 3.1.10; a read of either bit shall release the latch for all the bits.

45.2.3.47d.10 Tx LPI indication (3.519.6)

Bit 3.519.6 indicates the current LPI mode status of the local 1000BASE-H based PHY transmit path. When read as one, the PHY transmitter is currently in LPI mode (transmitting refresh and quiet). When read as zero, the PHY transmitter is not in LPI mode (see 115.4.1). Bit 3.519.6 is a copy of bit 3.1.9.

45.2.3.47d.11 Rx LPI indication (3.519.5)

Bit 3.519.5 indicates the current LPI mode status of the local 1000BASE-H based PHY receive path. When read as a one, the PHY is receiving LPI mode signals (refresh and quiet). When read as a zero, the PHY is not receiving LPI mode signals (see 115.4.2). Bit 3.519.5 is a copy of bit 3.1.8.

45.2.3.47d.12 Remote 1000BASE-H OAM ability (3.519.3)

Bit 3.519.3 indicates the 1000BASE-H OAM ability of the remote PHY received in the PHD field PHD.CAP.OAM (see Table 115–6). When read as one, bit 3.519.3 indicates the remote PHY has both 1000BASE-H OAM ability and the 1000BASE-H OAM is enabled. When read as zero, bit 3.519.3 indicates that the remote PHY either does not have 1000BASE-H OAM ability or 1000BASE-H OAM is disabled.

45.2.3.47d.13 Remote EEE ability (3.519.2)

Bit 3.519.2 indicates the EEE ability of the remote PHY received in the PHD field PHD.CAP.LPI (see Table 115–6). When read as one, bit 3.519.2 indicates the remote PHY has both EEE ability and EEE is enabled. When read as zero, bit 3.519.2 indicates that the remote PHY either does not have EEE ability or EEE is disabled.

45.2.3.47d.14 1000BASE-H OAM ability (3.519.1)

Bit 3.519.1 indicates the 1000BASE-H OAM ability of the 1000BASE-H based PHY (see 115.9). When read as one, bit 3.519.1 indicates that the 1000BASE-H based PHY supports the 1000BASE-H OAM protocol. When read as zero, bit 3.519.1 indicates the 1000BASE-H based PHY does not support the 1000BASE-H OAM protocol.

A PHY indicating in bit 3.519.1 support of 1000BASE-H OAM shall provide the functions of registers 3.500 through 3.517 as specified in 115.9.

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45.2.3.47d.15 EEE ability (3.519.0)

Bit 3.519.0 indicates the EEE ability of the 1000BASE-H based PHY. When read as one, bit 3.519.0 indicates that the 1000BASE-H based PHY implements EEE, and is able to enter LPI mode (see 115.4). When read as zero, bit 3.519.0 indicates the 1000BASE-H based PHY does not implement EEE operation.

45.2.3.47e 1000BASE-H PCS status 2 register (Register 3.520)

The assignment of bits in the 1000BASE-H PCS status 2 register is shown in Table 45–160e.

Table 45–160e—1000BASE-H PCS status 2 register bit definitions

Bit(s)	Name	Description	R/W[a]
3.520.15:8	Reserved	Value always 0	RO
3.520.7:0	Local link margin	Reports the local link margin	RO

[a]RO = Read only

45.2.3.47e.1 Local link margin (3.520.7:0)

Bits 3.520.7:0 indicate the link margin of the receiver. Link margin is defined in 115.3.7.2 and is fixed-point formatted (8,3). See 115.3.8 for fixed-point format definition.

45.2.3.47f 1000BASE-H PCS status 3 register (Register 3.521)

The assignment of bits in the 1000BASE-H PCS status 3 register is shown in Table 45–160f.

