Abstract: This amendment to IEEE Std 802.3–2008 provides physical layer specifications and management parameters for 10G-EPON on point–to–multipoint passive optical networks. As such, the 10G-EPON extends the network architecture of P802.3ah 1G-EPON, providing support for both symmetric and asymmetric data rates while maintaining complete backward compatibility with already ~~deployment~~ equipment.
The objectives of this amendment are:

1) Support subscriber access networks using point to multipoint topologies on optical fiber
2) PHY(s) to have a BER better than or equal to 10^{-12} at the PHY service interface
3) Provide physical layer specifications:
   - PHY for PON, 10 Gb/s downstream/1 Gb/s upstream, single SM fiber
   - PHY for PON, 10 Gb/s downstream/10 Gb/s upstream, single SM fiber
4) Define up to 3 optical power budgets that support split ratios of 1:16 and 1:32, and distances of at least 10 and at least 20 km.

Keywords: 10 Gb/s Ethernet Passive Optical Networks (10G-EPON), PON, Point to Multipoint (P2MP), Physical Medium Dependent (PMD), Multi-Point MAC Control (MPMC), Reconciliation Sublayer (RS), Physical Coding Sublayer (PCS), and Physical Media Attachment (PMA), Forward Error Correction (FEC)

1.4 Definitions

Insert after 1.4.35 10GBASE-LX4, renumber as appropriate

10GBASE-PR:IEEE 802.3 Physical Layer specification for a 10 Gb/s (10/10G-EPON) point-to-multipoint link over one single-mode optical fiber (See IEEE 802.3 Clause 75, Clause 76 and Clause 77).

Insert after 1.4.41 10GBASE-X, renumber as appropriate

10/1GBASE-PRX:IEEE 802.3 Physical Layer specification for a 10 Gb/s downstream, 1 Gb/s upstream (10/1G-EPON) point-to-multipoint link over one single-mode optical fiber (see IEEE 802.3 Clause 75, Clause 76, Clause 77).

Change subclause 1.4.95 as follows:

1.4.95 channel insertion loss: As used in IEEE 802.3 for fiber optic links, the static loss of light through a link between a transmitter and receiver. It includes the loss of the fiber, connectors, and splices and, for EPON links, optional power splitter/combiner.

Insert after 1.4.269 pause, renumber as appropriate

pause_quantum: The unit of measurement for pause time specified in 31B.2.

Insert after 1.4.343 Tomlinson-Harashima precoder (THP), renumber as appropriate

time_quantum: The unit of time_quantum used by all mechanisms synchronized to the advancement of the localTime variable for EPON. Each time_quantum is 16 ns.

1.5 Abbreviations

Insert a new abbrevation to the list, sort the list alphabetically:

10/10G-EPONEPONs with 10 Gb/s symmetric-rate

10/1G-EPONEPONs with 10/1 Gb/s asymmetric-rate

10G-EPONEPONs with 10/1 Gb/s asymmetric-rate and 10 Gb/s symmetric-rate

1G-EPON EPON with 1 Gb/s symmetric-rate

EPON Ethernet Passive Optical Networks

SCB Single Copy Broadcast

SLD Start of LLID Delimiter

TQ time_quantum

If a Clause 45 MDIO Interface to the PCS is present, then this attribute will map to the FEC corrected blocks counter (see 45.2.7.5 and 45.2.1.86 for 10GBASE–R, 45.2.1.132 for 10GBASE–PR and 10/1GBASE–PRX).;

30.5.1.1.16 aFECUncorrectableBlocks

Modify the behaviour definition to read as follows:

For 1000BASE–PX ~~PHYs or,~~ 10GBASE–R, 10GBASE–PR or 10/1GBASE–PRX PHYs, a count of uncorrectable FEC blocks. This counter will not increment for other PHY types.

Increment the counter by one for each received block that is corrected by the FEC function in the PHY.

If a Clause 45 MDIO Interface to the PCS is present, then this attribute will map to the FEC uncorrectable blocks counter (see 45.2.7.5 and 45.2.1.87 for 10GBASE–R, 45.2.1.133 for 10GBASE–PR and 10/1GBASE–PRX).;

Create a new subclause 30.3.8 with the following contents:

30.3.8 EXTENSION entity managed object class

This subclause formally defines the behaviours for the oEXTENSION managed object class attributes.

30.3.8.1 aEXTENSIONMACCtrlFramesTransmitted

ATTRIBUTE

APPROPRIATE SYNTAX:

Generalized nonresetable counter. This counter has a maximum increment rate of 1 600 000 counts per second at 1000 Mb/s

BEHAVIOUR DEFINED AS:

A count of EXTENSION frames passed to the MAC sublayer for transmission. This counter is incremented when a MA_CONTROL.request primitive is generated within the MAC Control sublayer with an opcode indicating the EXTENSION operation.;

30.3.8.2 aEXTENSIONMACCtrlFramesReceived

ATTRIBUTE

APPROPRIATE SYNTAX:

Generalized nonresetable counter. This counter has a maximum increment rate of 1 600 000 counts per second at 1000 Mb/s

BEHAVIOUR DEFINED AS:

A count of MAC Control frames passed by the MAC sublayer to the MAC Control sublayer. This counter is incremented when a ReceiveFrame function call returns a valid frame with: (1) a lengthOrType field value equal to the reserved Type for 802.3_MAC_Control as specified in 31.4.1.3, and (2) an opcode indicating the EXTENSION operation.;

Add new managed object oEXTENSION in 30.2.2.1 with the following definition, placing it between oGroup and oMACControlEntity managed object definitions:

oEXTENSION	If implemented, oEXTENSION is contained within oMACControlEntity. The oEXTENSION managed object class provides the management controls necessary to allow an instance of the MAC Control function to be managed.

