100G PSM4 Specification

Parallel Single Mode 4 lane

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3/5/2014

Revision 1.0

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Revision History:

Draft	Date	Revised Item
1.0	March 5 2014	Initial Public Release

100G PSM4 Specification

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1. Introduction

The 100G PSM4 Specification provides a low cost solution to long reach data center optical interconnects. The growth in data center size along with the increased data rates of optical interconnects has created a need for low cost solutions capable of at least 500m reach. The 100G PSM4 Specification is targeted to service that need on a parallel single mode infrastructure, as a critical need of next generation data centers.

This specification defines a four lane (per direction) 100 Gb/s optical interface to single mode fiber (SMF) media. As shown in Figure 1, the 100G PSM4 Transceiver Module (100G PSM4 Module) provides Transmit Optics and Receive Optics between the Host IC and the fiber optic media. A particular form factor, e.g. QSFP28 or CFP4, is not defined and the 100G PSM4 Transceiver Module may be implemented in various form factors. Since management and control interfaces are form factor dependent, definition of these interfaces are outside the scope of this specification.

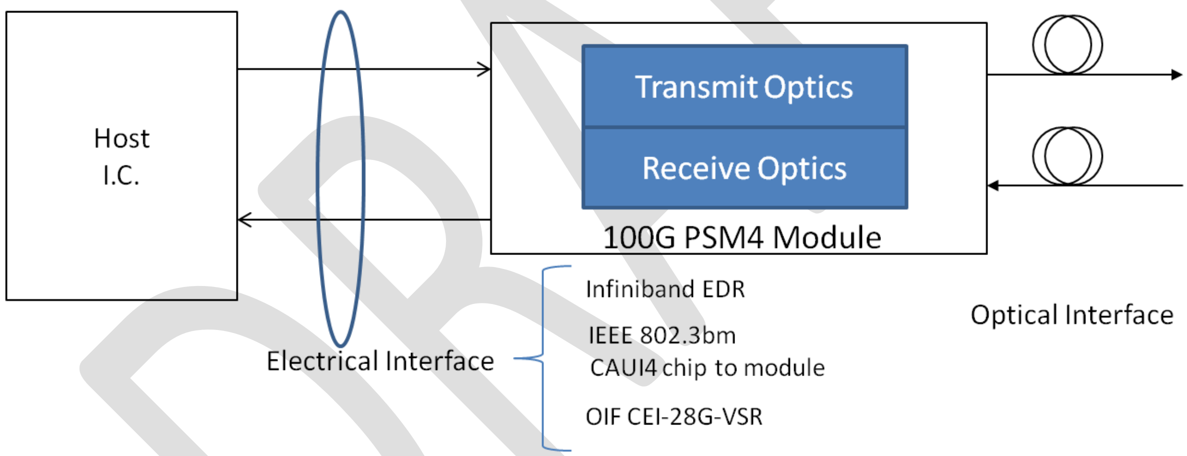

Figure 1: PSM4 system block diagram

The 100G PSM4 Specification defines requirements for a point-to-point 100 Gb/s link over eight single mode fibers up to at least 500 m. Four identical and independent lanes are used for each signal direction. Table 1 shows the primary attributes of the 100G PSM4 Specification.

Table 1: Summary of PSM4

Parameter	Value	Units
Fiber type	Single Mode	
Number of fibers	8	
Nominal wavelength	1310	nm
Required operating range	2-500	m
Signaling rate, each lane	25.78125	GBd

PSM4 uses four identical lanes per direction. The electrical connections from the module to the host can be done using standard specific designs. Examples would be CAUI-4 (four electrical lanes with a 10dB host channel). See Fibre Channel FC-PI-6p for operation at 28Gbps over four electrical lanes with a 15dB host channel.

2. References

IEEE 802.3bm Annex 83E (CAUI-4 chip to module)

IEEE 802.3bj Clause 91 (RS-FEC)

OIF CEI-28G-VSR

Infiniband EDR

QSFP: SFF-8665

CDFP

CFP2

CFP4

TIA-604-5D

FC-PI6p

3. 100G PSM4 functional specifications

The 100G PSM4 Module provides a bi-directional electrical interface with the Host and a bi-directional optical interface with the fiber media. It performs Transmit and Receive functions that convey data between the Host and the media.

3.1 100G PSM4 Transmit/Receive block diagram

A 100G PSM4 Transmit/Receive block diagram is shown in Figure 2. The electrical and optical interface compliance points are identified as TP1 for the electrical input signals, TP2 for the optical output signal, TP3 for the optical input signal and TP4 for the electrical output signal. Reference test fixtures/compliance boards, are used to access the electrical signals for parametric measurements. The electrical signals, compliance boards and measurements are beyond the scope of this specification and the reader is referred to the appropriate specification, e.g. OIF CEI-28G-VSR or 802.3 Annex 83E. It is not required that the compliance points are exposed or measurable as defined, however, if not, a conforming implementation must behave as though the interfaces are compliant. The optical transmit signal is defined at the output end of a singlemode fiber patch cord (TP2), between 2 m and 5 m in length. Unless specified otherwise, all optical transmitter measurements and tests defined in section 5.1 are made at TP2. The optical receive signal is defined at the output of the fiber optic cabling (TP3). Unless specified otherwise, all optical receiver measurements and tests defined in section 5.2 are made at TP3.