Table 45–160f—1000BASE-H PCS status 3 register bit definitions

Bit(s)	Name	Description	R/W[a]
3.521.15:8	Reserved	Value always 0	RO
3.521.7:0	Remote link margin	Link margin reported by the link partner	RO

[a]RO = Read only

45.2.3.47f.1 Remote link margin (3.521.7:0)

Bits 3.521.7:0 report the link margin of the remote PHY receiver as it is received in the PHD field PHD.RX.LINKMARGIN (see Table 115–6). Link margin is defined in 115.3.7.2 and is fixed-point formatted (8,3). See 115.3.8 for fixed-point format definition.

45.2.3.47g 1000BASE-H PCS status 4 register (Register 3.522)

The assignment of bits in the 1000BASE-H PCS status 4 register is shown in Table 45–160g.

Bits 3.522.15:0 are a 16-bit counter that counts the number of bits received with value 1 at the output of the binary descrambler, when the 1000BASE-H based PHY receiver is operating in test mode 1. These bits shall be reset to all zeros when the counter is read. The counter shall be held at all ones in the case of overflow.

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Table 45–160g—1000BASE-H PCS status 4 register bit definitions

Bit(s)	Name	Description	R/W[a]
3.522.15:0	BER test mode counter	A 16-bit counter used when operating in test mode 1	RO, NR

[a]RO = Read only, NR = Non Roll-over

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45.5 Protocol implementation conformance statement (PICS) proforma for Clause 45, Management Data Input/Output (MDIO) interface[1]

45.5.3 PICS proforma tables for the Management Data Input Output (MDIO) interface

45.5.3.2 PMA/PMD MMD options

Insert the following row at the end of table 45.5.3.2 PMA/PMD MMD options (as modified by IEEE Std 802.3bw-2015, IEEE Std 802.3bn-2016, IEEE Std 802.3bz-2016, and IEEE Std 802.3bq-2016):

Item	Feature	Subclause	Value/Comment	Status	Support
*BH	Implementation of a BASE-H PMA/PMD			PMA:O	Yes [ ] No [ ]

45.5.3.3 PMA/PMD management functions

Insert PICS items MM150 through MM151 at the bottom of the table in 45.5.3.3 (as modified by IEEE Std 802.3bw-2015, IEEE Std 802.3by-2016, and IEEE Std 802.3bp-2016) as follows:

Item	Feature	Subclause	Value/Comment	Status	Support
MM150	Writes to the register 1.22 have no effect			PMA:O	Yes [ ] N/A [ ]
MM151	Writes of reserved values or modes of operation different of those advertised by register 1.22, to bits 1.900.3:0 have no effect			BH:M	Yes [ ] N/A [ ]

[1] *Copyright release for PICS proformas:* Users of this standard may freely reproduce the PICS proforma in this subclause so that it can be used for its intended purpose and may further publish the completed PICS.

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45.5.3.6 PCS options

Insert the following rows at the end of table 45.5.3.6 PCS options:

Item	Feature	Subclause	Value/Comment	Status	Support
*BHOAM	1000BASE-H OAM channel implementation	45.2.3.47a and 45.2.3.47b		PCS:O	Yes [ ] No [ ]

45.5.3.7 PCS management functions

Insert PICS items RM137 through RM156 at the bottom of the table in 45.5.3.7 (as modified by IEEE Std 802.3bp-2016) as follows:

Item	Feature	Subclause	Value/Comment	Status	Support
RM137	1000BASE-H OAM message format to be transmitted	45.2.3.47a.5	TXO_DATA0[10:0] = OUI[23:12], TXO_DATA1[15:3] = OUI[11:0], and TXO_DATA1[3:0] = protocol number. Content of TXO_DATA2 to TXO_DATA8 is vendor specific per OUI or Company ID	PCS *BHOAM :M	Yes [ ] N/A [ ]
RM138	Default operation mode	45.2.3.47c.1	Default value of bits 3.518.15:13 is binary 000 (normal mode)	PCS:M	Yes [ ] N/A [ ]
RM139	Test operation modes	45.2.3.47c.1	Values binary 001 through binary 110 of bits 3.518.15:13 select test modes of Table 45–160c, with behavior per 115.5	PCS:M	Yes [ ] N/A [ ]
RM140	Default loopback mode	45.2.3.47c.2	Default value of bits 3.518.12:10 is binary 000 (no loopback operation)	PCS:M	Yes [ ] N/A [ ]
RM141	Loopback modes	45.2.3.47c.2	Bits 3.518.12:10 select loopback modes with behavior per 115.10	PCS:M	Yes [ ] N/A [ ]
RM142	1000BASE-H OAM conditional enable	45.2.3.47c.3	Write a 1 to bit 3.518.1 only produces effect if bit 3.519.1 is read as 1	PCS *BHOAM :M	Yes [ ] N/A [ ]
RM143	1000BASE-H OAM disable	45.2.3.47c.3	Write a 0 to bit 3.518.1 prevents 1000BASE-H OAM channel establishment with link partner	PCS *BHOAM :M	Yes [ ] N/A [ ]