Annex 31A

(normative)

MAC Control opcode assignments

Editors' Note 45-1 (to be removed prior to release): This amendment is based on the current edition of IEEE P802.3ay (D2.2). The editing instructions define how to merge the material contained in this amendment into the base document set to form the new comprehensive standard as created by the addition of IEEE P802.3av.

External cross references are marked with "forest green" font.
The editing instructions are shown in bold italic. Four editing instructions are used: change, delete, insert, and replace. Change is used to make corrections in existing text or tables. The editing instruction specifies the location of the change and describes what is being changed by using ~~strikethrough~~ (to remove old material) and underscore (to add new material). Delete removes existing material. Insert adds new material without disturbing the existing material. Insertions may require renumbering. If so, renumbering instructions are given in the editing instruction. Replace is used to make changes in figures or equations by removing the existing figure or equation and replacing it with a new one. Editing instructions, change markings, and this NOTE will not be carried over into future editions because the changes will be incorporated into the base standard..:

Editors' Note 45-2 (to be removed prior to release): Draft D2.1revision history for Annex 31A

Version	*Date*	*Comments*
Draft 2.0	*Jul 2008*	*Draft for Work Group review with comment resolution from July 2008 meeting*
Draft 2.1	*Oct 2008*	*Draft for Work Group review with comment resolution from September 2008 meeting*

Replace Table 31A–1 as presented below:

Table 31A–1—MAC Control opcodes

Opcode (Hexadecimal)	MAC Control function	Specified in	Value/Comment	Timestamp[a]
00–00	Reserved			
00–01	PAUSE	Annex 31B	Requests that the recipient stop transmitting non–control frames for a period of time indicated by the parameters of this function.	No
00–02	GATE	Clause 64, Clause 77	Request that the recipient allow transmission of frames at a time, and for a period of time indicated by the parameters of this function.	Yes
00–03	REPORT	Clause 64, Clause 77	Notify the recipient of pending transmission requests as indicated by the parameters of this function.	Yes
00–04	REGISTER_REQ	Clause 64, Clause 77	Request that the station be recognized by the protocol as participating in a gated transmission procedure as indicated by the parameters of this function.	Yes
00–05	REGISTER	Clause 64, Clause 77	Notify the recipient that the station is recognized by the protocol as participating in a gated transmission procedure as indicated by the parameters of this function.	Yes

Table 31A–1—MAC Control opcodes

Opcode (Hexadecimal)	MAC Control function	Specified in	Value/Comment	Timestamp[a]
00–06	REGISTER_ACK	Clause 64, Clause 77	Notify the recipient that the station acknowledges participation in a gated transmission procedure.	Yes
00–07 to FF–FD	Reserved			
FF–FE	EXTENSION	Annex 31C	This frame is used for Organization–Specific Extension. Upon reception of this message, the MAC Control generates MA_CONTROL.Indication informing the MAC Control Client to perform the relevant action.	No
FF–FF	Reserved			

[a]The timestamp field is generated by MAC Control and is not exposed through the client interface.

Replace Table 31A–3 as presented below:

Table 31A–3—GATE MAC Control indications

GATE (opcode 0x0002)		
indication_operand_list element	**Value**	**Interpretation**
start	32 bit	Time when transmission should be initiated.
length	16 bit	Interval of time during which transmission is allowed.
status	arrive	Indicates that a grant has been received for future activation.
	active	Indicates that the GATE function is allowing transmission of frames.
	deactive	Indicates that the GATE function is inhibiting transmission of frames.
force_report	true	The OLT expects the ONU to transmit a REPORT message during the transmission opportunity identified by start and length fields.
	false	The OLT does not request the ONU to transmit a REPORT message during the transmission opportunity identified by start and length fields.
discovery	true	This grant is reserved for use during discovery.
	false	This grant is not reserved for use by the discovery process, and is available for use by all traffic.
discoveryInformation[a]	16 bits	See Table 77–3 for the internal structure of the discoveryInformation field.

[a]only present in 10G–EPON GATE MAC Control indication (Clause 77).

Replace Table 31A–5 as presented below:

Table 31A–5—REGISTER_REQ MAC Control indications

REGISTER_REQ (opcode 0x0004)		
indication_operand_list element	**Value**	**Interpretation**
status	incoming	Indicates that a station is requesting recognition.
	retry	Indicates that the station should reattempt registration.
flags	register	Indicates that the station is requesting to register.
	deregister	Indicates that the station is requesting to deregister.
pending_grants	Integer	Indicates the maximal number of future GATES that can be stored by the GATE function.
RTT	32 bit	Indicates the calculated round trip time for the station, as calculated following the REGISTER_REQ message reception.
laserOnTime[a]	8 bits	Indicates the Laser On Time characteristic for the given ONU transmitter, expressed in the units of time_quanta.
laserOffTime[a]	8 bits	Indicates the Laser Off Time characteristic for the given ONU transmitter, expressed in the units of time_quanta.
discoveryInformation[a]	16 bits	See Table 77–7 for the internal structure of the discoveryInformation field.