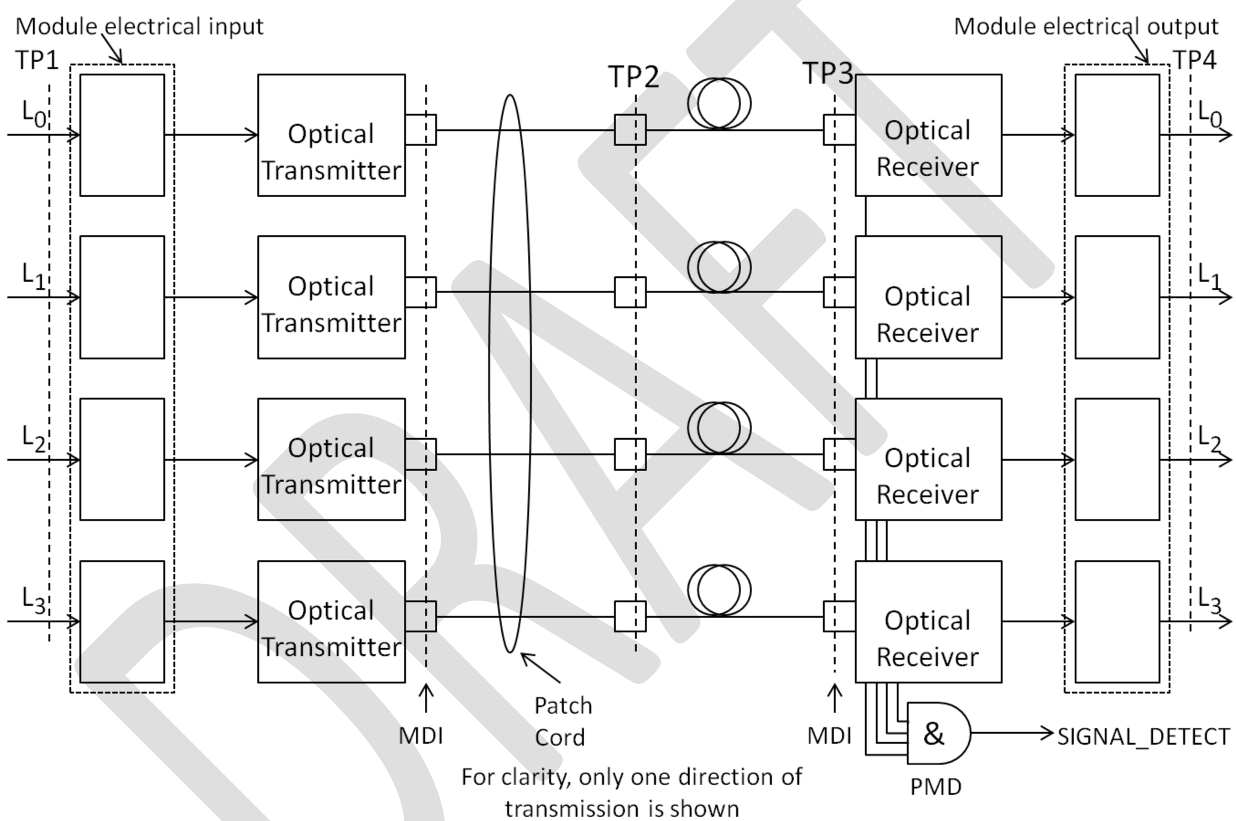

Figure 2: Block diagram for PSM4 transmit/receive path

3.2 100G PSM4 transmit function

The 100G PSM4 Transmit function shall convert the four electrical signals received from the host into the same number of optical signals. The optical signals are delivered to a fiber media that contains four parallel light paths for transmit, according to the transmit optical requirements in this specification. Higher optical power level in each signal stream shall correspond to tx_bit = one

3.3 100G PSM4 transmit disable function

The TX_DISABLE function is a global parameter that disables the transmission of optical signals on all output optical ports and puts all of the optical outputs in the 'off' state. The TX_DISABLE function is initiated via the management interface. The output of the transmitter when presented with the TX_DISABLE request shall meet the requirements of Table 2. This 100G PSM4 Specification imposes no response time requirements on the transmit function when presented with the transmit disable request.

3.4 100G PSM4 transmit fault function

The 100G PSM4 TX_FAULT function shall report its state via the management interface. TX_FAULT shall be a global indicator of the state of the transmit output.

3.5 100G PSM4 receive function

The 100G PSM Receive function shall convert the four optical signals received from the fiber media into the same number of electrical signals according to the receive optical requirements in this specification. The higher optical power level in each signal stream shall correspond to rx_bit = one.

3.6 100G PSM4 receive fault function

The 100G PSM4 RX_FAULT function shall report its state via the management interface. RX_FAULT shall be a global indicator of the state of the receiver input.

3.7 100G PSM4 global signal detect function

The 100G PSM4 signal detect function shall report the state of SIGNAL_DETECT via the Management interface. SIGNAL_DETECT shall be a global indicator of the presence of optical signals on all lanes. The value of the SIGNAL_DETECT parameter shall be generated according to the conditions defined in Table 2. The PMD receiver is not required to verify whether a compliant PSM4 signal is being received. This 100G PSM4 Specification imposes no response time requirements on the generation of the SIGNAL_DETECT parameter.

Table 2: SIGNAL_DETECT and TX_DISABLE value definition

Function	Receive conditions	Transmit conditions
SIGNAL_DETECT Fail	For any lane: Average optical power at TP3 ≤ -30 dBm	
SIGNAL_DETECT OK	For each lane: [(Optical power at TP3 ≥ -10.5 dBm	
TX_DISABLE ON		Average Optical power at TP2 < -30 dBm
TX_DISABLE OFF		For all lanes: Optical power at TP2 > minimum OMA

As an unavoidable consequence of the requirements for the setting of the SIGNAL_DETECT parameter, implementations must provide adequate margin between the input optical power level at which the SIGNAL_DETECT parameter is set to OK, and the inherent noise level of the 100G PSM4 including the effects of crosstalk, power supply noise, etc.

Various implementations of the Signal Detect function are permitted by 100G PSM4 Specification, including implementations that generate the SIGNAL_DETECT parameter values in response to the amplitude of the modulation of the optical signal and implementations that respond to the average optical power of the modulated optical signal.

3.8 100G PSM4 lane-by-lane signal detect function

Various implementations of the Signal Detect function are permitted by 100G PSM4 Specification. Each 100G PSM4_signal_detect_*i*, where *i* represents the lane number *in the range 0:3*, shall be continuously set in response to the optical signal on its associated lane, according to the requirements of Table 2.

