

141. Physical Medium Dependent (PMD) sublayer and medium for 25G-EPON, 50G-EPON, and 100G-EPON passive optical networks

141.1 Overview

Clause 141 describes Physical Medium dependent (PMD) sublayer for Ethernet Passive Optical Networks operating at the line rate of 25, 50, or 100 Gb/s, in either downstream or in both downstream and upstream directions.

141.1.1 Terminology and conventions

EPONs operate over a point-to-multipoint (P2MP) topology, also called a tree or trunk-and-branch topology. The device connected at the root of the tree is called an Optical Line Terminal (OLT) and the devices connected as the leaves are referred to as Optical Network Units (ONUs). The direction of transmission from the OLT to the ONUs is referred to as the *downstream* direction, while the direction of transmission from the ONUs to the OLT is referred to as the *upstream* direction.

141.1.2 Power budget classes

Clause 141 defines the following power budget classes:

- Medium power budget class supports P2MP media channel insertion loss of ≤ 24 dB e.g., a PON with the split ratio of at least 1:16 and the distance of at least 20 km or a PON with the split ratio of at least 1:32 and the distance of at least 10 km.
- High power budget class supports P2MP media channel insertion loss of ≤ 29 dB e.g., a PON with the split ratio of at least 1:32 and the distance of at least 20 km.

141.1.3 Power budgets

Each power budget class is represented by PR-S-type power budget and PR-A-type power budget as follows:

- PR-S power budget describes symmetric-rate PHY for PON operating at 25 Gb/s or 50 Gb/s, in both downstream and upstream directions, over a single SMF
- PR-A power budget describes asymmetric-rate PHY for PON operating at 25 Gb/s or 50 Gb/s in the downstream direction and 10 Gb/s and above in the upstream direction, over a single SMF

Each power budget is further identified with a numeric representation of its class, where a value of 20 represents the medium power budget and a value of 30 represents the high power budget. Thus, the following power budgets are defined in Clause 141:

- PR-S20: symmetric-rate, medium power budget,
- PR-S30: symmetric-rate, high power budget,
- PR-A20: asymmetric-rate, medium power budget,
- PR-A30: asymmetric-rate, high power budget.

Table 141–1 shows the primary attributes of all power budget types defined in Clause 141.

Table 141–1—Power budgets

Description	Medium Power Budget		High Power Budget		Units
	PR-S20	PR-A20	PR-S30	PR-A30	
Number of fibers	1				–
Number of downstream wavelengths	1 or 2				–
Number of upstream wavelengths	1 or 2	1	1 or 2	1	–
Nominal downstream line rate	25.78125	25.78125	25.78125	25.78125	GBd
Nominal upstream line rate	25.78125	10.3125	25.78125	10.3125	GBd
Nominal downstream wavelength	1358±2 or 1342±2				nm
Nominal upstream wavelength	1270±10 or 1300±10	<TBD>	1270±10 or 1300±10	<TBD>	nm
Maximum reach ^a	≥20				km
Maximum channel insertion loss	24		29		dB
Minimum channel insertion loss	10		15		dB

^aA compliant system may exceed the maximum reach designed for given power budget as long as optical power budget and other mandatory optical layer specifications are met.

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141.1.4 Positioning of PMD sublayer within the IEEE 802.3 architecture

Figure 141–1 depicts the relationships of symmetric-rate (25G-EPON and 50G-EPON) and asymmetric-rate (25/10G-EPON, 50/25G-EPON, and 50/10G-EPON) PMD sublayer (shown hatched) with other sublayers and the ISO/IEC Open System Interconnection (OSI) reference model.

141.2 PMD types

The characteristics of the P2MP topology result in significantly different ONU and OLT PMDs. For example, the OLT PMD operates in a continuous mode in the transmit direction (downstream), but uses a burst mode in the receive direction (upstream). On the other hand, the ONU PMD receives data in a continuous mode, but transmits in a burst mode. To differentiate OLT PMDs from ONU PMDs, the OLT PMD name has a suffix “D” appended to it, where D stands for a downstream-facing PMD, whereas the ONU PMD has a suffix “U” appended to it, where U stands for an upstream-facing PMD.

Editorial NOTE (to be removed prior to publication): Figure 200-1 is a placeholder right now, to be replaced with updated drawing once complete architecture is available.

In the downstream direction, the signal transmitted by the D-type PMD is received by all U-type PMDs. In the upstream direction, the D-type PMD receives data bursts from each of the U-type PMDs.

Clause 141 defines several D-type and several U-type PMDs, that differ in their receive and/or transmit characteristics. Such PMDs are further distinguished by appending a digit after the suffix D or U.

The following OLT PMDs (D-type) are defined in this subclause:

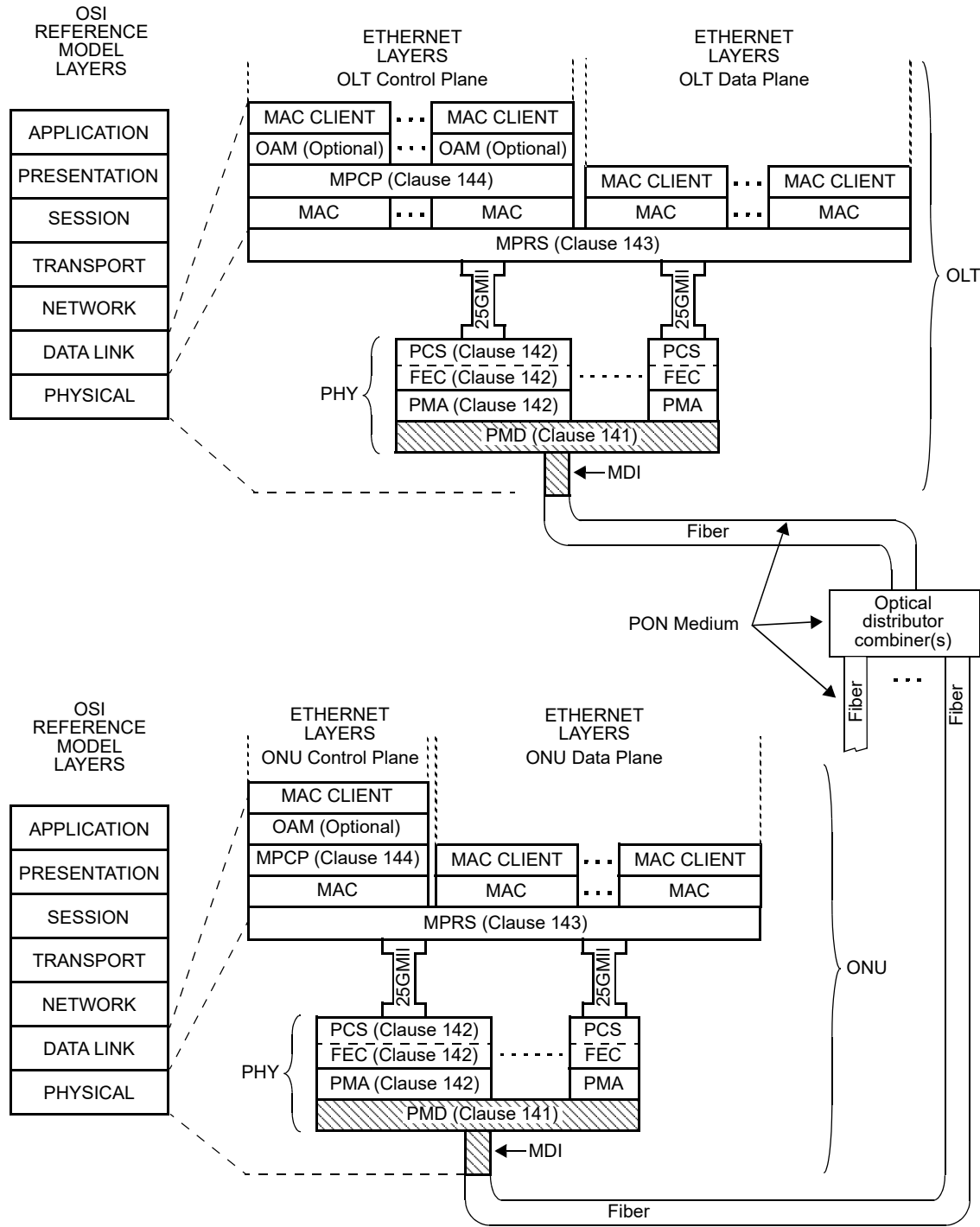
- a) Asymmetric-rate D-type PMDs (collectively referred to as PR-S-D), transmitting at 25 Gb/s (or more) continuous mode and receiving at 25 Gb/s (or more) burst mode:
 - 1) {PMD-S-D} types
- b) Symmetric-rate D-type PMDs (collectively referred to as {PR-A-D}), transmitting at {TBD} GBd continuous mode and receiving at {TBD} GBd burst mode:
 - 1) {PMD-A-D} types

The following ONU PMDs (U-type) are defined in this subclause:

- a) Asymmetric-rate U-type PMDs (collectively referred to as 10/1GBASE-PRX-U), transmitting at 1.25 GBd burst mode and receiving at 10.3125 GBd continuous mode:
 - 1) {PMD_Y_D} types
- b) Symmetric-rate U-type PMDs (collectively referred to as 10GBASE-PR-U), transmitting at 10.3125 GBd burst mode and receiving at 10.3125 GBd continuous mode:
 - 1) {PMD_X_D} types

Editorial Note (to be removed prior to publication): Need a scrub of the draft to remove all references to 1.25 GBd PHYs, 1G-EPON, and use proper PMD names

A specific power budget is achieved by combining an OLT PMD (D-type) with an ONU PMD (U-type) as shown in 141.2.1. Detailed PMD receive and transmit characteristics for D-type PMDs are given in 141.5 and characteristics for U-type PMDs are presented in 141.6. Every PMD has non-overlapping transmit and receive wavelength bands and operates over a single SMF (see {TBD future ANNEX}).



PMD and MDI described in this clause

25GMII=25 GIGABIT MEDIA INDEPENDENT INTERFACE
 MDI = MEDIUM DEPENDENT INTERFACE
 OAM = OPERATIONS, ADMINISTRATION & MAINTENANCE
 OLT = OPTICAL LINE TERMINAL
 MPRS= MULTI-POINT RECONCILIATION SUBLAYER
 MPCP= MULTI-POINT CONTROL PROTOCOL

ONU = OPTICAL NETWORK UNIT
 PCS = PHYSICAL CODING SUBLAYER
 PHY = PHYSICAL LAYER DEVICE
 PMA = PHYSICAL MEDIUM ATTACHMENT
 PMD = PHYSICAL MEDIUM DEPENDENT

Figure 141-1—Relationship of EPON P2MP PMD to the ISO/IEC OSI reference model and the IEEE 802.3 Ethernet model

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141.2.1 Mapping of PMDs to power budgets

The power budget is determined by the PMDs located at the ends of the physical media. This subclause describes how PMDs may be combined to achieve the power budgets listed in Table 141-1.

141.2.1.1 Symmetric-rate, {PMD_X} power budgets ({NG} type)

Table 141-2 illustrates recommended pairings of symmetric-rate ONU PMDs with symmetric-rate OLT PMDs to achieve the power budgets as shown in Table 141-1.

Table 141-2—PMD – power budget mapping for symmetric-rate {NG}-type power budgets

		OLT PMDs			
ONU PMDs					

141.2.1.2 Asymmetric-rate, {PMD_Y} power budgets ({NG} type)

Table 141-3 illustrates recommended pairings of asymmetric-rate ONU PMDs with asymmetric-rate OLT PMDs to achieve the power budgets as shown in Table 141-1.

Table 141-3—PMD – power budget mapping for asymmetric-rate {NG}-type power budgets

		OLT PMDs			
ONU PMDs					

141.3 PMD functional specifications

The {NG-EPON type} PMDs perform the transmit and receive functions that convey data between the PMD service interface and the MDI.

141.3.1 PMD service interface

The following specifies the services provided by Clause 141 PMDs. These PMD sublayer service interfaces are described in an abstract manner and do not imply any particular implementation.

The PMD Service Interface supports the exchange of a continuous stream of bits, representing 256B/257B blocks, between the PMA and PMD entities. The PMD translates the serialized data received from the compatible PMA to and from signals suitable for the specified medium. The following primitives are defined:

- PMD_UNITDATA.request
- PMD_UNITDATA.indication
- PMD_SIGNAL.request
- PMD_SIGNAL.indication

141.3.1.1 Delay constraints

{TBD}

141.3.1.2 PMD_UNITDATA.request

This primitive defines the transfer of a serial data stream from the [Clause 201](#) PMA to the PMD.

{TBD, depending on the structure of PMA}

141.3.1.3 PMD_UNITDATA.indication

This primitive defines the transfer of data from the PMD to the [Clause 201](#) PMA.

