Serial EDC Proposal for 10GBASE-LRM

Working Document

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1. Physical medium dependent (PMD) sublayer type 10GBASE-LRM (long wavelength, 64B/66B coding, multimode fiber)

1.1 Overview

This clause specifies the PMD for the 10GBASE-LRM serial PHY for multimode fiber. In order to form a complete Physical Layer, this PMD is combined with the 10GBASE-R physical sublayer, as described in 52.1.1 and 52.1.2, and optionally with the management functions that may be accessible through the management interface defined in 45 and 52.1.3.

1.1.2 Positioning of this PMD set within the IEEE 802.3 architecture

Figure 1–1 depicts the relationships of the PMD (shown hatched) with other sublayers and the ISO/IEC Open System Interconnection (OSI) reference model.

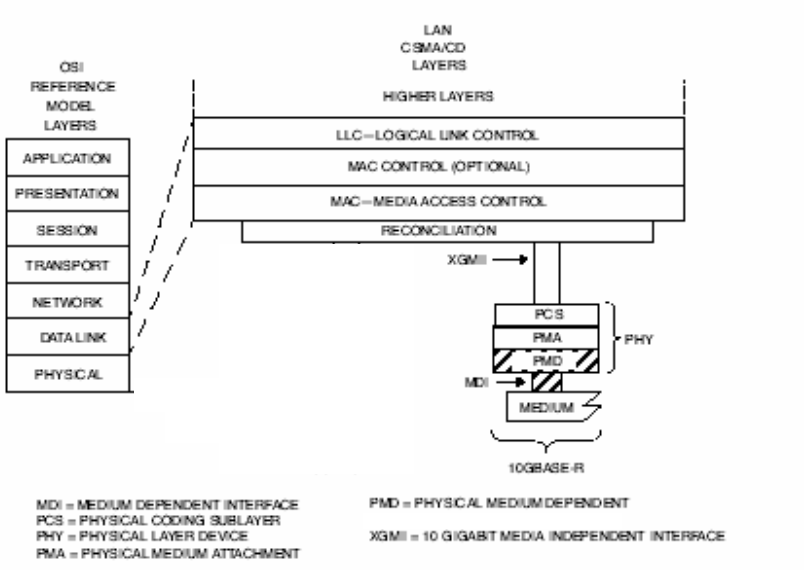

Figure 1-1 – 10GBASE-LRM PMD relationship to the ISO/IEC Open Systems Interconnection (OSI) reference model and the IEEE 802.3 CSMA/CD LAN model

1.1.3 Terminology and conventions

The following list contains references to terminology and conventions used in this clause:

Basic terminology and conventions, see 1.1 and 1.2.

Normative references, see 1.3.

Definitions, see 1.4.

Abbreviations, see 1.5.

Informative references shown referenced in the format [Bn], see Annex A.

Introduction to 10 Gb/s baseband network, see Clause 44.

1.2 PMD functional specifications

The 10GBASE-LRM PMD performs the transmit and receive functions that convey data between the PMD service interface and the MDI.

1.2.1 PMD block diagram

For the purposes of 10GBASE-LRM PMD conformance testing, two test points are defined, as shown in Figure 1-2. TP2 enables PMD transmitter optical output measurements. TP3 enables an optical stimulus to be applied to the PMD receiver input.