[a]only present in 10G–EPON REGISTER_REQ MAC Control indication (Clause 77).

Replace Table 31A–6 as presented below:

Table 31A–6—REGISTER MAC Control indications

REGISTER (opcode 0x0005)		
indication_operand_list element	**Value**	**Interpretation**
SA	48 bit	MAC address of OLT to which registration is being performed.
ID	16 bit	LLID assigned by the OLT for use by the ONU.
status	accepted	Indicates that the requested registration is successful.
	denied	Indicates that the requested registration attempt is denied by the higher–layer–entity.
	deregistered	Indicates that the ONU has been deregistered, i.e., the associated LLID has been deallocated.
	reregistered	Indicates that the ONU is explicitly asked to re–register.
laserOnTime[a]	8 bits	Indicates the Laser On Time characteristic for the given ONU transmitter, expressed in the units of time_quanta.
laserOffTime[a]	8 bits	Indicates the Laser Off Time characteristic for the given ONU transmitter, expressed in the units of time_quanta.

[a]only present in 10G–EPON REGISTER MAC Control indication (Clause 77).

31C.3.1 Receive state diagram (INITIATE MAC CONTROL FUNCTION) for EXTENSION operation

Figure 31C–2 depicts the INITIATE MAC CONTROL FUNCTION for the EXTENSION operation (See 31.5.3). Upon reception of EXTENSION frames, the frame is sent to the MAC CONTROL client.

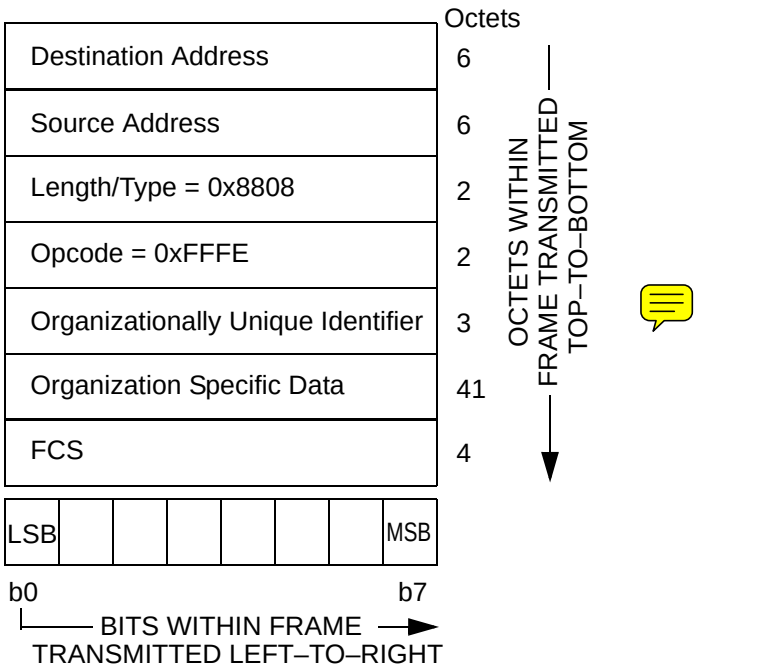

Figure 31C–1—MAC Control EXTENSION Frame

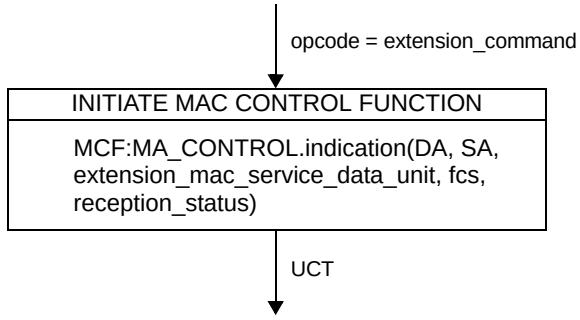

Figure 31C–2—EXTENSION receive function

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

Bit(s)	Name	Description	R/W[a]
1.7.15:~~4~~5	Reserved	Value always 0, writes ignored	R/W
1.7.~~3~~4:0	PMA/PMD type selection	4 3 2 1 0 1 1 0 1 0 = 10GBASE-PR-U3 1 1 0 0 1 = 10GBASE-PR-U1 1 1 0 0 0 = 10/1GBASE-PRX-U3 1 0 1 1 1 = 10/1GBASE-PRX-U2 1 0 1 1 0 = 10/1GBASE-PRX-U1 1 0 1 0 1 = 10GBASE-PR-D3 1 0 1 0 0 = 10GBASE-PR-D2 1 0 0 1 1 = 10GBASE-PR-D1 1 0 0 1 0 = 10/1GBASE-PRX-D3 1 0 0 0 1 = 10/1GBASE-PRX-D2 1 0 0 0 0 = 10/1GBASE-PRX-D1 0 1 1 1 1 = 10BASE-T PMA/PMD type 0 1 1 1 0 = 100BASE-TX PMA/PMD type 0 1 1 0 1 = 1000BASE-KX PMA/PMD type 0 1 1 0 0 = 1000BASE-T PMA/PMD type 0 1 0 1 1 = 10GBASE-KR PMA/PMD type 0 1 0 1 0 = 10GBASE-KX4 PMA/PMD type 0 1 0 0 1 = 10GBASE-T PMA type 0 1 0 0 0 = 10GBASE-LRM PMA/PMD type 0 0 1 1 1 = 10GBASE-SR PMA/PMD type 0 0 1 1 0 = 10GBASE-LR PMA/PMD type 0 0 1 0 1 = 10GBASE-ER PMA/PMD type 0 0 1 0 0 = 10GBASE-LX4 PMA/PMD type 0 0 0 1 1 = 10GBASE-SW PMA/PMD type 0 0 0 1 0 = 10GBASE-LW PMA/PMD type 0 0 0 0 1 = 10GBASE-EW PMA/PMD type 0 0 0 0 0 = 10GBASE-CX4 PMA/PMD type	R/W

[a]R/W = Read/Write

Change first three rows of Table 45-11 as follows.