{TBD, depending on the structure of PMA}

141.3.1.4 PMD_SIGNAL.request

{TBD, depending on the structure of PMA}

141.3.1.5 PMD_SIGNAL.indication

{TBD, depending on the structure of PMA}

141.3.2 PMD block diagram

The PMD sublayer is defined at the eight reference points shown in Figure 141–2 for 100G-EPON PMDs.

For 100G-EPON PMDs, test points TP1 through TP4 refer to the downstream channel, while test points TP5 through TP8 refer to the upstream channel. In the downstream channel, TP2 and TP3 are compliance points, while in the upstream channel TP6 and TP7 are compliance points. TP1, TP4, TP5, and TP8 are reference points for use by implementers. The optical transmit signal is defined at the output end of a patch cord (TP2 for the downstream channel and TP6 for the upstream channel), between 2 m and 5 m in length, of a fiber type consistent with the link type connected to the transmitter. Unless specified otherwise, all transmitter measurements and tests defined in 141.8 are made at TP2 or TP6. The optical receive signal is defined at the output of the fiber optic cabling (TP3 for the downstream channel and TP7 for the upstream channel) connected to the receiver. Unless specified otherwise, all receiver measurements and tests defined in 141.8 are made at TP3 or TP7.

The electrical specifications of the PMD service interface (TP1 and TP4 for the downstream channel and TP5 and TP8 for the upstream channel) are not system compliance points (these are not readily testable in a system implementation).

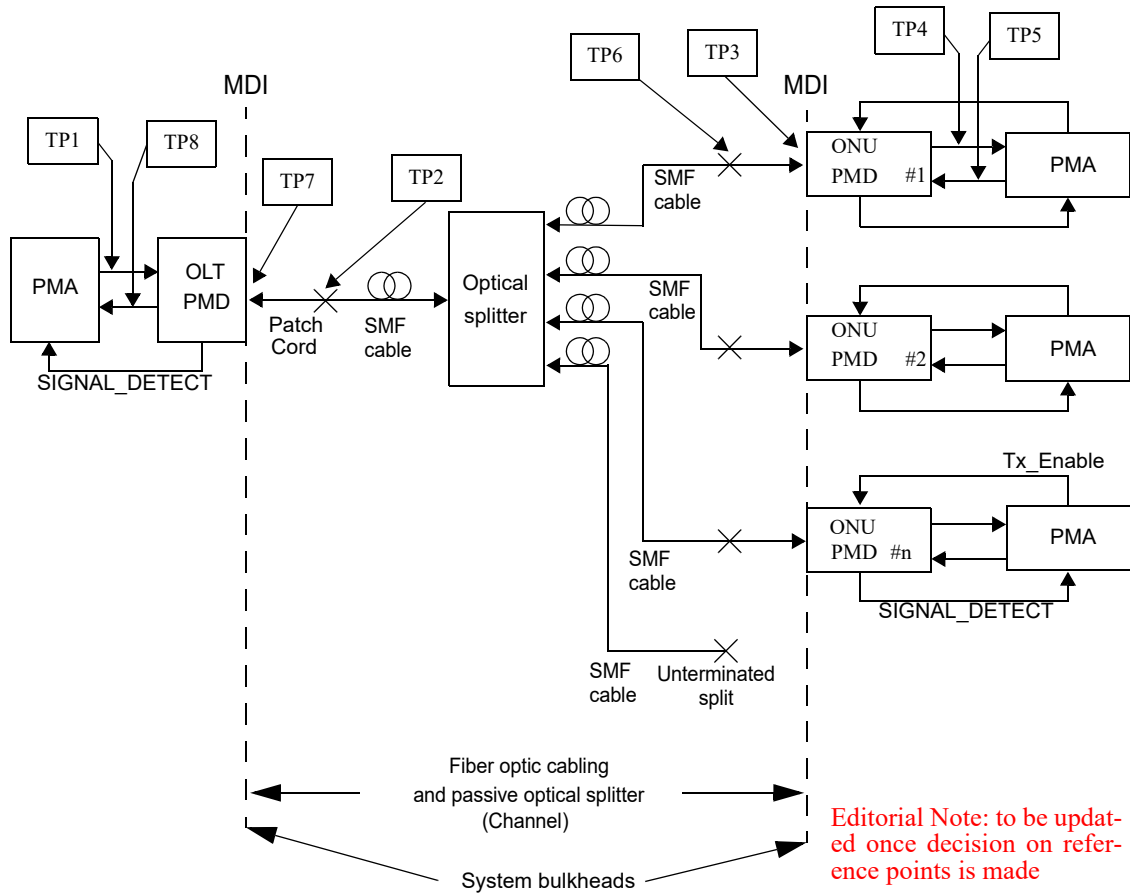


Figure 141-2—10GBASE-PR and 10/1GBASE-PRX block diagram

141.3.3 PMD transmit function

{TBD, depending on the structure of PMA}

141.3.4 PMD receive function

{TBD, depending on the structure of PMA}

141.3.5 PMD signal detect function

141.3.5.1 ONU PMD signal detect

{TBD, depending on the structure of PMA}

141.3.5.2 OLT PMD signal detect

The response time for the PMD Signal Detect function for the burst mode upstream signal may be longer or shorter than a burst length; thus, it may not fulfill the traditional requirements placed on Signal Detect. PMD_SIGNAL.indication is intended to be an indicator of optical signal presence. The signal detect function in the OLT may be realized in the PMD or the Clause 142 PMA sublayer.

The value of the SIGNAL_DETECT parameter shall be generated according to the conditions defined in Table 141-4 for PMDs defined in Clause 141. The 100G-EPON PMD receiver is not required to verify whether a compliant 100G-EPON signal is being received.

141.3.5.3 100G-EPON Signal detect functions

The Signal Detect value definitions for Clause 141 PMDs are shown in Table 141-4.

Table 141-4—SIGNAL_DETECT value definitions for Clause 141 PMDs

PMD type	Receive conditions	SIGNAL_DETECT value
100G-EPON PMD	Average input optical power \leq Signal Detect Threshold (min) in Table {TBD} at the specified receiver wavelength	FAIL
	Average input optical power \geq Receive sensitivity (max) in Table {TBD} with a compliant signal input at the specified receiver wavelength	OK
	All other conditions	Unspecified

141.3.6 PMD transmit enable function for ONU

PMD_SIGNAL.request(tx_enable) is defined for all ONU PMDs specified in Clause 141. PMD_SIGNAL.request(tx_enable) is asserted prior to data transmission by the ONU PMDs.