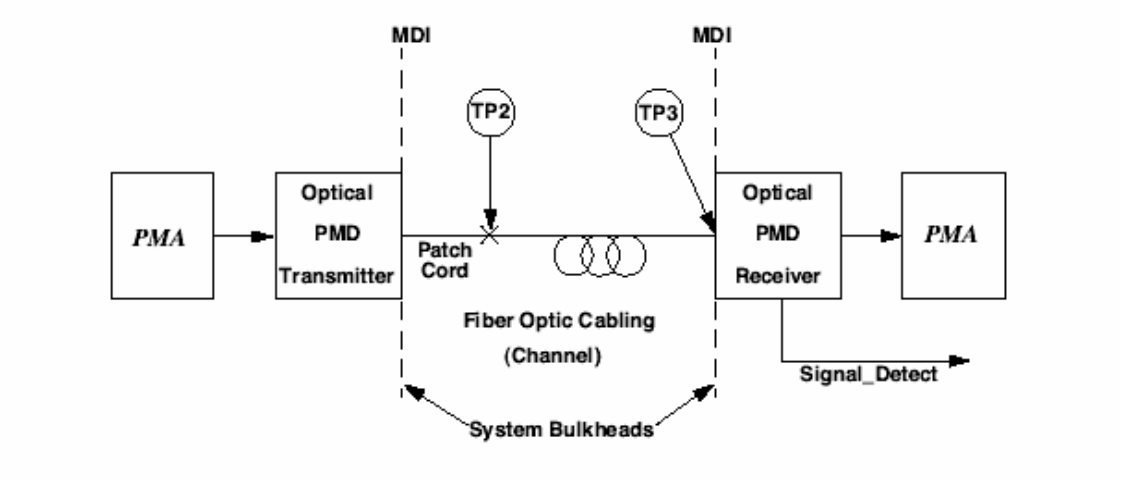

Figure 1-2 - Block Diagram

1.2.2 PMD transmit function

The PMD Transmit function shall convey the bits requested by the PMD service interface message PMD_UNITDATA.request(tx_bit) to the MDI according to the optical specifications in this clause. The higher optical power level shall correspond to tx_bit = ONE.

1.2.3 PMD receive function

The PMD Receive function shall convey the bits received from the MDI according to the optical specifications in this clause to the PMD service interface using the message PMD_UNITDATA.indicate(rx_bit) to the MDI according to the optical specifications in this clause. The higher optical power level shall correspond to rx_bit = ONE.

1.2.4 PMD Signal Detect function

The PMD Signal Detect function shall report to the PMD service interface using the message PMD_SIGNAL.indicate(SIGNAL_DETECT) which is signaled continuously. PMD_SIGNAL.indicate shall be an indicator of optical signal presence.

Various implementation of the Signal Detect function are permitted, including implementations that generate the SIGNAL_DETECT parameter values in response to the amplitude of the modulation of the received optical signal and implementations that respond to the average power of the received optical signal.

Table 1-1 – SIGNAL_DETECT value definition

Receive Conditions	Signal Detect value
Input optical power in OMA ≤ -30 dBm	FAIL
Input optical power in OMA ≥ Receiver power in OMA (min) in Table 1-4.	OK
All other conditions	Unspecified

The PMD receiver is not required to verify whether a compliant 10GBASR-LRM signal is being received. This standard imposes no response time requirements on the generation of the SIGNAL_DETECT parameter.

1.3 Delay constraints

An upper bound to the delay through the PMA and PMD is required for predictable operation of the MAC Control PAUSE operation. The PMA and PMD shall incur a round-trip delay (transmit and receive) of not more than 512 bit-times, or 1 pause_quantum, including 2 meters of fiber. A description of overall system delay constraints and the definitions for bit_times and pause_quanta can be found in 44.3.

1.4 PMD to MDI optical specifications

An optical fiber link is considered operational if it meets all of the 10GBASE-LRM specifications, including BER of no more than 10^{-12}.

The operating ranges are given in Table 1-2

A PMD that exceeds the operational range requirements specified in this clause, while meeting all other specifications, is considered compliant.

Table 1-2 – 10GBASE-LRM operating ranges

Multimode Fiber type	Minimum overfilled launch modal bandwidths at 850 nm and 1300 nm (MHz.km)[a]	Operating range (m)
62.5 μm	160/500 and 200/500	0.5 to 220
50 μm	400/500 and 500/500	0.5 to 220
50 μm	1500/500	300

[a]Pairs of bandwidth values, separated by "/", are for 850 nm and 1300 nm respectively.