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Item	Feature	Subclause	Value/Comment	Status	Support
RM144	1000BASE-H OAM enable change effect	45.2.3.47c.3	Changes in the value of bit 3.518.1 only takes effect after PMA reset	PCS *OAM:M	Yes [ ] N/A [ ]
RM145	EEE conditional enable	45.2.3.47c.4	Write a 1 to bit 3.518.0 only produces effect if bit 3.519.0 is read as 1	PCS *EEE:M	Yes [ ] N/A [ ]
RM146	EEE disable	45.2.3.47c.4	Write a 0 to bit 3.518.0 prevents EEE operation with link partner	PCS *EEE:M	Yes [ ] N/A [ ]
RM147	EEE enable change effect	45.2.3.47c.4	Changes in the value of bit 3.518.0 only takes effect after PMA reset	PCS *EEE:M	Yes [ ] N/A [ ]
RM148	Link status behavior	45.2.3.47d.3	Bit 3.519.13 has latching low behavior	PCS:M	Yes [ ] N/A [ ]
RM149	Link status mirroring	45.2.3.47d.3	Bit 1.1.2, bit 3.1.2, and bit 3.519.13 reflect same state variable link_status and a read of any of them releases the latch of all the bits	PCS:M	Yes [ ] N/A [ ]
RM150	PHD lock status behavior	45.2.3.47d.6	Bit 3.519.10 has latching low behavior	PCS:M	Yes [ ] N/A [ ]
RM151	Tx Assert LPI received behavior	45.2.3.47d.8	Bit 3.519.8 has latching high behavior	PCS *EEE:M	Yes [ ] N/A [ ]
RM152	Tx Assert LPI received mirroring	45.2.3.47d.8	Bit 3.519.8 is a copy of bit 3.1.11 and a read of any of them releases the latch of all the bits	PCS *EEE:M	Yes [ ] N/A [ ]
RM153	Rx Assert LPI generated behavior	45.2.3.47d.9	Bit 3.519.7 has latching high behavior	PCS *EEE:M	Yes [ ] N/A [ ]
RM154	Rx Assert LPI generated mirroring	45.2.3.47d.9	Bit 3.519.7 is a copy of bit 3.1.10 and a read of any of them releases the latch of all the bits	PCS *EEE:M	Yes [ ] N/A [ ]
RM155	1000BASE-H OAM ability	45.2.3.47d.14	Registers 3.500 through 3.517 are implemented and 3.519.1 reads as 1	PCS *BHOAM :M	Yes [ ] N/A [ ]
RM156	BER test mode counter is reset to all zeros when read	45.2.3.47g		PCS:M	Yes [ ] N/A [ ]
RM157	BER test mode counter holds all ones in case of overflow	45.2.3.47g		PCS:M	Yes [ ] N/A [ ]

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78. Energy-Efficient Ethernet (EEE)

78.1.4 PHY types optionally supporting EEE

Insert new 1000BASE-RHx rows into Table 78-1 after the entry for 1000BASE-T1 (inserted by IEEE Std 802.3bp-2016), and before the entry for 2.5GBASE-T (inserted by IEEE Std 802.3bz-2016) as follows:

Table 78–1—Clauses associated with each PHY or interface type

PHY or interface type	Clause
1000BASE-RHA	115
1000BASE-RHB	115
1000BASE-RHC	115

78.2 LPI mode timing parameters descriptions

Insert new 1000BASE-RHx rows into Table 78-2 after the entry for 1000BASE-T1 (inserted by IEEE Std 802.3bp-2016), and before the entry for 2.5GBASE-T (inserted by IEEE Std 802.3bz-2016) as follows:

Table 78–2—Summary of the key EEE parameters for supported PHYs or interfaces

PHY Type	T_s (μs)		T_q (μs)		T_r (μs)	
	Min	Max	Min	Max	Min	Max
1000BASE-RHA	0	0	23.52	23.52	1.3	1.3
1000BASE-RHB	0	0	23.52	23.52	1.3	1.3
1000BASE-RHC	0	0	23.52	23.52	1.3	1.3

78.5 Communication link access latency

Insert new 1000BASE-RHx rows into Table 78-4 after 1000BASE-T1 (inserted by IEEE Std 802.3bp-2016) as follows:

Table 78–4—Summary of the LPI timing parameters for supported PHYs or interfaces

PHY Type	Case	$T_{w_sys_tx}$ (min) (μs)	T_{w_phy} (min) (μs)	$T_{phy_shrink_tx}$ (min) (μs)	$T_{phy_shrink_rx}$ (min) (μs)	$T_{w_sys_rx}$ (min) (μs)
1000BASE-RHA		25	25	25	0	0
1000BASE-RHB		25	25	25	0	0
1000BASE-RHC		25	25	25	0	0

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115. Physical Coding Sublayer (PCS), Physical Medium Attachment (PMA) sublayer, and Physical Medium Dependent (PMD) sublayer, types 1000BASE-RHA, 1000BASE-RHB, and 1000BASE-RHC

115.1 Overview

1000BASE-H comprises a Physical Coding Sublayer (PCS) and a Physical Medium Attachment (PMA) sublayer that supports Physical Medium Dependent (PMD) sublayers for operation at 1000 Mb/s over duplex plastic optical fiber (POF) as the transmission medium. The following three port types with different PMDs are defined: 1000BASE-RHA, 1000BASE-RHB, and 1000BASE-RHC (collectively referred to as 1000BASE-RHx).

1000BASE-RHA specifications are driven by the requirements of home and other consumer networks. Connection of the PMD to the step index plastic optical fiber (SI-POF) medium is typically not a mated connector. Rather, a bare duplex cable is attached with a clamp in the PMD receptacle.

1000BASE-RHB specifications are driven by the requirements for industrial applications. Connection of PMD to the SI-POF medium is typically with a PMD receptacle and mated plug. A harsh environment is expected (e.g., extended temperature range, dust), and the connector is typically terminated in the field to facilitate flexible equipment interconnection layout.

1000BASE-RHC specifications are driven by requirements for automotive applications. Connection of PMD to the SI-POF medium is with a PMD receptacle and mated plug. PMD and in-line connectors and the cable have to support specific requirements for installation in a vehicle: Kojiri-safe, dust protection, vibration robustness, tensile strength, etc.

115.1.1 Features

The following are the features of the 1000BASE-H set of PHYs:

a) Specified to operate with the GMII (Clause 35).
b) Full duplex operation.
c) Support for BER of 10^{-12} or better.
d) Communication side-channel for PHY management, operations, administration, and maintenance between link partners.
e) Operation in automotive, industrial, and home network environments.

115.1.2 Conventions

The notation used in the state diagrams in this clause follows the conventions in 21.5. Should there be a discrepancy between a state diagram and descriptive text, the state diagram prevails.

115.1.3 Relationship of 1000BASE-RHx to other standards

The relationship between a 1000BASE-RHx PHY, the ISO Open Systems Interconnection (OSI) Reference Model, and the IEEE 802.3 Ethernet Model is shown in Figure 115–1. The physical layer connects one Annex 4A Media Access Control (MAC) to the medium. This clause specifies the Physical Coding Sublayer (PCS), Physical Medium Attachment (PMA), and Physical Medium Dependent (PMD) components of the physical layer device (PHY).