141.4 Wavelength channel allocation

Downstream channel wavelength assignments are defined in Table 141-5.

Table 141-5—Downstream channel wavelength assignments

Channel Name	Center frequency (THz)	Center wavelength (nm)	Wavelength range (nm)
DW0	TBD	1358	± 2
DW1	TBD	1342	± 2

Upstream channel wavelength assignments are defined in Table 141-6.

Table 141-6—Upstream channel wavelength assignments

Wavelength Name	Center frequency (THz)	Center wavelength (nm)	Wavelength range (nm)
UW0	TBD	1270	± 10
UW1	TBD	1300	± 10
UW2	TBD	1320	± 2

141.5 PMD to MDI optical specifications for 25G-EPON and 50G-EPON OLT PMDs

This subclause details the PMD to MDI optical specifications for 25G-EPON and 50G-EPON OLT PMDs, as specified in 141.2. Specifically, 141.5.1 defines the OLT transmit parameters, while 141.5.2 defines the OLT receive parameters.

The operating ranges for {XXX} power budget classes are defined in Table 141–1. A {XXX} compliant transceiver operates over the media types listed in Table 141–15 according to the specifications described in 141.10. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant.

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.

141.5.1 Transmitter optical specifications

Table 141–7—OLT PR20 Transmit Characteristics

Parameter		25GBASE-PR20-D	50GBASE-PR20-D 50/25GBASE-PR20-D	Unit
Channel wavelength ranges	DW0	1358 ± 2	1358 ± 2	nm
	DW1	N/A	1342 ± 2	nm
Signaling rate, (range)		25.78125 ± 100 ppm		GBd
Side-mode suppression ratio (SMSR), (min)				dB
Total average launch power (max)				dBm
Average launch power, each channel (max)				dBm
Average launch power, each channel ^a (min)				dBm
Optical Modulation Amplitude (OMA), each channel (max)				dBm
Optical Modulation Amplitude (OMA), each channel (min) ^b				dBm
Difference in launch power between any two channels (OMA) (max)				dB
Launch power in OMA minus TDP, each channel (min)				dBm
Transmitter and dispersion penalty (TDP), each channel (max)				dB
Average launch power of OFF transmitter, each channel (max)				dBm
Extinction ratio (min)				dB
RIN _{15OMA} (max)				dB/Hz
Optical return loss tolerance (max)				dB
Transmitter reflectance ^c (max)				dB
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3}				UI
Decision timing offset for transmitter and dispersion penalty				UI

^a Average launch power, each channel (min) is informative and not the principal indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.

^b Even if the TDP < TBD dB, the OMA (min) must exceed this value.

^c Transmitter reflectance is defined looking into the transmitter.

Table 141–8—OLT PR30 Transmit Characteristics

Parameter		25GBASE-PR30-D	50GBASE-PR30-D 50/25GBASE-PR30-D	Unit
Channel wavelength ranges	DW0	1358 ± 2	1358 ± 2	nm
	DW1	N/A	1342 ± 2	nm
Signaling rate, each channel (range)		25.78125 ± 100 ppm		GBd
Side-mode suppression ratio (SMSR), (min)				dB
Total average launch power (max)				dBm
Average launch power, each channel (max)		4.8		dBm
Average launch power, each channel ^a (min)				dBm
Optical Modulation Amplitude (OMA), each channel (max)				dBm
Optical Modulation Amplitude (OMA), each channel (min) ^b				dBm
Difference in launch power between any two channels (OMA) (max)				dB
Launch power in OMA minus TDP, each channel (min)				dBm
Transmitter and dispersion penalty (TDP), each channel (max)				dB
Average launch power of OFF transmitter, each channel (max)				dBm
Extinction ratio (min)		8		dB
RIN _{15OMA} (max)				dB/Hz
Optical return loss tolerance (max)				dB
Transmitter reflectance ^c (max)				dB
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3}				UI
Decision timing offset for transmitter and dispersion penalty				UI

^a Average launch power, each channel (min) is informative and not the principal indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.

^b Even if the TDP < TBD dB, the OMA (min) must exceed this value.

^c Transmitter reflectance is defined looking into the transmitter.

{TBD}

141.5.2 Receiver optical specifications

141.6 PMD to MDI optical specifications for 25G-EPON and 50G-EPON ONU PMDs

This subclause details the PMD to MDI optical specifications for 25G-EPON and 50G-EPON ONU PMDs, as specified in 141.2. Specifically, 141.6.1 defines the ONU transmit parameters, while 141.6.2 defines the ONU receive parameters.

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Table 141–9—OLT PR20 Receive Characteristics

Parameter		25GBASE-PR20-D 50/25GBASE-PR20-D	50GBASE-PR20-D	25/10GBASE-PR20-D 50/10GBASE-PR20-D	Unit
Channel wavelength ranges	UW0	TBD.UC0range	TBD.UC0range	1270 ± 10	nm
	UW1		TBD.UC1range	1300 ± 10	nm
	UW2				nm
Signaling rate, each channel (range)		25.78125 ± 100 ppm		See Table 75-6	GBd
Bit error ratio (max) ^a		10 ⁻²			
Damage Threshold ^b		See Table 75-6			dBm
Average receive power, each channel (max)					dBm
Average receive power, each channel ^c (min)					dBm
Receive power, each channel (OMA) (max)					dBm
Receiver reflectance (max)					dB
Receiver sensitivity (OMA), each channel ^d (max)					dBm
Signal detect threshold, each channel (min)					GHz
Stressed receiver sensitivity (OMA), each channel ^e (max)					dBm
Receiver settling time (max)					ns
Conditions of stressed receiver sensitivity test:					
Vertical eye closure penalty, ^f each channel					dB
Stressed eye J2 Jitter, ^e each channel					UI
Stressed eye J9 Jitter, ^e each channel					UI

^a The BER of 10^{-TBD} is achieved by the utilization of FEC as described in XX.X.

^b The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level.

^c Average receive power, each channel (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.

^d Receiver sensitivity (OMA), each channel (max) is informative.

^e Measured with conformance test signal at TP7 (see xx.xx.xx.xx) for BER = 10^{-TBD}.

^f Vertical eye closure penalty, stressed eye J2 Jitter, and stressed eye J9 Jitter are test conditions for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

The operating ranges for {XXX} power budget classes are defined in Table 141–1. A {XXX} compliant transceiver operates over the media types listed in Table 141–15 according to the specifications described in 141.10. A transceiver which exceeds the operational range requirement while meeting all other optical specifications is considered compliant.