1.4.1 10GBASE-LRM transmitter optical specification

The 10GBASE-LRM transmitter shall meet the specifications defined in Table 1-3 per measurement techniques defined in 1.5 for test point TP2.

Table 1-3 – 10GBASE-LRM transmit characteristics

Description	Type	Value	Unit
Signaling speed	nominal	10.3125	GBd
Signaling speed variation from nominal	max	± 100	ppm
Center wavelength	range	1260 to 1355	nm
RMS spectral width[a]	max	5	nm
Launch power in OMA	max	+1.5	dBm
Launch power in OMA	min	-4.5	dBm
Extinction ratio	min	3.5	dB
Average launch power	max	0.5	dBm
Average launch power[b] (informative)	min	-7.5	dBm
Average launch power of OFF transmitter	max	-30	dBm
$RIN_{12}OMA$ (max)	max	-128	dB/Hz
Transmitted eye mask definition {X1, X2, X3, Y1, Y2, Y3}[c]		{0.25, 0.40, 0.45, 0.25, 0.28, 0.40} TBC	
Encircled flux for use with 50 μm fiber		> 86 % in 19 μm radius < 30 % in 4.5 μm radius	
Encircled flux for use with 62.5 μm fiber		> 86 % in 24 μm radius < 30 % in 4.5 μm radius	
Optical return loss tolerance	max	12	dB
Transmitter reflectance[d]	max	-12	dB

[a]RMS spectral width is the standard deviation of the spectrum.

[b]This standard imposes no requirement on average launch power (min). However, for information, the average launch power (min) follows from the implemented extinction ratio together with the transmitted OMA (min) requirement. Example 1) An extinction ratio of 3.5 dB implies an average launch power (min) of -3.3 dBm. Example 2) An extinction ratio of 10 dB implies an average launch power (min) of -6.6 dBm.

[c]Definition of the eye mask parameters is given in 1.5.2.2

[d]Transmitter reflectance is defined looking into the transmitter.

1.4.2 10GBASE-LRM receiver optical specification

The 10GBASE-LRM receiver shall meet the specifications defined in Table 1-4 per measurement techniques defined in 1.5.3, for test point TP3.

Table 1-4 – 10GBASE-LRM receive characteristics

Description	Type	Value	Unit
Signaling speed	nominal	10.3125	GBd
Signaling speed variation from nominal	max	±100	ppm
Center wavelength	range	1260 to 1355	nm
Received power in OMA	max	+1.5	dBm
Received power in OMA[a]	min	-6.9	dBm
Static stressed receiver sensitivity in OMA[b]	max	-7.6 (TBC)	dBm
Clock sinusoidal jitter frequency	-	TBD	MHz
Clock sinusoidal jitter amplitude	-	TBD	UI
Sinusoidal interferer frequency	-	TBD	MHz
Sinusoidal interferer amplitude	-	TBD	dB
ISI generator amplitudes{A_1, C, A_2}	-	TBD	-
ISI generator differential delay, ΔT	-	TBD	ps
Simple stressed receiver sensitivity in OMA[c] (informative)	max	-8.5 (TBC)	dBm
ISI generator amplitudes{A_1, C, A_2}	-	TBD	-
ISI generator differential delay, ΔT	-	TBD	ps
Dynamic stressed receiver sensitivity in OMA[d]	max	-8.1 (TBC)	dBm
OR			
Dynamic receiver penalty in OMA[d]	max	0.5 (TBC)	dB
ISI generator amplitudes{A_1, C, A_2}	-	TBD	-
ISI generator differential delay, ΔT	-	TBD	ps
Average receive power[e]	max	0.5	dBm
Average received power (informative)[f]	min	-9.9	dBm

Receiver reflectance	max	-12	dB

[a]Received power in OMA (min) is used in the signal detect function specification. It does not define receiver sensitivity. A received power in OMA below this value cannot be compliant; however, a value above this does not ensure compliance.