4. Lane assignments

100G PSM4 provides a fixed relationship between electrical input and optical output lanes and between optical input and electrical output. The electrical input on electrical lane 0 will appear as an optical output on optical lane 0. The positioning of transmit and receive lanes at the optical interface is specified in 10.1

5. Optical interface requirements for 100G PSM4

The required operating range for the PSM4 is defined in Table 3. A compliant 100G PSM4 operates on singlemode fibers according to the specifications of Table 11. A 100G PSM4 which exceeds the operating range requirement while meeting all other optical specifications is considered compliant (e.g., operating at 600 m meets the operating range requirement of 2 m to 500 m). The signaling rate for a lane of a 100G PSM4 shall be as defined in Table 4. The optical signal at the transmit and receive side of the MDI is specified in Tables 4 and 5. Test points are defined in Figure 2.

The bit error ratio (BER) shall be less than 5×10^{-5}. Note for 100G Ethernet applications the error statistics must be sufficiently random that the BER results in an Ethernet frame loss ratio (see IEEE 802.3bj clause 1.4.209a) of less than 6.2×10^{-10} for 64-octet frames with minimum inter-packet gap when processed according to IEEE 802.3bj Clause 91. Note: The use of the IEEE 802.3bj Clause 91 RS-FEC will result in a corrected BER of less than 1×10^{-12}.

Table 3: PSM4 operating range

100G PSM4 type	Required operating range
PSM4	2 m to 500 m

5.1 Transmitter optical specifications

Each lane of a 100G PSM4 optical transmitter shall meet the specifications of Table 4 per the definitions in section 6.

Table 4: 100G PSM4 transmit characteristics

Parameter	Unit	Value
Signaling rate, each lane (range)	GBd	25.78125 +/- 100 ppm
Lane wavelengths (range)	nm	1295 to 1325
Side-mode suppression ratio (SMSR)(min)	dB	30
Total average launch power (max)	dBm	8.0
Average launch power, each lane (max)[a]	dBm	2.0
Average launch power, each lane (min)[b]	dBm	-9.4
Optical Modulation Amplitude (OMA) (max)	dBm	2.2
Transmitter and dispersion penalty (TDP), each lane (max)	dB	3.8
Transmit OMA, each lane (min)	dBm	See section 6.1.1
Average launch power of OFF transmitter, each lane (max)	dBm	-30
Extinction ratio (min)	dB	3.5
Optical return loss tolerance (max)	dB	11.9
Transmitter reflectance (max)[c]	dB	-12
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3}[d]		{0.23,0.34,0.43,0.26,0.36,0.4}

[a] Total average launch power is the combined average launch power from all four lanes.

[b] Average launch power, each lane (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.

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

[d] See Figure 5

5.1.1 Transmitter OMA, each lane (min)

The OMA of each transmit lane shall meet Equation 1 which is illustrated in Figure 3 for both maximum TDP and for TDP less than or equal to 0.8 dB.

$$Tx_{OMA} \geq \text{MAX}\left(-8.65 + \frac{(\lambda - 1310)^2}{100}, -8.05\right) + \text{MAX}\,(TDP, 0.8) \quad \text{dBm}$$

Where

Tx_{OMA} Is the OMA of each transmit lane
λ Is the wavelength of the transmit lane
TDPIs the transmitter and dispersion penalty of the transmit lane

Equation 1: Transmitter OMA

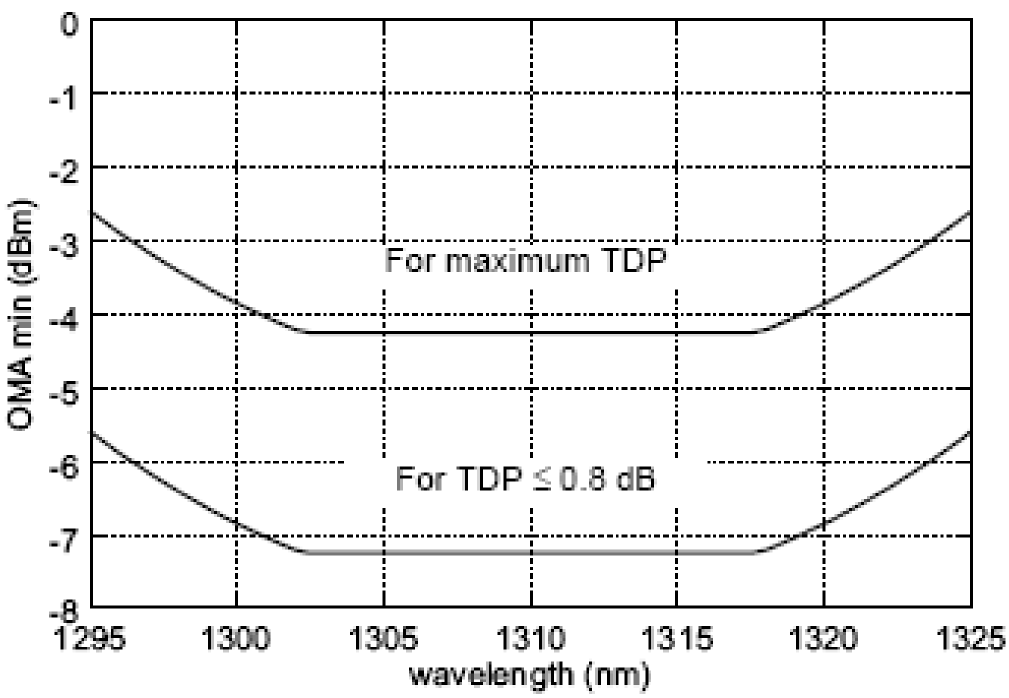

Figure 3: Transmitter minimum OMA

5.2 100G PSM4 receive optical specifications

The 100G PSM4 receiver shall meet the specifications defined in Table 5 per the definitions in section 6