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.

Table 141–10—OLT PR30 Receive Characteristics

Parameter		25GBASE-PR30-D 50/25GBASE-PR30-D	50GBASE-PR30-D	25/10GBASE-PR30-D 50/10GBASE-PR30-D	Unit	
Channel wavelength ranges	UW0	TBD.UC0range	TBD.UC0range	1270 ± 10	nm	
	UW1		TBD.UC1range	1300 ± 10	nm	
	UW2				nm	
Signaling rate, each channel (range)	25.78125 ± 100 ppm			See Table 75-6	GBd	
Bit error ratio (max) ^a	10 ⁻²					
Damage Threshold ^b					See Table 75-6	dBm
Average receive power, each channel (max)						dBm
Average receive power, each channel ^c (min)						dBm
Receive power, each channel (OMA) (max)						dBm
Receiver reflectance (max)						dB
Receiver sensitivity (OMA), each channel ^d (max)	-25.0					dBm
Signal detect threshold, each channel (min)						GHz
Stressed receiver sensitivity (OMA), each channel ^e (max)						dBm
Receiver settling time (max)						ns
Conditions of stressed receiver sensitivity test:						
Vertical eye closure penalty, ^f each channel						dB
Stressed eye J2 Jitter, ^e each channel						UI
Stressed eye J9 Jitter, ^e each channel						UI

^a The BER of 10^{-TBD} is achieved by the utilization of FEC as described in XX.X.

^b The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level.

^c Average receive power, each channel (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.

^d Receiver sensitivity (OMA), each channel (max) is informative.

^e Measured with conformance test signal at TP7 (see xx.xx.xx.xx) for BER = 10^{-TBD}.

^f Vertical eye closure penalty, stressed eye J2 Jitter, and stressed eye J9 Jitter are test conditions for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

141.6.1 Transmitter optical specifications

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Table 141–11—ONU PR20 Transmit Characteristics

Parameter		25GBASE-PR20-U 50/25GBASE-PR20-U	50GBASE-PR20-U	25/10GBASE-PR20-U 50/10GBASE-PR20-U	Unit
Channel wavelength ranges	UW0	TBD.UC0range	TBD.UC0range	1270 ± 10	nm
	UW1		TBD.UC1range	1300 ± 10	nm
	UW2				nm
Signaling rate, each channel (range)		25.78125 ± 100 ppm			GBd
Side-mode suppression ratio (SMSR), (min)					dB
Total average launch power (max)					dBm
Average launch power, each channel (max)					dBm
Average launch power, each channel ^a (min)					dBm
Optical Modulation Amplitude (OMA), each channel (max)					dBm
Optical Modulation Amplitude (OMA), each channel (min) ^b					dBm
Difference in launch power between any two channels (OMA) (max)					dB
Launch power in OMA minus TDP, each channel (min)					dBm
Transmitter and dispersion penalty (TDP), each channel (max)					dB
Average launch power of OFF transmitter, each channel (max)					dBm
Extinction ratio (min)					dB
RIN ₁₅ OMA (max)					dB/Hz
Optical return loss tolerance (max)					dB
Transmitter reflectance ^c (max)					dB
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3}					UI
Turn-on time (max)					ns
Turn-off time (max)					ns
Decision timing offset for transmitter and dispersion penalty					UI

See Table 75-8

^a Average launch power, each channel (min) is informative and not the principal indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.

^b Even if the TDP < TBD dB, the OMA (min) must exceed this value.

^c Transmitter reflectance is defined looking into the transmitter.

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Table 141–12—ONU PR30 Transmit Characteristics

Parameter		25GBASE-PR30-U 50/25GBASE-PR30-U	50GBASE-PR30-U	25/10GBASE-PR30-U 50/10GBASE-PR30-U	Unit
Channel wavelength ranges	UW0	TBD.UC0range	TBD.UC0range	1270 ± 10	nm
	UW1		TBD.UC1range	1300 ± 10	nm
	UW2				nm
Signaling rate, each channel (range)		25.78125 ± 100 ppm			GBd
Side-mode suppression ratio (SMSR), (min)					dB
Total average launch power (max)					dBm
Average launch power, each channel (max)					dBm
Average launch power, each channel ^a (min)					dBm
Optical Modulation Amplitude (OMA), each channel (max)					dBm
Optical Modulation Amplitude (OMA), each channel (min) ^b					dBm
Difference in launch power between any two channels (OMA) (max)					dB
Launch power in OMA minus TDP, each channel (min)					dBm
Transmitter and dispersion penalty (TDP), each channel (max)		4 <i>Editorial Note (to be removed prior to publication): Motion #7 from 2018/03 states "25G ONU transmitter: ERmin = 5 dB, (AVP minus TDP)min = 4.0dBm and update the draft" but there is no AVP minus TDP entry in tables.</i>			dB
Average launch power of OFF transmitter, each channel (max)					dBm
Extinction ratio (min)		5			dB
RIN ₁₅ OMA (max)					dB/Hz
Optical return loss tolerance (max)					dB
Transmitter reflectance ^c (max)					dB
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3}					UI
Turn-on time (max)					ns
Turn-off time (max)					ns
Decision timing offset for transmitter and dispersion penalty					UI

^a Average launch power, each channel (min) is informative and not the principal indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.

^b Even if the TDP < TBD dB, the OMA (min) must exceed this value.

^c Transmitter reflectance is defined looking into the transmitter.

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141.6.2 Receiver optical specifications

The signaling speed, operating wavelength, overload, stressed sensitivity, reflectance, and signal detect for receivers forming part of the {PMD-types} ONU PMDs (as specified in 141.2) shall meet the specifications defined in Table 141–5 for Clause 141 ONU PMDs, per measurement techniques defined in 141.7. Their unstressed receive characteristics should meet the values listed in Table 141–5 per measurement techniques described in 141.7.11. Either the damage threshold included in Table 141–5 shall be met, or the receiver shall be labeled to indicate the maximum optical input power level to which it can be continuously exposed without damage.

The damage threshold included in Table 141–5 does not guarantee direct ONU–OLT connection, which may result in damage of the receiver. If direct ONU–OLT connection is necessary, optical attenuators and/or equivalent loss components should be inserted to decrease receive power below damage threshold.