Table 45–11—PMA/PMD Extended Ability register bit definitions

Bit(s)	Name	Description	R/W[a]
1.11.15:10~~9~~	Reserved	Ignore on read	RO
1.11.9	P2MP ability	1 = PMA/PMD has P2MP abilities listed in register 1.12 0 = PMA/PMD does not have P2MP abilities	RO
1.11.8	10BASE-T ability	1 = PMA/PMD is able to perform 10BASE-T 0 = PMA/PMD is not able to perform 10BASE-T	RO

[a]RO = Read only

Insert Subclause 45.2.1.11 and Table 45-12 as shown below, renumber succeding paragraphs and tables.

Table 45–12—P2MP PMA/PMD Ability register bit definitions

Bit(s)	Name	Description	R/W[a]
1.12.15:11	Reserved	Ignore on read	RO
1.12.10	10/1GBASE-PRX-D1 ability	1 = PMA/PMD is able to perform 10/1GBASE-PRX-D1 0 = PMA/PMD is not able to perform 10/1GBASE-PRX-D1	RO
1.12.9	10/1GBASE-PRX-D2 ability	1 = PMA/PMD is able to perform 10/1GBASE-PRX-D2 0 = PMA/PMD is not able to perform 10/1GBASE-PRX-D2	RO
1.12.8	10/1GBASE-PRX-D3 ability	1 = PMA/PMD is able to perform 10/1GBASE-PRX-D3 0 = PMA/PMD is not able to perform 10/1GBASE-PRX-D3	RO
1.12.7	10GBASE-PR-D1 ability	1 = PMA/PMD is able to perform 10GBASE-PR-D1 0 = PMA/PMD is not able to perform 10GBASE-PR-D1	RO
1.12.6	10GBASE-PR-D2 ability	1 = PMA/PMD is able to perform 10GBASE-PR-D2 0 = PMA/PMD is not able to perform 10GBASE-PR-D2	RO
1.12.5	10GBASE-PR-D3 ability	1 = PMA/PMD is able to perform 10GBASE-PR-D3 0 = PMA/PMD is not able to perform 10GBASE-PR-D3	RO
1.12.4	10/1GBASE-PRX-U1 ability	1 = PMA/PMD is able to perform 10/1GBASE-PRX-U1 0 = PMA/PMD is not able to perform 10/1GBASE-PRX-U1	RO
1.12.3	10/1GBASE-PRX-U2 ability	1 = PMA/PMD is able to perform 10/1GBASE-PRX-U2 0 = PMA/PMD is not able to perform 10/1GBASE-PRX-U2	RO
1.12.2	10/1GBASE-PRX-U3 ability	1 = PMA/PMD is able to perform 10/1GBASE-PRX-U3 0 = PMA/PMD is not able to perform 10/1GBASE-PRX-U3	RO
1.12.1	10GBASE-PR-U1 ability	1 = PMA/PMD is able to perform 10GBASE-PR-U1 0 = PMA/PMD is not able to perform 10GBASE-PR-U1	RO
1.12.0	10GBASE-PR-U3 ability	1 = PMA/PMD is able to perform 10GBASE-PR-U3 0 = PMA/PMD is not able to perform 10GBASE-PR-U3	RO

[a]RO = Read only

45.2.1.11.1 10/1GBASE-PRX-D1 ability (1.12.10)

When read as a one, bit 1.12.10 indicates that the PMA/PMD is able to operate as a 10/1GBASE-PRX-D1 PMA/PMD type. When read as a zero, bit 1.12.10 indicates that the PMA/PMD is not able to operate as a 10/1GBASE-PRX-D1 PMA/PMD type.

45.2.1.11.2 10/1GBASE-PRX-D2 ability (1.12.9)

When read as a one, bit 1.12.9 indicates that the PMA/PMD is able to operate as a 10/1GBASE-PRX-D2 PMA/PMD type. When read as a zero, bit 1.12.9 indicates that the PMA/PMD is not able to operate as a 10/1GBASE-PRX-D2 PMA/PMD type.

45.2.1.11.3 10/1GBASE-PRX-D3 ability (1.12.8)

When read as a one, bit 1.12.8 indicates that the PMA/PMD is able to operate as a 10/1GBASE-PRX-D3 PMA/PMD type. When read as a zero, bit 1.12.8 indicates that the PMA/PMD is not able to operate as a 10/1GBASE-PRX-D3 PMA/PMD type.

45.2.3.30 10GBASE-PR and 10/1GBASE-PRX FEC control register (Register 3.75)

The assignment of bits in the 10GBASE-PR FEC control register is shown in Table 45–108.