Table 5: 100G PSM4 Receive Characteristics

Parameter	Unit	Value
Signaling rate, each lane (range)	GBd	25.78125 +/- 100 ppm
Lane wavelengths (range)	nm	1295 to 1325
Damage threshold[a]	dBm	3.0
Average receive power, each lane (max)	dBm	2.0
Average receive power, each lane (min)[b]	dBm	-12.66
Receive power, each lane (OMA) (max)	dBm	2.2
Receiver reflectance (max)	dB	-12
Receiver sensitivity (OMA), each lane (max)[c]	dBm	See section 6.2.1
Conditions of stressed receiver sensitivity test:		
Vertical eye closure penalty, each lane	dB	1.2
Stressed eye J2 Jitter, each lane	UI	0.3
Stressed eye J4 Jitter, each lane	UI	0.41
Stressed eye mask definition {X1, X2, X3, Y1, Y2, Y3}[d]		{0.2, 0.34, 0.5, 0.17, 0.32, 0.4}

[a] The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level.
[b] Average receive power, each lane (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.
[c] Receiver sensitivity (OMA), each lane (max) is informative.
[d] See Figure 5

5.2.1 Receiver sensitivity (OMA), each lane (max)

Receiver sensitivity, which is defined for an ideal input signal, is informative and compliance is not required. The receiver sensitivity is given in Equation 2 which is illustrated in Figure 4.

$$Rx_{sens} \leq \mathrm{MAX}\left(-11.89 + \frac{(\lambda - 1310)^2}{100}, -11.4\right) \text{ dBm}$$

where
Rx_sens is the receiver sensitivity (OMA) of each receive lane
λ is center wavelength (in nm).

Equation 2: Receiver sensitivity

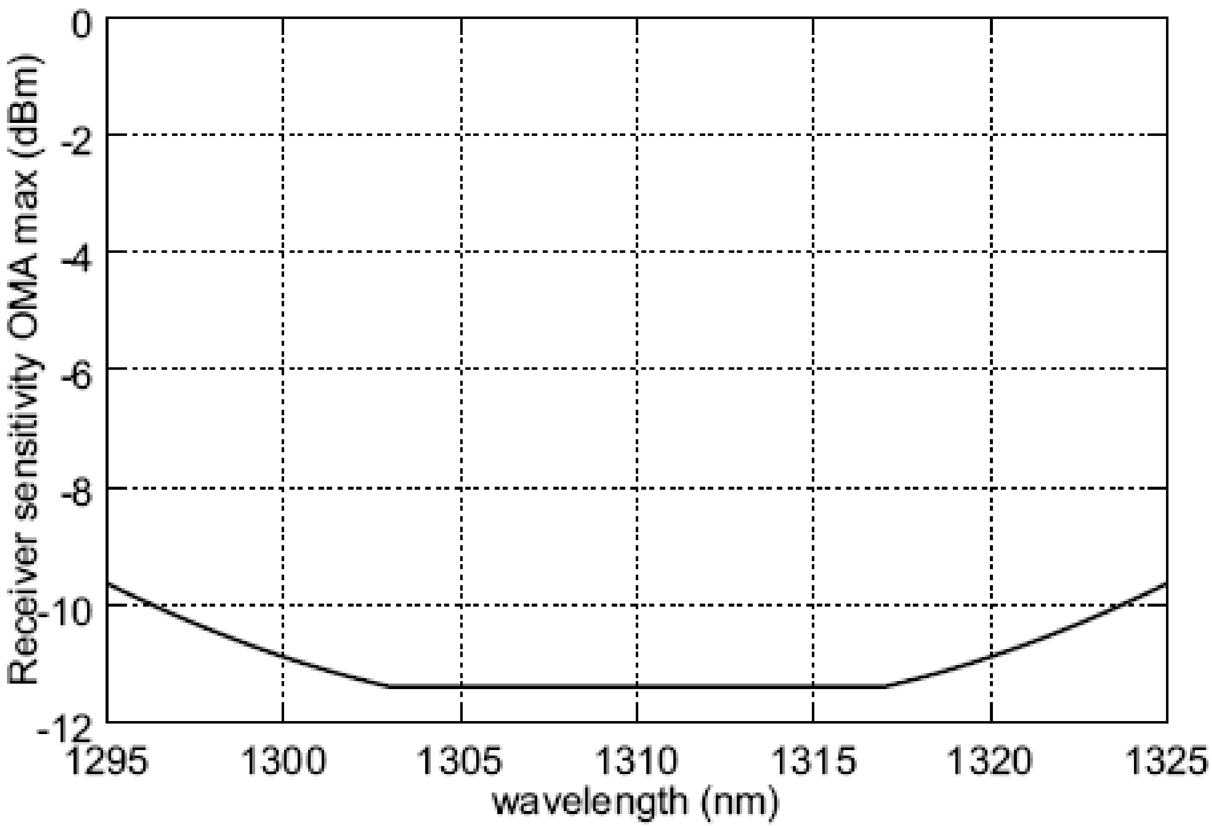

Figure 4: Receiver sensitivity

5.3 100G PSM4 illustrative link power budget

Illustrative power budgets and penalties for 100G PSM4 optical channels are shown in Table 6.

Table 6: 100G PSM4 illustrative link power budget

Parameter	Unit	Value
Power budget (at max TDP)	dB	7.07
Operating distance	m	500
Channel insertion loss (max) [a]	dB	3.26
Maximum discrete reflectance[b]	dB	-35
Allocation for penalties (at max TDP)[c]	dB	3.8
Additional insertion loss allowed	dB	0

[a] Channel insertion loss is calculated using the maximum distance specified in Table 3 and cabled optical fiber attenuation of 0.514 dB/km at 1295 nm plus an allocation for connection and splice loss given in 9.2.1.
[b] Per ISO/IEC 11801
[c] Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.

6. Definitions of optical parameters and measurement methods

All transmitter optical measurements shall be made through a short patch cable, between 2 m and 5 m in length, unless otherwise specified.

6.1 Test patterns for optical parameters

While compliance is to be achieved in normal operation, specific test patterns are defined for measurement consistency and to enable measurement of some parameters. Table 8 gives the test patterns to be used in each measurement, unless otherwise specified, and also lists references to the sections in which each parameter is defined. Any of the test patterns given for a particular test in Table 8 may be used to perform that test. The test patterns used in this specification are shown in Table 7.