Table 141–13—ONU PR20 Receive Characteristics

Parameter		25GBASE-PR20-U	50GBASE-PR20-U 50/25GBASE-PR20-U	Unit
Channel wavelength ranges	DW0	1358 ± 2	1358 ± 2	nm
	DW1	N/A	1342 ± 2	nm
Signaling rate, each channel (range)		25.78125 ± 100 ppm		GBd
Bit error ratio (max) ^a		10 ⁻²		
Damage Threshold ^b				dBm
Average receive power, each channel (max)				dBm
Average receive power, each channel ^c (min)				dBm
Receive power, each channel (OMA) (max)				dBm
Receiver reflectance (max)				dB
Receiver sensitivity (OMA), each channel ^d (max)				dBm
Detect threshold, each channel (min)				dBm
Stressed receiver sensitivity (OMA), each channel ^e (max)				dBm
Conditions of stressed receiver sensitivity test				
Vertical eye closure penalty, ^f each channel				dB
Stressed eye J2 Jitter, ^e each channel				UI
Stressed eye J9 Jitter, ^e each channel				UI

^a The BER of 10^{-TBD} is achieved by the utilization of FEC as described in xx.xx.xx.xx.

^b The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level.

^c Average receive power, each channel (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.

^d Receiver sensitivity (OMA), each channel (max) is informative.

^e Measured with conformance test signal at TP3 (see xx.xx.xx.xx) for BER = 10^{-TBD}.

^f Vertical eye closure penalty, stressed eye J2 Jitter, and stressed eye J9 Jitter are test conditions for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

Table 141–14—ONU PR30 Receive Characteristics

Parameter		25GBASE-PR30-U	50GBASE-PR30-U 50/25GBASE-PR30-U	Unit
Channel wavelength ranges	DW0	1358 ± 2	1358 ± 2	nm
	DW1	N/A	1342 ± 2	nm
Signaling rate, each channel (range)		25.78125 ± 100 ppm		GBd
Bit error ratio (max) ^a		10 ⁻²		
Damage Threshold ^b				dBm
Average receive power, each channel (max)				dBm
Average receive power, each channel ^c (min)		-25.7		dBm
Receive power, each channel (OMA) (max)				dBm
Receiver reflectance (max)				dB
Receiver sensitivity (OMA), each channel ^d (max)		-24.1		dBm
Detect threshold, each channel (min)				dBm
Stressed receiver sensitivity (OMA), each channel ^e (max)				dBm
Conditions of stressed receiver sensitivity test				
Vertical eye closure penalty, ^f each channel				dB
Stressed eye J2 Jitter, ^e each channel				UI
Stressed eye J9 Jitter, ^e each channel				UI

^a The BER of 10^{-TBD} is achieved by the utilization of FEC as described in xx.xx.xx.xx.

^b The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level.

^c Average receive power, each channel (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.

^d Receiver sensitivity (OMA), each channel (max) is informative.

^e Measured with conformance test signal at TP3 (see xx.xx.xx.xx) for BER = 10^{-TBD}.

^f Vertical eye closure penalty, stressed eye J2 Jitter, and stressed eye J9 Jitter are test conditions for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

141.7 Definitions of optical parameters and measurement methods

When measuring jitter at TP1 and TP5, it is recommended that jitter contributions at frequencies below receiver corner frequencies (i.e., {TBD}) are filtered at the measurement unit. The following subclauses describe definitive patterns and test procedures for Clause 141 PMDs. Implementers using alternative verification methods should ensure adequate correlation and allow adequate margin such that specifications are met by reference to the definitive methods. All optical measurements, except TDP and RIN₁₅OMA shall be made through a short patch cable between 2 m and 5 m in length.

141.7.1 Insertion loss

Insertion loss for SMF fiber optic cabling (channel) is defined at {TBD, NG-EPON wavelengths}, depending on the particular PMD. A suitable test method is described in ITU-T G.650.1.

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141.7.2 Allocation for penalties in 100G-EPON PMDs

{TBD}

141.7.3 Test patterns

{TBD}

141.7.4 Wavelength and spectral width measurement

The center wavelength and spectral width (RMS) shall meet the specifications when measured according to TIA-455-127-A under modulated conditions using an appropriate PRBS or a valid 100G-EPON signal, or another representative test pattern.

NOTE—The allowable range of central wavelengths is narrower than the operating wavelength range by the actual RMS spectral width at each extreme.

141.7.5 Optical power measurements

Optical power shall meet specifications according to the methods specified in ANSI/EIA-455-95. A measurement may be made with the port transmitting any valid encoded 256B/257B data stream.

141.7.6 Extinction ratio measurements

The extinction ratio shall meet the specifications when measured according to IEC 61820-2-2 with the port transmitting a repeating idle pattern /12/ ordered set (see 36.2.4.12) or valid 100G-EPON signal, and with minimal back reflections into the transmitter, lower than -20 dB. The test receiver has the frequency response as specified for the transmitter optical waveform measurement.

141.7.7 Optical modulation amplitude (OMA) test procedure

{TBD, depending on whether OMA is used in NG-EPON at all}

141.7.8 Relative intensity noise optical modulation amplitude (RIN_xOMA) measuring procedure

{TBD, need to confirm whether RIN measurements are applicable at all}

141.7.9 Transmit optical waveform (transmit eye)

The required transmitter pulse shape characteristics are specified in the form of a mask of the transmitter eye diagram as shown in {TBD} for upstream direction of 100G-EPON PMD and {TBD} for downstream direction of 100G-EPON PMD.

{TBD}

141.7.10 Transmitter and dispersion penalty (TDP)

TDP measurement tests transmitter impairments, including chromatic dispersion effects, due to signal propagation in SMF used in PON. Possible causes of impairment include intersymbol interference, jitter, and RIN. Meeting the separate requirements (e.g., eye mask, spectral characteristics) does not in itself guarantee the TDP. The TDP limit shall be met. For 10 Gb/s PHYs, TDP is measured as defined in 52.9.10 with an optical channel that meets the requirements listed in {TBD}.