[b] Static stressed receiver test is described in 1.5.3.1

[c] Simple stressed receiver test is described in 1.5.3.2

[dc] Dynamic stressed receiver test is described in 1.5.3.3

[e] The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having a power level equal to the average receive power (max) plus at least 1 dB.

[f]Average receive power (min) is informative and does not define receiver sensitivity. An average received power below this value cannot be compliant; however, a value above this does not ensure compliance.

1.4.3 10GBASE-LRM link power budget (informative)

An example link power budget and penalties for a 10GBASE-LRM channel are shown in Table 1-5

Table 1-5 – Example 10GBASE-LRM link power budget for 220m

Parameter	Value (dB)
Fiber attenuation	0.4
Connector losses	2
Receiver dynamic adaptation budget	0.5
“Consequent” penalty	0.2
Modal noise	0.5
RIN	0.4

The attenuation budget allows for 220 m with an attenuation coefficient of 1.5 dB/km.

The connector losses budget allows for up to four connectors with 0.5 dB loss per connector.

1.5 10GBASE-LRM optical measurement methods

1.5.1 OMA measurements

Both transmitter and receiver compliance tests involve OMA measurements. The relationship between OMA, extinction ratio and average power is described in 58.7.6. Figure 1-3 illustrates the region of transmitter compliance and also the relationship between OMA, average power and extinction ratio.

The OMA measurement method is as follows …

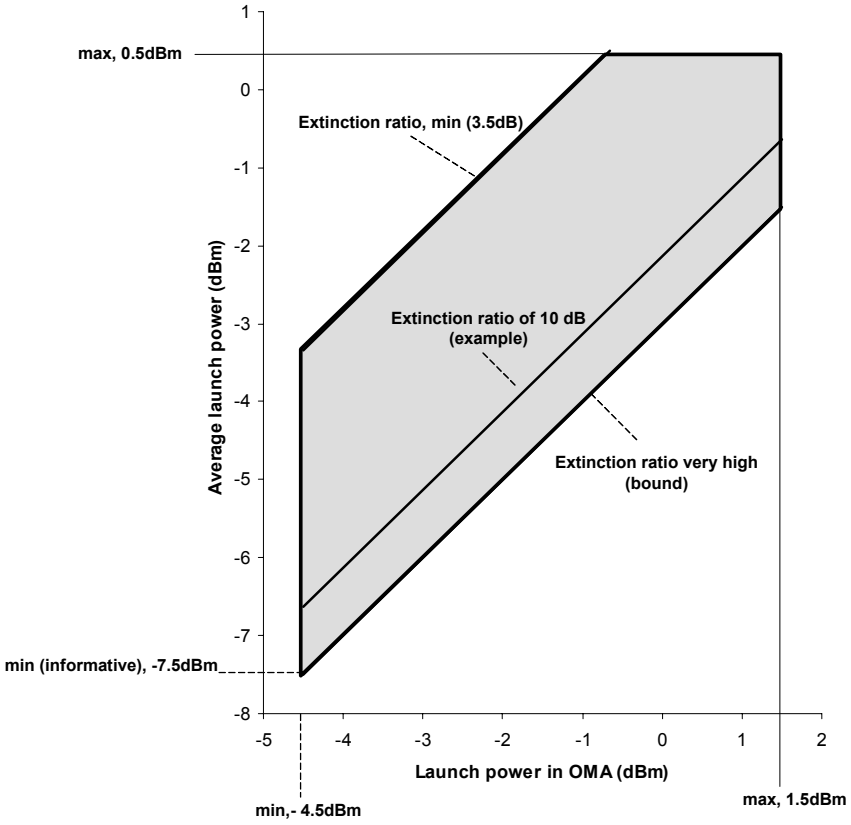

Figure 1-3 – Region of transmitter compliance (shown shaded).