Table 7: Test patterns

Pattern no.	Pattern Description	Pattern defined in
Square wave	Square wave (8 ones, 8 zeros)	IEEE 802.3 clause 83.5.10
3	PRBS31	IEEE 802.3 clause 83.5.10
4	PRBS9	IEEE 802.3 clause 83.5.10
5	RS-FEC encoded Scrambled idle*	IEEE 802.3 clause 82.2.10

*The pattern defined in IEEE 802.3 clause 82.2.10 as encoded by IEEE 802.3 Clause 91 RS-FEC for PSM4

Table 8: Test-pattern definitions and related sections

Parameter	Pattern	Related
Wavelength	3,5 or valid 100GBASE-R signal	Section 6.2
Side mode suppression ratio	3,5 or valid 100GBASE-R	-
Average optical power	3,5 or valid 100GBASE-R	Section 6.3
OMA (modulated optical power)	Square wave or 4	Section 6.4
Extinction ratio	3,5 or valid 100GBASE-R	Section 6.6
Transmitted optical waveform (eye mask)	3,5 or valid 100GBASE-R	Section 6.7
TDP (transmitter and dispersion penalty)	3 or 5	Section 6.5
Stressed receiver sensitivity	3 or 5	Section 6.9
Calibration of OMA for receiver tests	Square wave or 4	IEEE 802.3 clause 87.8.11
Vertical eye closure penalty calibration	3 or 5	IEEE 802.3 clause 87.8.11

6.1.1 Multi-lane testing considerations

TDP is defined for each lane, at the BER specified in section 5 on that lane. Stressed receiver sensitivity and receiver jitter tolerance are defined for an interface at the BER specified in section 5. The interface BER is the average of the four BERs of the receive lanes when they are stressed.
Measurements with Pattern 3 (PRBS31) allow lane-by-lane BER measurements. Measurements with Pattern 5 (scrambled idle) give the interface BER if all lanes are stressed at the same time. If each lane is stressed in turn, the BER is diluted by the three unstressed lanes, and the BER for that stressed lane alone must be found, e.g., by multiplying by four if the unstressed lanes have low BER. To allow TDP measurement with Pattern 5, unstressed lanes for the error detector may be created by setting the power at the reference receivers well above their sensitivities, or by copying the contents of the transmit lanes not under BER test to the error detector by other means. For stressed receiver sensitivity and receiver jitter tolerance measurements, unstressed lanes may be created by setting the power at the receiver under test well above its sensitivity and/or not stressing those lanes with ISI and jitter, or by other means. Each receive lane is stressed in turn while all are operated. All aggressor lanes are operated as specified. To find the interface BER, the BERs of all the lanes when stressed are averaged.
Where relevant, parameters are defined with all co-propagating and counter-propagating lanes operational so that crosstalk effects are included. Where not otherwise specified, the maximum amplitude (OMA or VMA) for a particular situation is used, and for counter-propagating lanes, the minimum transition time is used. Alternative test methods that generate equivalent results may be used. While the lanes in a particular direction may share a common clock, the Tx and Rx directions are not synchronous to each other. If Pattern 3 is used for the lanes not under test using a common clock, there is at least 31 UI delay between the PRBS31 patterns on one lane and any other lane.

6.2 Wavelength

The wavelength of each optical lane shall be within the range given in Table 4 if measured per TIA/EIA-455-127-A or IEC 61280-1-3. The lane under test is modulated using the test pattern defined in Table 8.

6.3 Average optical power

The average optical power of each lane shall be within the limits given in Table 4 if measured using the methods given in IEC 61280-1-1. The average optical power is measured using the test pattern defined in Table 8, per the test setup in IEEE 802.3 clause 53 Figure 53-6.

6.4 Optical Modulation Amplitude (OMA)

OMA shall be as defined in IEEE 802.3 clause 52.9.5 for measurement with a square wave (8 ones, 8 zeros) test pattern or IEEE 802.3 clause 68.6.2 (from the variable Measured OMA in IEEE 802.3 clause 68.6.6.2) for measurement with a PRBS9 test pattern.

6.5 Transmitter and dispersion penalty (TDP)

Transmitter and dispersion penalty (TDP) shall be as defined in IEEE 802.3 clause 52.9.10 with the exception that each optical lane is tested individually. The measurement procedure for PSM4 is detailed in 6.5.1 to 6.5.4. The lanes not under test shall be operating with PRBS31 or valid 100GBASE-R bit streams.

6.5.1 Reference transmitter requirements

The reference transmitter is a high-quality instrument-grade device, which can be implemented by a CW laser modulated by a high-performance modulator. The basic requirements are as follows:
a) Rise/fall times of less than 12 ps at 20% to 80%.
b) The output optical eye is symmetric and passes the transmitter optical waveform test of 5.7.
c) In the center 20% region of the eye, the worst-case vertical eye closure penalty as defined in IEEE 802.3 clause 87.8.11.2 is less than 0.5 dB. d) Total Jitter less than 0.2 UI peak-to-peak. e) RIN of less than –140 dB/Hz.
f) Transmitter reflectance less than –50 dB.

6.5.2 Channel requirements

The transmitter is tested using an optical channel that meets the requirements listed in Table 9.

Table 9: Transmitter compliance channel specifications

Dispersion (ps/nm)[a]		Insertion loss[b]	Optical Return loss[c]	Max mean DGD
Minimum	Maximum			
$0.011625x\lambda x[1-(1324 / \lambda)^4]$	$0.011625x\lambda x[1-(1300 / \lambda)^4]$	Minimum	11.9 dB	2.24 ps

[a] The dispersion is measured for the wavelength of the device under test (in nm). The coefficient assumes 500 m for PSM4.

[b] There is no intent to stress the sensitivity of the BERT's optical receiver.

[c] The optical return loss is applied at TP2.

A PSM4 transmitter is to be compliant with a total dispersion at least as negative as the "minimum dispersion" and at least as positive as the "maximum dispersion" columns specified in Table 9 for the wavelength of the device under test. This may be achieved with channels consisting of fibers with lengths chosen to meet the dispersion requirements.