{TBD, if we end up using modulation which relies on ISI, we may have to update the text in this section quite a bit, to specify the minimum ISI level that is required and maximum allowable ISI levels. To be updated when more details of the PHY are known}

141.7.11 Receive sensitivity

{TBD}

141.7.12 Stressed receiver conformance test

{TBD}

141.7.13 Jitter measurements

{TBD}

141.7.14 Laser on/off timing measurement

{TBD, individual values will have to be examined and adapted to 100G-EPON}

The laser on/off timing measurement procedure is described in 141.TBD with the following changes:

- a) T_{on} is defined in 141.TBD, and its value is less than 512 ns (defined in Table 141-TBD).
- b) $T_{receiver_settling}$ is defined in 141.TBD, and its value is defined in Table 141-TBD.
- c) T_{CDR} is defined in 142.TBD, and its value is less than 400 ns.
- d) $T_{code_group_align}$ is defined in 36.3.2.4, and its value is less than 4 ten bit code-groups for 1 Gb/s PHYs, and is defined as 0 for 10 Gb/s PHYs.
- e) T_{off} is defined in 141.TBD, and its value is less than 512 ns (defined in Table 141-TBD).

Editorial Note (to be removed prior to publication): note that refercnes to Tables and subclauses are TBD at this time. Once the decisions on 10Gb/s PHY is made and parameters are established, we can decide whether back references to 10G-EPON are appropriate or not.

141.7.15 Receiver settling timing measurement

141.7.15.1 Definitions

$T_{receiver_settling}$ is denoted as the time beginning from the time that the optical power in the receiver at TP7 reaches the conditions specified in 141.7.12 and ending at the time that the electrical signal after the PMD at TP8 reaches within 15 % of its steady state parameterverage power, jitter) (see {TBD}). $T_{receiver_settling}$ is presented in **Figure <TBD>**. The data transmitted may be any valid 256B/257B symbols (or a specific power synchronization sequence). The optical signal at TP7, at the beginning of the locking, may have any valid 256B/257B pattern, optical power level, jitter, or frequency shift matching the standard specifications.

Editorial Note (to be removed prior to publication): a figure representing individual parameters discussed in 141.7.14 will be inserted (contributions are needed).

141.7.15.2 Test specification

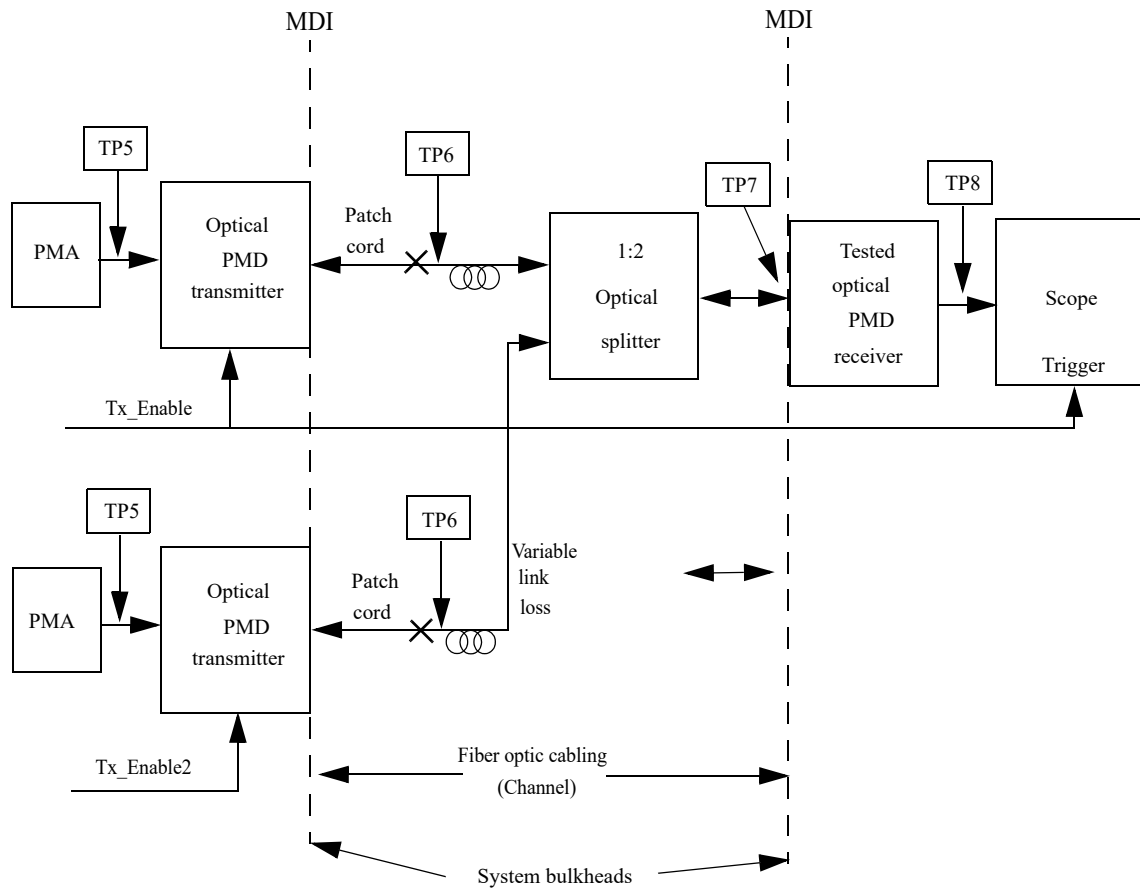


Figure 141-3—Receiver settling time measurement setup

Figure 141-3 illustrates the test setup for the OLT PMD receiver (upstream) $T_{\text{receiver_settling}}$ time. The optical PMD transmitter has well-known parameters, with a fixed known T_{on} time. After T_{on} time the parameters of the reference transmitter, at TP6 and therefore at TP7, reach within 15% of its steady state values as specified in {TBD}.

Define $T_{\text{receiver_settling}}$ time as the time from the Tx_Enable assertion, minus the known T_{on} time, to the time the electrical signal at TP8 reaches within 15% of its steady state conditions.

Conformance should be assured for an optical signal at TP7 with any level of its specified parameters before the Tx_Enable assertion. Especially the $T_{\text{receiver_settling}}$ time must be met in the following scenarios:

- Switching from a ‘weak’ (minimal received power at TP7) ONU to a ‘strong’ (maximal received power at TP7) ONU, with minimal guard band between.
- Switching from a ‘strong’ ONU to a ‘weak’ ONU, with minimal guard band between.
- Switching from noise level, with maximal duration interval, to ‘strong’ ONU power level.

A non-rigorous way to describe this test setup would be (using a transmitter with a known T_{on}).

For a tested PMD receiver with a declared $T_{\text{receiver_settling}}$ time, measure all PMD receiver electrical parameters at TP8 after $T_{\text{receiver_settling}}$ from the TX_ENABLE trigger minus the reference transmitter T_{on} , reassuring conformance to within 15% of its specified steady state values.