Table 45–108—10GBASE-PR and 10/1GBASE-PRX FEC control register bit definitions

Bit(s)	Name	Description	R/W[a]
3.75.15:2	Reserved	Value always zero, Writes ignored	RO
3.75.1	enable FEC error indication	A write of 1 to this bit configures the 10 Gb/s FEC decoder to indicate uncorrectable codeword errors to the higher layer. In a 10/1GBASE-PRX OLT, this bit is undefined.	R/W
3.75.0	10 Gb/s FEC enable	Always reads as 1 since 10 Gb/s FEC is always enabled	RO

[a]RO read only, R/W read write

45.2.3.30.1 FEC enable error indication (3.75.1)

This bit instructs the 10 Gb/s FEC decoder component of the 10GBASE-PR and 10/1GBASE-PRX PCS indicate decoding errors to the upper layers (see 45.2.3.30 and 76.2.3.3).

When written as a one, the receiving PCS invalidates 66B blocks received in uncorrectable FEC codewords. As a consequence, the receiving MAC discards any packet which includes data that was received in an uncorrectable FEC codeword (even though the packet itself might or might not contain errors).

When written as a zero, the receiving PCS does not modify 66B blocks received in uncorrectable FEC codewords. As a consequence, the receiving MAC performs regular processing on a packet that includes data that was received in an uncorrectable FEC codeword (though the packet itself may contain errors which might or might not be detected by the MAC FCS)

45.2.3.30.2 10 Gb/s FEC Enable (3.75.0)

This bit indicates whether 10 Gb/s FEC is enabled in the 10GBASE-PR and 10/1GBASE-PRX PCS and always reads as one.

The register describing ability to enable forward error correction in the 10/1GBASE-PRX upstream is specified in 45.2.7.3.

45.2.3.31 10GBASE-PR and 10/1GBASE-PRX corrected FEC codewords counter (Register 3.76, 3.77)

The assignment of bits in the 10/1GBASE-PRX and 10GBASE-PR corrected FEC codewords counter register is shown in Table 45–109. See 76.2.3.1.2 for a definition of this counter. These bits shall be reset to all

45.2.3.33 10GBASE-PR and 10/1GBASE-PRX Clause 76 BER Monitor Control register (Register 3.80)

The assignment of bits in the 10GBASE-PR and 10/1GBASE-PRX BER Monitor Control Register is shown in Table 45–111. This register is only required when 10GBASE-PR or 10/1GBASE-PRX ONU capability is supported. The 10G-EPON BER Monitor is described in 76.2.3.4.

Table 45–111—PCS control 1 register bit definitions

Bit(s)	Name	Description	R/W[a]
3.80.0:7	10G-EPON BER Monitor Timer	Duration (in units of 5 microseconds) of the timer used by the 10G-EPON BER Monitor function Default value is 25 (ie. 125 microseconds). A value of 0 indicates that the BER monitor function is disabled	R/W
3.80.8:15	10G-EPON BER Monitor Threshold	Number of Sync Header errors within a timer interval that triggers a high BER condition for the 10G-EPON BER Monitor function. Default value is 16. A value of 0 indicates that the BER monitor function is disabled.	R/W

[a]R/W = Read/Write

45.2.3.34 10GBASE-PR and 10/1GBASE-PRX BER Monitor Status (Register 3.81)

The assignments of bits in the 10GBASE-PR and 10/1GBASE-PRX BER Status Register is shown in Table 45–112. This register is only required when 10GBASE-PR or 10/1GBASE-PRX ONU capability is supported.

Table 45–112—PCS status 1 register bit definitions

Bit(s)	Name	Description	R/W[a]
3.81.7:2	Reserved	Value always zero, Writes ignored	RO
3.81.1	Latched high BER	1 = 10GBASE-PR or 10/1GBASE-PRX PCS reported a high BER. 0 = 10GBASE-PR or 10/1GBASE-PRX PCS did not report a high BER.	RO/NR
3.81.0	high BER	1 = 10GBASE-PR or 10/1GBASE-PRX PCS reporting a high BER. 0 = 10GBASE-PR or 10/1GBASE-PRX PCS not reportiong a high BER.	RO

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

45.2.3.34.1 10GBASE-PR and 10/1GBASE-PRX PCS high BER (3.81.0)

In 10GBASE-PR and 10/1GBASE-PRX PCS, when read as a one, bit 3.81.0 indicates that the receiver is detecting a BER greater than the configurable threshold. When read as a zero, bit 3.81.0 indicates that the

receiver is detecting a BER lower than the configurable threshold. This bit mirrors the state of the hi_ber variable, defined in 76.2.3.4.

45.2.3.34.2 10GBASE-PR and 10/1GBASE-PRX PCS latched high BER (3.81.1)

In 10GBASE-PR and 10/1GBASE-PRX PCS, when read as a one, bit 3.81.1 indicates that the receiver detected a BER greater than the configurable threshold (high BER state). When read as a zero, bit 3.81.1 indicates that the receiver detected BER lower than the configurable threshold (low BER state).

The latched high BER shall be implemented with latching high behavior.

This bit is a latching high version of the 10GBASE-PR and 10/1GBASE-PRX high BER status bit (3.81.0).