To verify that the fiber has the correct amount of dispersion, the measurement method defined in IEC 60793-1-42 may be used. The measurement is made in the linear power regime of the fiber.

The channel provides an optical return loss specified in Table 9. The state of polarization of the back reflection is adjusted to create the greatest RIN.

The mean DGD of the channel is to be less than the value specified in Table 9.

6.5.3 Reference receiver requirements

The reference receiver is required to have the bandwidth given in section 6.9. The sensitivity of the reference receiver is limited by Gaussian noise. The receiver has minimal threshold offset, deadband, hysteresis, baseline wander, deterministic jitter, or other distortions. Decision sampling has minimal uncertainty and setup/hold times.

The nominal sensitivity of the reference receiver, S, is measured in OMA using the setup shown in IEEE 802.3 Figure 52-12 of clause 52.9.10.3 without the test fiber and with the transversal filter removed. The sensitivity S must be corrected for any significant reference transmitter impairments including any vertical eye closure. It is measured while sampling at the eye center or corrected for off-center sampling. It is calibrated at the wavelength of the transmitter under test.

Center of the eye is defined as the time halfway between the left and right sampling points within the eye where the measured BER is greater than or equal to $1x10^{-3}$

The clock recovery unit (CRU) used in the TDP measurement has a corner frequency of 10 MHz and a slope of 20 dB/decade. When using a clock recovery unit as a clock for BER measurements, passing of low-frequency jitter from the data to the clock removes this low-frequency jitter from the measurement.

6.5.4 Test procedure

The test procedure is as defined in IEEE 802.3 clause 52.9.10.4 with the exception that all lanes are operational in both directions (transmit and receive) and the BER as specified in section 5 has to be met by the lane under test on its own.

6.6 Extinction ratio

The extinction ratio of each lane shall be within the limits given in Table 4 if measured using the methods specified in IEC 61280-2-2. The extinction ratio is measured using the test pattern defined in Table 8.

NOTE—Extinction ratio and OMA are defined with different test patterns (see Table 8)

6.7 Transmitter optical waveform (transmit eye)

The required optical transmitter pulse shape characteristics are specified in the form of a mask of the transmitter eye diagram as shown in Figure 5. The transmitter optical waveform of a port transmitting the test pattern specified in Table 7 shall meet specifications of Table 5 when using a receiver with the fourth-order Bessel-Thomson response having a transfer function given by Equation 3. See Section 6.1.1 for multi-lane test considerations

$$H(y) = \frac{105}{105 + 105y + 45y^2 + 10y^3 + y^4}$$

where:

$$y = 2.114p\ ; \quad p = \frac{j\omega}{\omega_r}\ ; \quad \omega_r = 2\pi f_r\ ; \quad f_r = \text{Reference frequency in GHz}$$

Equation 3: Bessel Thompson Filter transfer function

Normalized times of 0 and 1 on the unit interval scale are determined by the eye crossing means measured at the average value of the eye pattern. A clock recovery unit (CRU) is used to trigger the oscilloscope for mask measurements. It has a high-frequency corner bandwidth of 10 MHz and a slope of –20 dB/decade. The CRU tracks acceptable levels of low-frequency jitter and wander. The filter nominal reference frequency *fr* is 19.34 GHz and the filter tolerances are as specified for STM-64 in ITU-T G.691. The Bessel-Thomson receiver is not intended to represent the noise filter used within a compliant optical receiver, but is intended to provide uniform measurement conditions at the transmitter. Compensation may be made for variation of the reference receiver filter response from an ideal fourth-order Bessel-Thomson response.

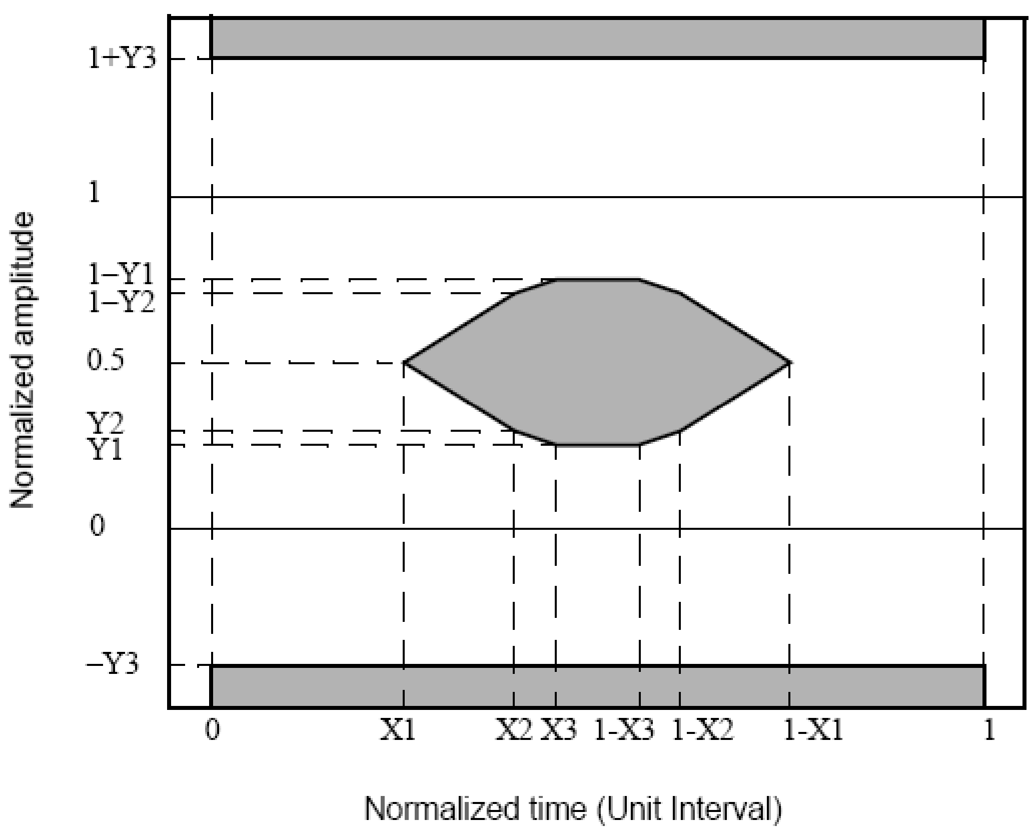

Figure 5: Eye Mask

6.8 Receiver sensitivity

Receiver sensitivity, which is defined for an ideal input signal, is informative and compliance is not required. If measured, the test signal should have negligible impairments such as intersymbol interference (ISI), rise/fall times, jitter and RIN. Instead, the normative requirement for receivers is stressed receiver sensitivity.