1.5.2 Transmitter measurements

1.5.2.2 Transmitter optical waveform

The transmitter optical waveform is specified using the eye mask definition. The details of set-up and measurement method are given in 52.9.7. Figure 1-4 illustrates the meanings of the parameters used in the specification.

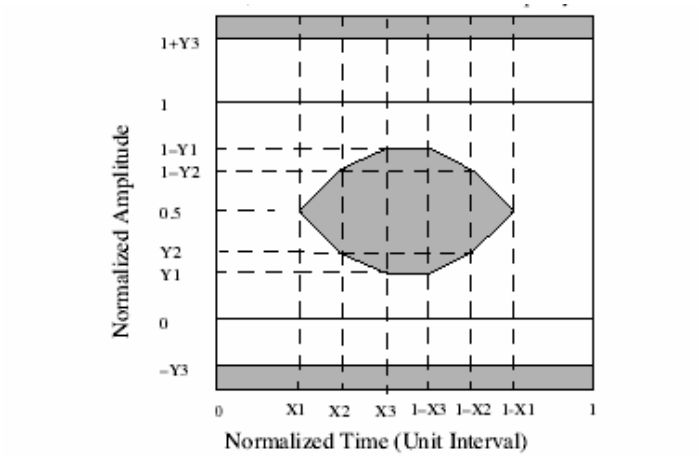

Figure 1-4 – Transmitter eye mask definition

1.5.2.3 Launch optical encircled flux measurements

The encircled flux measurement method is described in XXXX. Figure 1-5 illustrate the measurement method and specifications. To accommodate center launch integrated optics, the two tests described here may be performed using 50 μm and 62.5 μm offset launch patch cords. For transmitters with integrated encircled flux compliant launch optics, standard 50 μm and 62.5 μm patch cords are appropriate.