45.3 Management frame structure

45.4 Electrical interface

45.5 Protocol implementation conformance statement (PICS) proforma for Clause 45, MDIO interface

Add to the end of table 45.5.3.3 PMA/PMD management functions:

Item	Feature	Subclause	Value/Comment	Status	Support
MM119	Writes to this register have no effect	45.2.1.11		PMA:M	Yes [ ] No [ ] N/A [ ]

Add to the end of table 45.5.3.6 PCS options:

Item	Feature	Subclause	Value/Comment	Status	Support
*CPR	Implementation of 10GBASE-PR or 10/1GBASE-PRX PCS	45.2.3		PCS:O	Yes [ ] No [ ] N/A [ ]

75.5 PMD to MDI optical specifications for symmetric–rate and asymmetric–rate ONU PMDs

This section details the PMD to MDI optical specifications for symmetric–rate and asymmetric–rate ONU PMDs, as specified in 75.2. Specifically, 75.5.1 defines the ONU transmit parameters, while 75.5.2 defines the ONU receive parameters.

The operating ranges for PR and PRX power budget classes are defined in Table 75–1. A PR and PRX compliant transceiver operates over the media types listed in Table 75–14 according to the specifications described in 75.9. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant (e.g., a single–mode solution operating at 10.5 km meets the minimum range requirement of 0.5 m to 10 km for PR10).

NOTE—The specifications for OMA have been derived from extinction ratio and average launch power (minimum) or receiver sensitivity (maximum). The calculation is defined in 58.7.6.

75.5.1 Transmitter optical specifications

The signaling speed, operating wavelength, spectral width (for asymmetric–rate ONU PMDs) or side mode suppression ratio (for symmetric–rate ONU PMDs), average launch power, extinction ratio, return loss tolerance, OMA, eye and TDP for transmitters forming part of the symmetric–rate and asymmetric–rate ONU PMDs (as specified in 75.2) shall meet the specifications defined in Table 75–8 for symmetric–rate ONU PMDs and in Table 75–9 for asymmetric–rate ONU PMDs, per measurement techniques described in 75.7. Its $RIN_{15}OMA$ should meet the value listed in Table 75–8 or Table 75–9, ~~respectively~~, per measurement techniques described in 75.7.8.

Table 75–8—PR type ONU PMD transmit characteristics

Description	10GBASE –PR–U1	10GBASE –PR–U3	Unit
Signaling speed (range)	10.3125 ± 100 ppm	10.3125 ± 100 ppm	GBd
Wavelength (range)	1260 to 1280	1260 to 1280	nm
Side Mode Suppression Ratio (min)[a]	30	30	dB
Average launch power (max)	4	9	dBm
Average launch power (min)[b]	–1	4	dBm
Average launch power of OFF transmitter (max)	–45	–45	dBm
Extinction ratio (min)	6	6	dB
$RIN_{15}OMA$ (max)	–128	–128	dB/Hz
Launch OMA (min)[c]	–0.22 (0.95)	4.78 (3.01)	dBm (mW)
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3}	{0.25, 0.40, 0.45, 0.25, 0.28, 0.40}	{0.25, 0.40, 0.45, 0.25, 0.28, 0.40}	UI
Ton (max)	512	512	ns
Toff (max)	512	512	ns
Optical return loss tolerance (max)	15	15	dB
Transmitter reflectance (max)	–10	–10	dB
Transmitter and dispersion penalty (max)[c]	3.0	3.0	dB
Decision timing offset for transmitter and dispersion penalty	±0.0625	±0.0625	UI

[a]Transmitter is a single longitudinal mode device. Chirp is allowed such that the total optical path penalty does not exceed that found in Table 75B–2.
[b]Minimum average launch power and minimum launch OMA are valid for ER = 6 dB (see Figure 75–5 for details).
[c]If a transmitter has a lower TDP, the minimum transmitter launch OMA (OMA_{min}) and average minimum launch power (AVP_{min}) may be relaxed by the amount 3.0 dB – TDP.

Table 75–14—Optical fiber and cable characteristics

Description[a]	IEC 60793–2 B1.1, B1.3 SMF ITU–T G.652, G.675 SMF				Unit
Nominal wavelength[b]	1270	1310	1550	1577	nm
Cable attenuation (max)[c]	0.44	0.4	0.35	0.35	dB/km
Zero dispersion wavelength[d]	$1300 \leq \lambda_0 \leq 1324$				nm
Dispersion slope (max)	0.093				ps / $nm^2 \cdot km$

[a]The fiber dispersion values are normative, all other values in the table are informative.
[b]Wavelength specified is the nominal wavelength and typical measurement wavelength. Power penalties at other wavelengths are accounted for.
[c]Attenuation for single–mode optical fiber cables for 1310 nm and 1550 nm is defined in ITU–T G.652. The attenuation values in the 1270 nm and 1577 nm windows were calculated using spectral attenuation modelling method (5.4.4) included in G.650.1 (06/2004) and the matrix coefficients included in Appendix III therein. 1310 nm (0.4 dB/km), 1380 nm (0.5 dB/km) and 1550 nm (0.35 dB/km) attenuation values were used as the input for the predictor model.
[d]See IEC 60793 or ITU–T G.652.