6.9 Stressed receiver sensitivity

Stressed receiver sensitivity shall be within the limits given in Table 5 if measured using the method defined in IEEE 802.3-2012 clause 52.9.9 with the conformance test signal at TP3 and with the following exceptions:

a) The reference test procedure for a single lane is defined in 52.9.9. Multi-lane considerations for PSM4 modules are given in Section 6.1.1

b) The sinusoidal jitter is at a fixed 200 MHz frequency and between 0 and 0.05 UI peak-to-peak amplitude.

c) The sinusoidal amplitude interferer is replaced by a Gaussian noise generator.

d) The reference receiver used to verify the conformance test signal is required to have the bandwidth given in 6.9. The fourth-order Bessel-Thomson filter is replaced by a low-pass filter followed by a limiter and a fourth-order Bessel-Thomson filter.

e) The Gaussian noise generator, the amplitude of the sinusoidal jitter, and the Bessel-Thomson filter are adjusted so that the VECP, J2 Jitter and J4 Jitter specifications given in Table 5 are simultaneously met (the random noise effects such as RIN, random clock jitter do not need to be minimized).

f) After making the adjustments in e) the resultant signal is required to pass the mask defined in Figure 5 with a hit ratio of less than 5×10^{-5} using the stressed eye mask coordinates in Table 5.

g) The pattern for the received compliance signal is specified in Table 8.

h) The interface BER of the PMD receiver is the average of the BER of all receive lanes while stressed at the specified receive OMA.

i) Where CAUI-4 is exposed, a PMD receiver is considered compliant if it meets the CAUI-4 module electrical output specifications at TP4.

7. Safety, installation, environment, and labeling

7.1 General safety

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

7.2 Laser safety

PSM4 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.

8. Fiber optic cabling model

The fiber optic cabling model is shown in Figure 6.

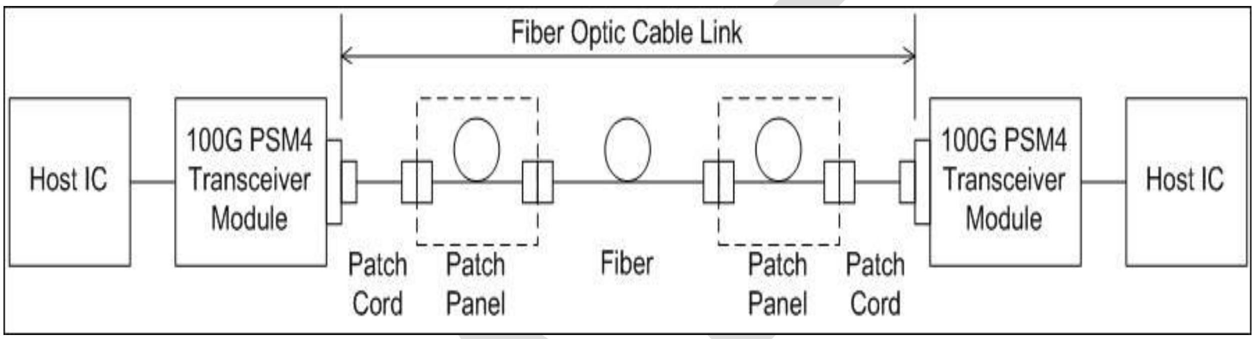

Figure 6: Fiber optic cabling model

The channel insertion loss is given in Table 10. A channel may contain additional connectors as long as the optical characteristics of the channel, such as attenuation, dispersion, reflections, and polarization mode dispersion meet the specifications. Insertion loss measurements of installed fiber cables are made in accordance with ANSI/TIA/EIA-526-7/method A-1. 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.

9. Characteristics of the fiber optic cabling (channel)

The PSM4 fiber optic cabling shall meet the specifications defined in Table 10. The fiber optic cabling consists of one or more sections of fiber optic cable and any intermediate connections required to connect sections together.

Table 10: Fiber optic cabling (Channel) Characteristics for PSM4

Description	Value	Unit
Operating distance(max)	500	m
Positive dispersion (max)	1.2	ps/nm
Negative dispersion (min)	-1.4	ps/nm
Channel insertion loss (max)	3.26	dB
Channel insertion loss (min)	0	dB
DGD_max	2.24	ps
Optical return loss (min)	35	dB

[a] These channel insertion loss values include cable, connectors, and splices.

[b] Over the wavelength range 1295 nm to 1325 nm.

[c] Differential Group Delay (DGD) is the time difference at reception between the fractions of a pulse that were transmitted in the two principal states of polarization of an optical signal. DGD_max is the maximum differential group delay that the system must tolerate.

9.1 Optical fiber cable

The fiber optic cable requirements are satisfied by cables containing IEC 60793-2-50 type B1.1 (dispersion un-shifted single-mode), type B1.3 (low water peak single-mode), or type B6_a (bend insensitive) fibers or the requirements in Table 11 where they differ.

Table 11: Fiber Specifications

Description	Value	Unit
Nominal fiber specification wavelength	1310	nm
Cabled optical fiber attenuation (max)	0.5[a]	dB/·km
Zero dispersion wavelength (λ_0)	$1300 \le \lambda_0 \le 1324$	nm
Dispersion slope (max) (S_0)	0.093	$ps/nm^2 \cdot km$

[a]The 0.5 dB/km attenuation is provided for Outside Plant cable as defined in ANSI/TIA 568-C.3.

