

# 40G SWDM4 MSA

## Technical Specifications

### Optical Specifications

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## CONTENTS

CONTENTS.....	2
TABLES .....	3
FIGURES .....	3
1 GENERAL.....	4
1.1 Scope.....	4
1.2 SWDM4 module block diagram .....	4
1.3 Functional description.....	5
1.4 Hardware signaling pins .....	5
1.5 Module management interface .....	5
1.6 High speed electrical characteristics .....	5
1.7 Mechanical dimensions.....	5
1.8 Operating environment.....	5
1.9 Power supplies and power dissipation .....	5
2 SWDM4 OPTICAL SPECIFICATIONS .....	6
2.1 Wavelength-division-multiplexed lane assignments.....	6
2.2 Optical specifications .....	6
2.2.1 40G-SWDM4 transmitter optical specifications.....	7
2.2.2 40G-SWDM4 receive optical specifications .....	8
2.2.3 40G-SWDM4 illustrative link power budget .....	9
3 DEFINITION OF OPTICAL PARAMETERS AND MEASUREMENT METHODS .....	10
3.1 Test patterns for optical parameters.....	10
3.1.1 Square wave pattern definition .....	10
3.2 Skew and Skew Variation .....	10
3.3 Wavelength and spectral width.....	10
3.4 Average optical power .....	10
3.5 Optical Modulation Amplitude (OMA) .....	10
3.6 Transmitter and dispersion eye closure (TDEC) .....	10
3.6.1 TDEC conformance test setup.....	11
3.6.2 Test procedure.....	11
3.7 Extinction ratio .....	11
3.8 Transmitter optical waveform (transmit eye).....	11
3.9 Stressed receiver sensitivity .....	11

# 40G-SWDM4 MSA Technical Specifications Rev 2

---

4	FIBER OPTIC CABLING MODEL.....	12
4.1	Fiber optic cabling model.....	12
4.2	Characteristics of the fiber optic cabling (channel).....	13
4.2.1	Optical fiber cable.....	13
4.2.2	Optical fiber connection.....	13
4.2.3	Connection insertion loss.....	13
4.2.4	Maximum discrete reflectance.....	14
4.3	Medium Dependent Interface (MDI).....	14
4.3.1	MDI requirements for 40G-SWDM4.....	14
5	SWDM4 MODULE COLOR CODING.....	14

## TABLES

Table 2-1:	Wavelength-division-multiplexed lane assignments.....	6
Table 2-2:	40G-SWDM4 operating range.....	6
Table 2-3:	40G-SWDM4 transmit characteristics.....	7
Table 2-4:	40G-SWDM4 receive characteristics.....	8
Table 2-5:	40G-SWDM4 illustrative power budget.....	9
Table 3-1:	Patterns for optical parameter testing.....	10
Table 3-2:	TDECadj versus optical lane.....	11
Table 4-1:	Fiber optic cabling (channel) characteristics for 40G-SWDM4.....	12
Table 4-2:	Optical fiber and cable characteristics.....	13
Table 5-1:	SWDM4 Module Color Coding.....	14

## FIGURES

Figure 1-1:	Block diagram for SWDM4 transmit/receive paths.....	4
Figure 4-1:	Fiber optic cabling model.....	12