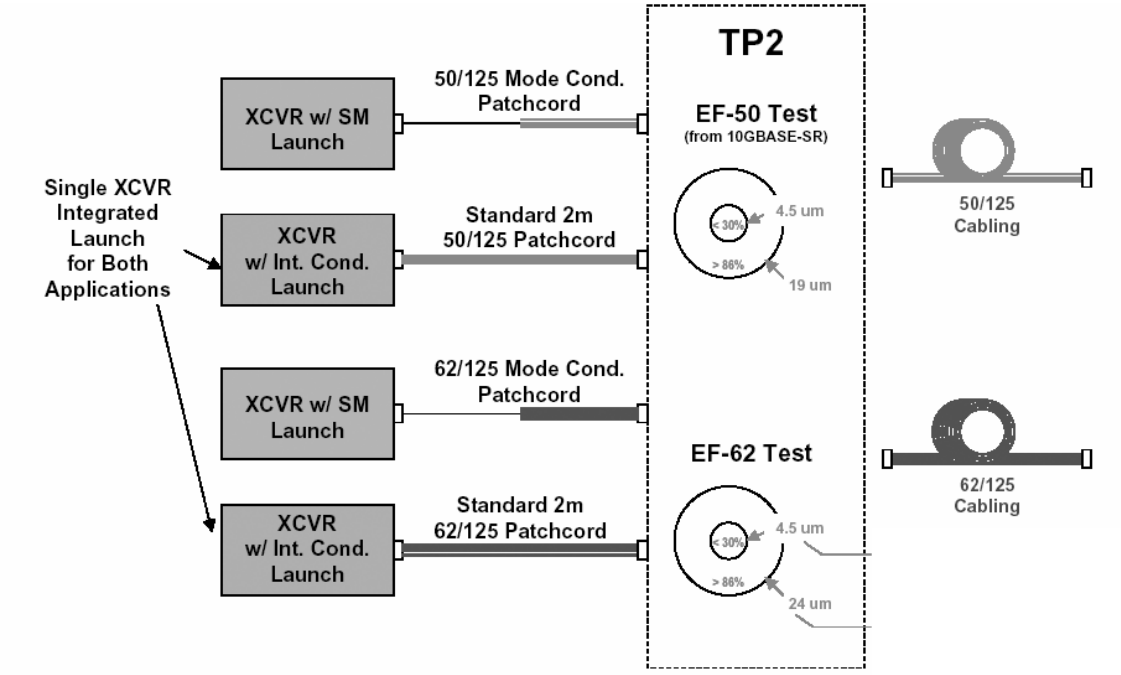

Figure 1-5 – Launch optical encircled flux measurements

1.5.2.4 Relative intensity noise optical modulation amplitude (RIN_xOMA)

The relative intensity noise optical modulation amplitude (RIN_xOMA) measuring procedure to be defined. [References 58.7.7 and 52.9.6]

1.5.3 Receiver measurements

Figure 1-6 gives the block diagram for the following stressed receiver sensitivity tests. These compliance tests require BER performance of 10^{-12} or better.

The test set-up procedure is as follows ….

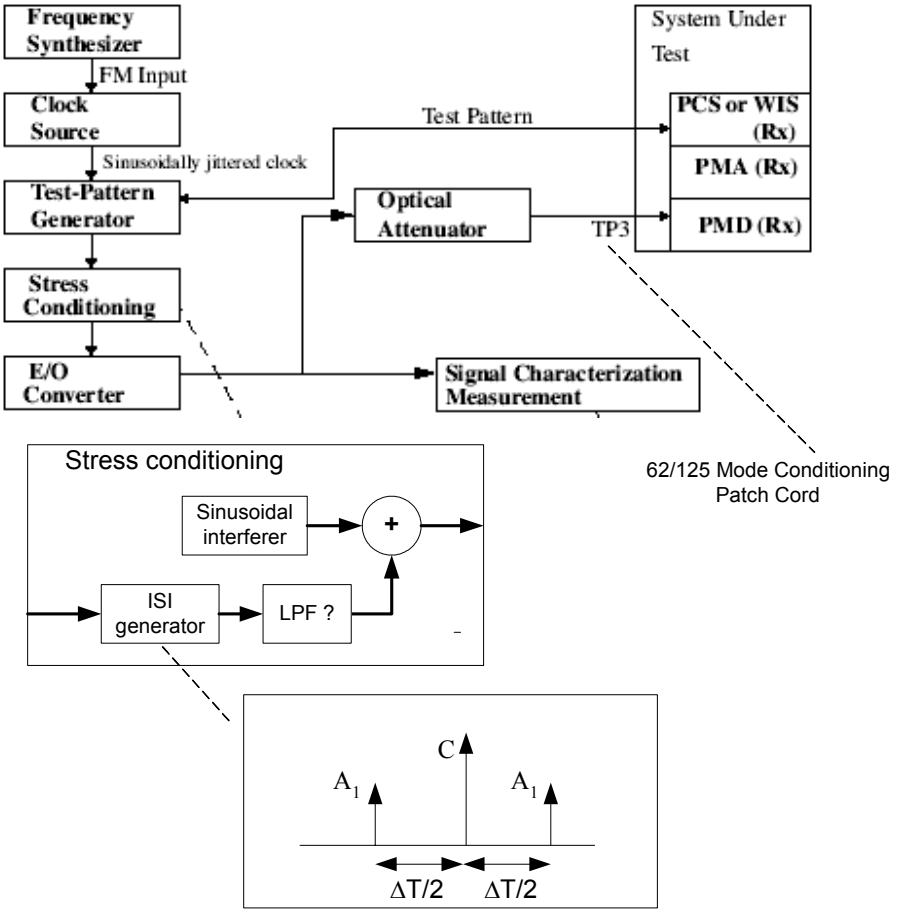

Figure 1-6 – Stressed receiver sensitivity test block diagram

1.5.3.1 Static stressed receiver test

1.5.3.2 Static stressed receiver test

1.5.3.3 Static stressed receiver test