The channel insertion loss was calculated under the assumption of 14.5 dB loss for a 1:16 splitter / 18.1 dB loss for a 1:32 splitter (ITU–T G.671 am 1). Unitary fiber attenuation for particular transmission wavelength is provided in Table 75–14. The number of splices / connectors is not predefined – the number of individual fiber sections between the OLT MDI and the ONU MDI is not defined. The only requirements are that the resulting channel insertion loss is with the limits specified in Table 75–1 and the maximum reach in Table 75–1 is not exceeded. Other fiber arrangements (~~i.e.~~ increasing the split ratio while decreasing the fiber length) are supported as long as the limits for the channel insertion loss specified in Table 75–1 are observed.

The maximum discrete reflectance for single–mode connections shall be less than –26 dB.

75.9.4 Medium Dependent Interface (MDI)

The 10GBASE–PR or 10/1GBASE–PRX PMD is coupled to the fiber cabling at the MDI. The MDI is the interface between the PMD and the “fiber optic cabling” as shown in Figure 75–3. Examples of an MDI include:

a) Connectorized fiber pigtail
b) PMD receptacle

When the MDI is a remateable connection, it shall meet the interface performance specifications of IEC 61753–1. The MDI carries the signal in both directions for 10GBASE–PR or 10/1GBASE–PRX PMD and couples to a single fiber.

NOTE—Compliance testing is performed at TP2 and TP3 as defined in 75.3.2, not at the MDI.

2 shows the mapping of PLS_DATA.indication primitives to receive interface signals for different types of OLTs and ONUs.

76.1.3 Summary of major concepts

A successful registration process, described in 77.3.3, results in the assignment of values to the MODE and LLID variables associated with a MAC. This may be one of many MACs in an OLT or a single MAC in an ONU. The MODE and LLID variables are used to identify a packet transmitted from that MAC and how received packets are directed to that MAC. The PCS in the OLT shall operate in unidirectional mode as defined in 66.2.2.

As described in 77.1.2, multiple MACs within an OLT are bound to a single XGMII, in case of a 10/10G-EPON OLT, or to an XGMII transmit path and a GMII receive path, in case of a 10/1G-EPON OLT. Correspondingly, only one PLS_DATA request primitive is active at any time.

At the ONU, the MAC is either bound to an XGMII, in case of a 10/10G-EPON ONU, or to an XGMII receive path and a GMII transmit path, in case of an 10/1G-EPON ONU.

In the transmit direction, the RS maps the active PLS_DATA.request to either the GMII signals (TXD<7:0>, TX_EN, TX_ER, and GTX_CLK) or the XGMII signals (TXD<31:0>, TXC<3:0>, and TX_CLK) according to the MAC instance generating the request. The RS replaces octets of preamble with the values of the transmitting MAC's MODE and LLID variables.

In the receive direction, the MODE and LLID values embedded within the preamble identify the MAC to which this packet should be directed. The RS establishes a temporal mapping of either the GMII signals (RXD<7:0>, RX_ER, RX_CLK, and RX_DV) or the XGMII signals (RXD<31:0>, RXC<3:0> and RX_CLK) to the correct PLS_DATA.indication and PLS_DATA_VALID.indication primitives.

76.1.3.1 Application

This subclause applies to the interface between the MAC and PHY in an OLT or an ONU. The physical implementation of the interface is primarily intended to be chip-to-chip, but may also be used as a logical interface between ASIC logic modules within an integrated circuit. These interfaces are used to provide media independence, so that an identical media access controller may be used with all 10GBASE-PR and 10/1GBASE-PRX PHY types.

76.1.3.2 Delay constraints

The MPCP relies on strict timing based on the distribution of timestamps. The actual delay is implementation dependent but an implementation shall maintain a combined delay variation through RS, PCS, and PMA sublayers of no more than 1 time_quantum (see 72.2.2.1)so as to comply with this mechanism.

76.1.4 GMII structure

See Clause 35.

76.1.5 XGMII structure

The XGMII structure is discussed in 46.1.6, and Figure 46-2 depicts a schematic view of the RS inputs and outputs.

The REGISTER_ACK MPCPDU shall be generated by a MAC Control instance mapped to an active ONU, and as such shall be marked with a unicast type of LLID.

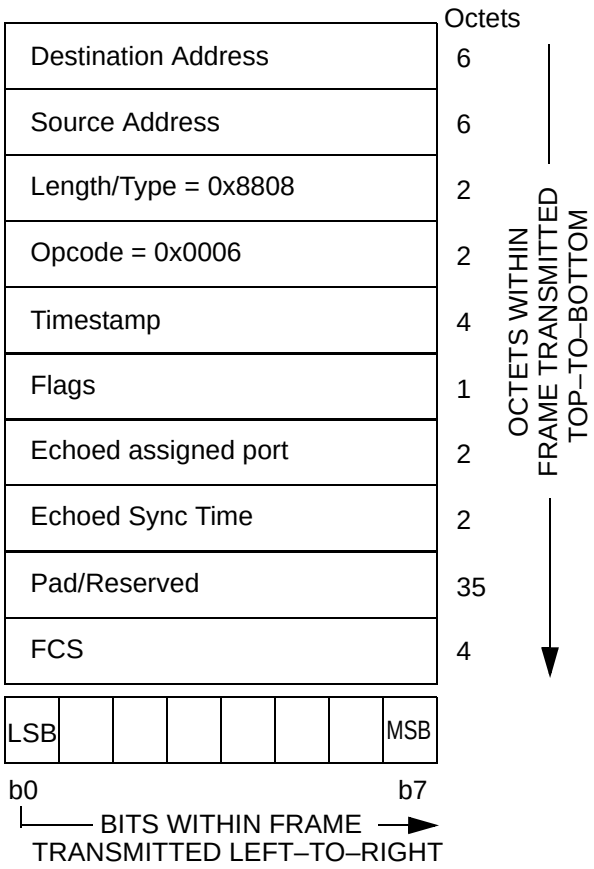

Figure 77–36—REGISTER_ACK MPCPDU

77.4 Discovery Process in dual–rate systems

The enhancements introduced to the Clause 77 discovery process for EPONs facilitate the coexistence of 10G–EPON with 1G–EPON.