141.8 Environmental, safety, and labeling

141.8.1 General safety

All equipment subject to this clause shall conform to IEC 60950–1.

141.8.2 Laser safety

100G-EPON optical transceivers shall conform to Hazard Level 1 laser requirements as defined in IEC 60825–1 and IEC 60825–2, under any condition of operation. This includes single fault conditions whether coupled into a fiber or out of an open bore.

Conformance to additional laser safety standards may be required for operation within specific geographic regions.

Laser safety standards and regulations require that the manufacturer of a laser product provide information about the product’s laser, safety features, labeling, use, maintenance, and service. This documentation explicitly defines requirements and usage restrictions on the host system necessary to meet these safety certifications.

141.8.3 Installation

It is recommended that proper installation practices, as defined by applicable local codes and regulation, be followed in every instance in which such practices are applicable.

141.8.4 Environment

The 100G-EPON operating environment specifications are as defined in 52.11, as defined in 52.11.1 for electromagnetic emission, and as defined in 52.11.2 for temperature, humidity, and handling.

See Annex 67A for additional environmental information. Two optional temperature ranges are defined in Table 60–18. Implementations shall be declared as compliant over one or both complete ranges, or not so declared (compliant over parts of these ranges or another temperature range).

141.8.5 PMD labeling

The 100G-EPON labeling recommendations and requirements are as defined in 52.12.

Defined PMDs are as follows:

- {list NG-EPON PMDs}

Each field-pluggable component shall be clearly labeled with its operating temperature range over which compliance is ensured.

141.9 Characteristics of the fiber optic cabling

The fiber optic cabling shall meet the dispersion specifications defined in Table 141–15. The fiber optic cabling consists of one or more sections of fiber optic cable and any intermediate connections required to connect sections together. It also includes a connector plug at each end to connect to the MDI. The fiber optic cabling spans from one MDI to another MDI, as shown in Figure 141–2.

141.9.1 Fiber optic cabling model

The fiber optic cabling model is shown in Figure 141–2.

NOTE—The optical splitter presented in Figure 141–2 may be replaced by a number of smaller 1:n splitters such that a different topology may be implemented while preserving the link characteristics and power budget as defined in Table 75B–1 and Table 75B–2.

The maximum channel insertion losses shall meet the requirements specified in Table 141–1. Insertion loss measurements of installed fiber cables are made in accordance with IEC 61280–4–2:2000. The fiber optic cabling model (channel) defined here is the same as a simplex fiber optic link segment. The term *channel* is used here for consistency with generic cabling standards.

141.9.2 Optical fiber and cable

The fiber optic cable requirements are satisfied by the fibers specified in IEC 60793-2-50 Type B1.1 (dispersion un–shifted SMF), Type B1.3 (low water peak SMF), and Type B6 (bend-insensitive SMF); ITU–T G.652 and ITU–T G.657 (bend-insensitive SMF).

141.9.3 Optical fiber connection

Table 141–15—Optical fiber and cable characteristics

Description ^a	IEC 60793-2-50 B.1.1, B1.3, and B6 SMF; ITU–T G.652 and G.657 SMF ^b				Unit
Nominal wavelength ^c					nm
Cable attenuation (max) ^d					dB/km
Zero dispersion wavelength ^e	1300≤λ ₀ ≤1324				nm
Dispersion slope (max)	0.093				ps/nm ² · km

^aThe fiber dispersion values are normative, all other values in the table are informative.

^bOther fiber types are acceptable if the resulting ODN meets channel insertion loss and dispersion requirements.

^cWavelength specified is the nominal wavelength and typical measurement wavelength. Power penalties at other wavelengths are accounted for.

^dAttenuation 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 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.

^eSee IEC 60793 or ITU–T G.652.

An optical fiber connection as shown in Figure 141–2 consists of a mated pair of optical connectors. The 100G-EPON PMD is coupled to the fiber optic cabling through an optical connection and any optical splitters into the MDI optical receiver, as shown in Figure 141–2. The channel insertion loss includes the loss for connectors, splices and other passive components such as splitters, including splitters specified in IEC 61753-031-3.

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 141–15. 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 within the limits specified in Table 141–1 and the maximum reach in Table 141–1 is not exceeded. Other fiber arrangements (e.g., increasing the split ratio while decreasing the fiber length) are supported as long as the limits for the channel insertion loss specified in Table 141–1 are observed.

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

141.9.4 Medium Dependent Interface (MDI)

The 100G-EPON 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 141–2. Examples of an MDI include the following:

- 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 100G-EPON PMD and couples to a single fiber.

NOTE—Compliance testing is performed at TP2 and TP3 as defined in 141.3.2, not at the MDI.

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141.10 Protocol implementation conformance statement (PICS) proforma for Clause 141, clause title¹

141.10.1 Introduction

The supplier of a protocol implementation that is claimed to conform to Clause 141, clause title, shall complete the following protocol implementation conformance statement (PICS) proforma.

A detailed description of the symbols used in the PICS proforma, along with instructions for completing the PICS proforma, can be found in [Clause 21](#).

141.10.2 Identification

141.10.2.1 Implementation identification

Supplier ¹	
Contact point for enquiries about the PICS ¹	
Implementation Name(s) and Version(s) ^{1,3}	
Other information necessary for full identification—e.g., name(s) and version(s) for machines and/or operating systems; System Name(s) ²	
NOTE 1—Required for all implementations. NOTE 2—May be completed as appropriate in meeting the requirements for the identification. NOTE 3—The terms Name and Version should be interpreted appropriately to correspond with a supplier’s terminology (e.g., Type, Series, Model).	

141.10.2.2 Protocol summary

Identification of protocol standard	IEEE Std 802.3xx-201x, Clause 141, clause title
Identification of amendments and corrigenda to this PICS proforma that have been completed as part of this PICS	
Have any Exception items been required? No [] Yes [] (See Clause 21 ; the answer Yes means that the implementation does not conform to IEEE Std 802.3xx-201x.)	

Date of Statement	
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141.10.3 Major capabilities/options

141.10.4 PICS proforma tables for clause title

141.10.4.1 PMD functional specifications

¹Copyright 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.

Item	Feature	Subclause	Value/Comment	Status	Support
					Yes [] No []
					Yes []

Item	Feature	Subclause	Value/Comment	Status	Support
					Yes []
					Yes [] No []
					Yes [] No [] N/A []

141.10.4.2 Management functions

Item	Feature	Subclause	Value/Comment	Status	Support
					Yes [] N/A []
					Yes [] No [] N/A []

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