9.2 Optical fiber connection

An optical fiber connection, as shown in Figure 5, consists of a mated pair of optical connectors.

9.2.1 Connection insertion loss

The maximum link distance is based on an allocation of 3 dB total connection and splice loss. For example, this allocation supports six connections with an average insertion loss per connection of 0.5 dB. Connections with different loss characteristics may be used provided the requirements of Table 10 are met.

9.2.2 Maximum discrete reflectance

The maximum discrete reflectance shall be less than –35 dB per ISO/IEC 11801.

10. Medium Dependent Interface (MDI)

The 100G PSM4 module is coupled to the fiber optic cabling at the MDI. The MDI is the interface between the 100G PSM4 module and the “fiber optic cabling” (as shown in Figure 5). The PSM4 100G module is coupled to the fiber optic cabling through one connector plug into the MDI optical receptacle as shown in Figure 7. Example constructions of the MDI include the following:

a) 100G PSM4 with a connectorized fiber pigtail plugged into an adapter;
b) 100G PSM4 receptacle.

10.1 Optical lane assignments

The 12 fiber MPO optical lane assignments are shown in Figure 7. The four transmit and four receive optical lanes of PSM4 shall occupy the positions depicted in Figure 7 when looking into the MDI receptacle with the connector keyway feature on top. The interface contains eight active lanes within twelve total positions. Definitions for higher density PSM4 implementations (200-400G) are under development and will be included in a future variant of the specification. The central 4 fibers may be physically present.

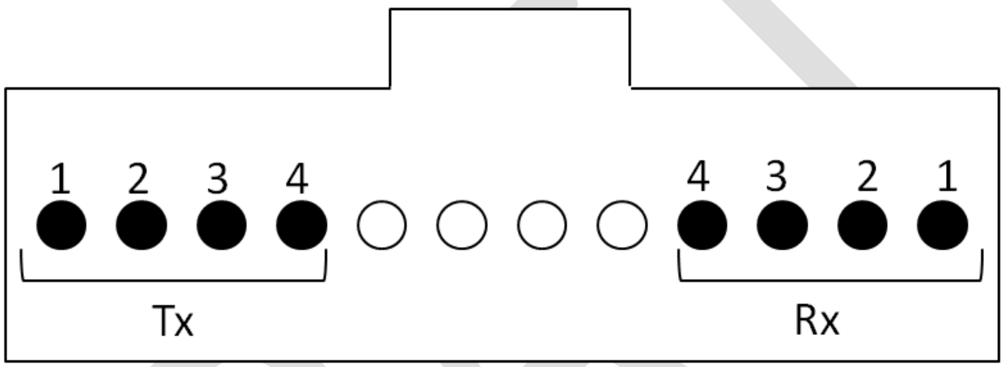

Figure 7: 12 fiber MPO optical lane assignments (looking into module optical port (MDI))

10.2 Medium Dependent Interface (MDI) requirements

The MDI shall meet the dimensional specifications of IEC 61754-7-1 interface 7-1-9: *MPO device receptacle, angled interface*. The plug terminating the optical fiber cabling shall meet the dimensional specifications of IEC 61754-7-1 interface 7-1-1: *MPO female plug connector, down-angled interface for 2 to 12 fibers*. The MDI shall optically mate with the plug on the optical fiber cabling. Figure 8 shows an MPO female plug connector with down-angled interface, and an MDI as an active device receptacle with angled interface.

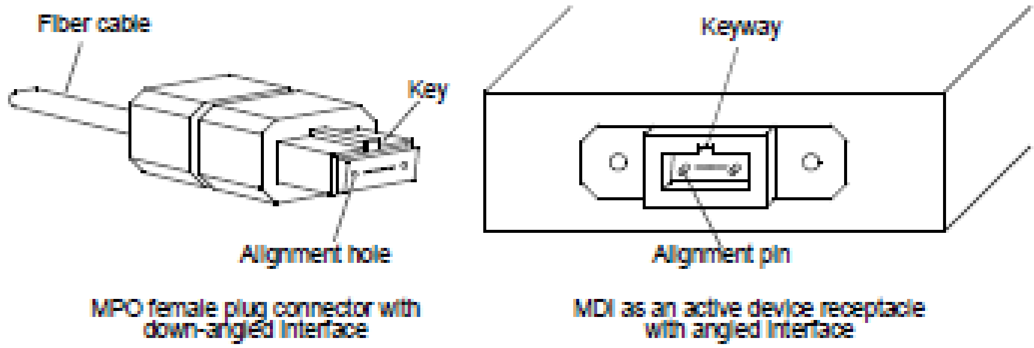

Figure 8: MPO female plug with down-angled interface and MDI active device receptacle with angled interface

The MDI shall meet the interface performance specifications of IEC 61793-021-2 for performance level D/3.

NOTE—Transmitter compliance testing is performed at TP2 as defined in 2.1, not at the MDI.

11 Definitions

MDI- Medium Dependent Interface: The mechanical and electrical or optical interface between the transmission medium and the PHY

MPO- The MPO-style connectors are most commonly defined by two different documents:

- IEC-61754-7 is the commonly cited standard for MPO connectors internationally
- EIA/TIA-604-5-D, also known as FOCIS 5, is the most common standard sited for in the US

Dispersion slope (S_0) - The rate of change of dispersion with respect to wavelength at the zero-dispersion point

TP1 – Electrical input to a PSM4 optical module

TP2 – Optical output of a PSM4 optical module

TP3 – Optical input of a PSM4 optical module

TP4 – Electrical output of a PSM4 optical module

Eye Mask – A template that bounds the dynamic signal characteristics in terms of amplitude and time.

Extinction Ratio - the ratio of the high optical power to the low optical power

OMA – Optical Modulation Amplitude: OMA is the difference in optical power for the nominal “1” and “0” levels of the optical signal

CAUI-4 - 100G Attachment Unit Interface-4 lanes: Defined in IEEE 802.3bm Annex 83E, CAUI-4 defines an optional 4 lane electrical interface for the PSM4 optical module.