77.4.1 OLT speed–specific discovery

The discovery GATE MPCPDU is defined in Clause 64 for 1 Gb/s operation and in Clause 77 for 10 Gb/s operation. An additional field (Discovery Information field) was added to the 10 Gb/s discovery GATE MPCPDU. This field allows the OLT to relay speed–specific information regarding the discovery window to the different ONUs that may co–exist in the same PON. The OLT has the ability to transmit common discovery GATE MPCPDUs on both the 1 Gb/s transmit path and 10 Gb/s transmit path, or it can send completely separate and independent GATE messages on these different paths. For each discovery window, the OLT is capable of opening windows for individual speeds or multiple speeds.

These different combinations allow the OLT MAC Control Client to open a number of discovery windows for all of the different ONU types. Table 77–9 shows the different types of windows that are possible, along with the necessary LLID and discovery information that also needs to be present in the discovery GATE MPCPDUs. For some combinations, it may be desirable for the OLT MAC Control Client to open overlapping discovery windows. It may do so by sending one discovery GATE MPCPDU on 1 Gb/s downstream

channel and a similar discovery GATE MPCPDU on 10 Gb/s downstream channel; both discovery GATE MPCPDUs having the same Start Time value.

Table 77–9—Discovery GATE MPCPDUs for all ONU types

ONU types targeted by discovery GATE MPCPDU [DS/US transmission speed]	LLID of discovery GATE(s)	Discovery Information			
		Upstream Capable		Discovery Window	
		1G	10G	1G	10G
1/1 Gb/s	0x7FFF	No Discovery Information field present			
10/1 Gb/s	0x7FFE	1	0	1	0
1/1 Gb/s and 10/1 Gb/s	0x7FFF[a]	No Discovery Information field present			
	0x7FFE[a]	1	0	1	0
10/10 Gb/s	0x7FFE	0	1	0	1
10/1 Gb/s and 10/10 Gb/s	0x7FFE	1	1	1	1
1/1 Gb/s, 10/1 Gb/s, and 10/10 Gb/s	0x7FFF[a]	No Discovery Information field present			
	0x7FFE[a]	1	1	1	1

[a]Two discovery GATE MPCPDUs are transmitted in two separate downstream broadcast channels: one with the LLID of 0x7FFF transmitted in the 1 Gb/s downstream broadcast channel and another one the LLID of 0x7FFE transmitted in the 10 Gb/s downstream broadcast channel.

Figure 77–37 shows the three primary combinations of discovery windows and the different types of REGISTER_REQ MPCPDUs that may be received during the window. Figure 77–37(a) shows reception of messages from 1 Gb/s and 10/1 Gb/s ONUs. Figure 77–37(b) shows reception of messages from 10 Gb/s ONUs. Figure 77–37(c) shows reception of messages from all types of ONUs.

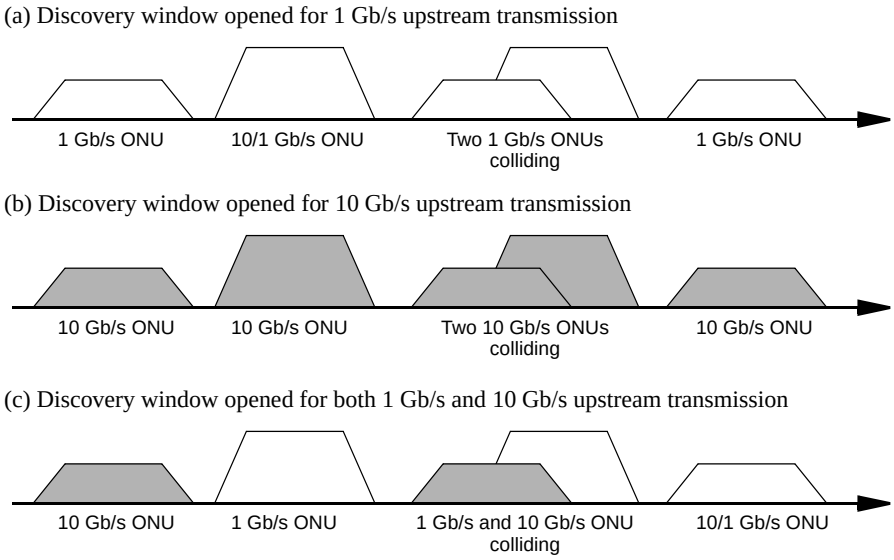

Figure 77–37—Combinations of REGISTER_REQ MPCPDUs during discovery window for 10G–EPON and 1G–EPON coexisting in the same PON

77.4.2 ONU speed–specific registration

A 1G–EPON ONU will only receive discovery GATE messages transmitted by the OLT in the 1 Gb/s broadcast channel. Operation and registration of these ONUs is specified in Clause 64.