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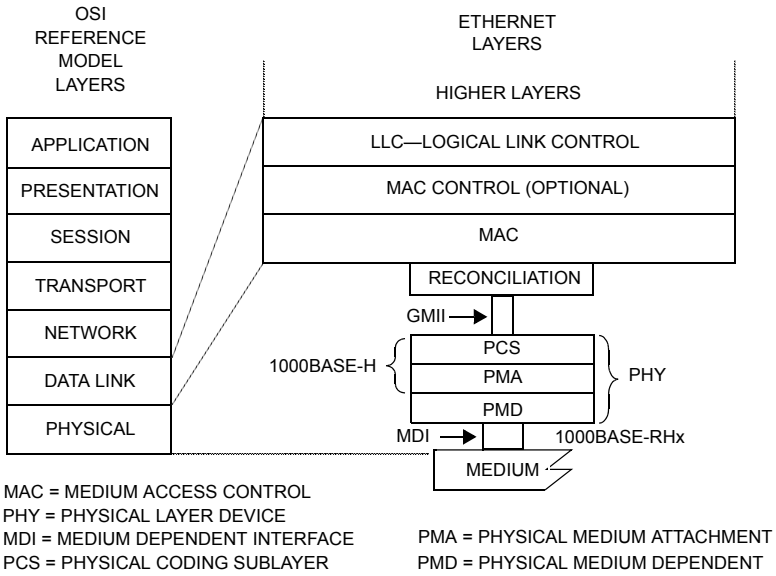

Figure 115–1—1000BASE-RHx PHY relationship to the ISO/IEC Open Systems Interconnection (OSI) Reference Model and the IEEE 802.3 Ethernet Model

115.1.4 Relationship to other Gigabit Ethernet PHY types

1000BASE-RHx PHY types are specified with the PCS interfacing to a GMII. Physical implementation of the GMII is optional. System operation from the perspective of signals at the MDI and management objects are identical whether the GMII is implemented or not. The MII Management Interface used with the initial set of Gigabit Ethernet PHYs is not used for 1000BASE-RHx PHY types.

115.1.5 Operation of 1000BASE-RHx

1000BASE-RHx PHY types support full duplex operation only, using two plastic optical fibers as the medium. Each fiber is used for unidirectional transmission with the 1000BASE-RHx port on one end of the link segment transmitting on one fiber and receiving on the second fiber. A cross-over in the cabling connects the local PMD transmitter to the link partner's PMD receiver, and the link partner's PMD transmitter to the local PMD receiver. The PMD TX and PMD RX compose the PMD sublayer.

The topology of 1000BASE-RHx is illustrated in Figure 115–2.

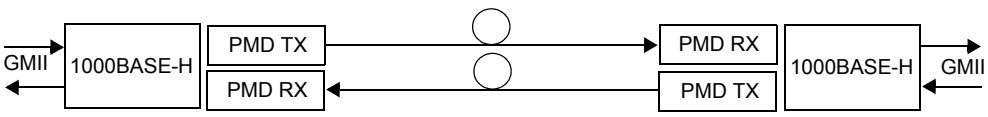

Figure 115–2—1000BASE-RHx topology

The 1000BASE-H PCS encapsulates and decapsulates the transmit and receive GMII data streams using a series of fixed length Transmit Blocks. A frame on the GMII can be contained in one or more Transmit Blocks. GMII frame boundaries have no correlation to Transmit Block boundaries.

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Transmit Blocks also include pilot signals and control information. This information keeps the receiver clock aligned with the transmitter, supports channel equalization, and provides link monitoring. These signals and control information are inserted at fixed locations within the Transmit Block interrupting the transmission of the GMII data stream also included in the Transmit Block. Encapsulation of the GMII data stream within the Transmit Block also includes forward error correction encoding in fixed-length codewords inserted at fixed locations.

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