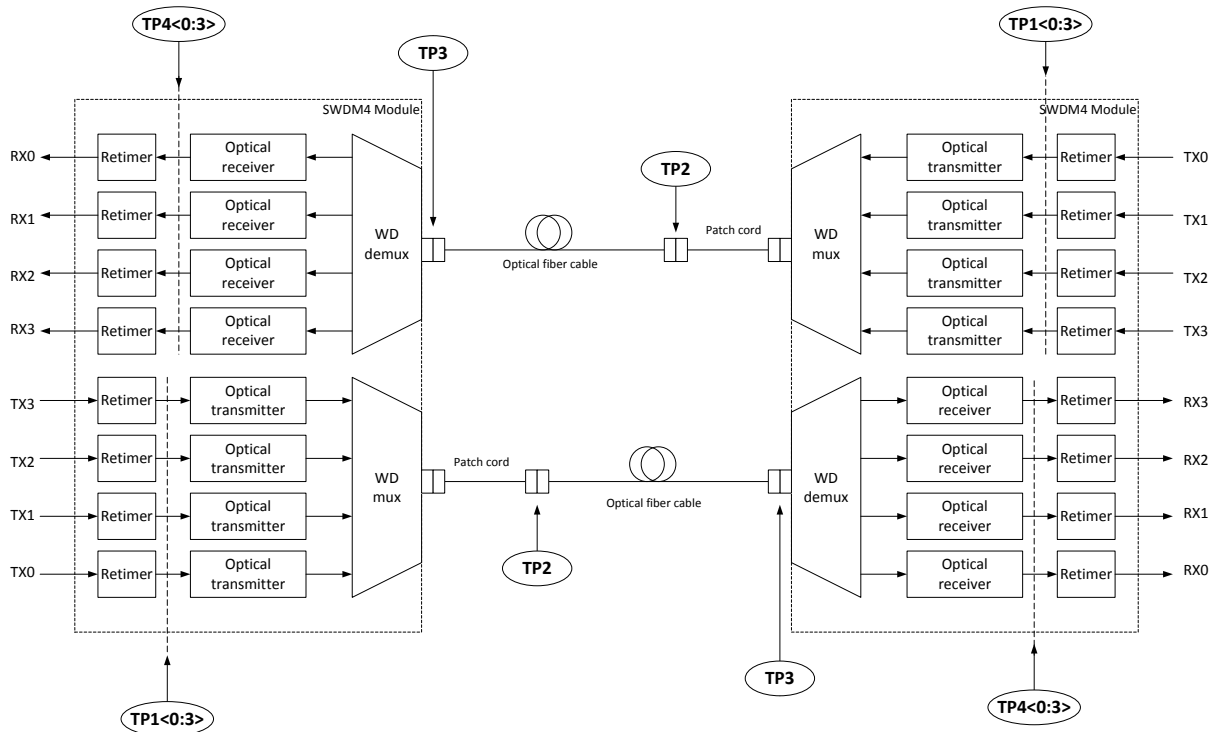
## 1 GENERAL

### 1.1 SCOPE

This Multi-Source Agreement (MSA) defines 4 x 10 Gbps Short Wavelength Division Multiplex (SWDM) optical interfaces for 100 Gbit/s optical transceivers for Ethernet applications including 40 GbE. Two transceivers communicate over multimode fibers (MMF) of length from 2 meters to 440 meters. The transceiver electrical interface is not specified by this MSA but can have, for example, four lanes in each direction with a nominal signaling rate of 10.3125 Gbps per lane.

Different form factors for the transceivers are possible. Initial implementations are expected to use the QSFP+ module form factor. Other form factors are possible and are not precluded by this MSA.

### 1.2 SWDM4 MODULE BLOCK DIAGRAM



WD = Wavelength division

NOTE – Specification of the retimer function is beyond the scope of this MSA.

**Figure 1-1: Block diagram for SWDM4 transmit/receive paths**

### ***1.3 FUNCTIONAL DESCRIPTION***

SWDM4 modules comply with the requirements of this document and have the following common features: four optical transmitters; four optical receivers with signal detect; wavelength division multiplexer and demultiplexer; and a duplex optical connector for multi-mode fiber. The optical connector type is vendor specific but can include LC types.

### ***1.4 HARDWARE SIGNALING PINS***

Hardware signaling pins are specified in the respective module form factor MSAs.

### ***1.5 MODULE MANAGEMENT INTERFACE***

The contents of the various ID registers shall comply with the requirements of the module MSA and the respective standards. In the case of QSFP+ modules, the management interface complies with SFF-8636.

### ***1.6 HIGH SPEED ELECTRICAL CHARACTERISTICS***

The detailed high speed electrical characteristics are not defined by this MSA. 40GE modules could be implemented in compliance with IEEE-Std™ 802.3 Annex 86A, Parallel Physical Interface (nPPI) for 40GBASE-SR4.

### ***1.7 MECHANICAL DIMENSIONS***

Mechanical dimensions are defined in the module form factor MSA specifications. QSFP+ is defined in SFF-8436.

### ***1.8 OPERATING ENVIRONMENT***

All specified minimum and maximum parameter values shall be met when the host system maintains the operating case temperature and supply voltages within the module vendor specified operating ranges. All minimum and maximum limits apply over the operating life of the system.

### ***1.9 POWER SUPPLIES AND POWER DISSIPATION***

Module vendors shall specify the module power supply requirements in accordance with the module MSA.

## 2 SWDM4 OPTICAL SPECIFICATIONS

### 2.1 WAVELENGTH-DIVISION-MULTIPLEXED LANE ASSIGNMENTS

The wavelength range for each lane of the SWDM PMD is defined in Table 2-1. The center wavelengths are spaced at 30 nm.

**Table 2-1: Wavelength-division-multiplexed lane assignments**

Lane	Center wavelength	Wavelength range	Module electrical lane
L <sub>0</sub>	850 nm	844 to 858 nm	Tx0, Rx0
L <sub>1</sub>	880 nm	874 to 888 nm	Tx1, Rx1
L <sub>2</sub>	910 nm	904 to 918 nm	Tx2, Rx2
L <sub>3</sub>	940 nm	934 to 948 nm	Tx3, Rx3

### 2.2 OPTICAL SPECIFICATIONS

The operating range for a 40G-SWDM4 PMD is defined in Table 2-2. An SWDM4 compliant PMD operates on multi-mode fibers according to the specifications defined in The channel insertion loss is given in Table 4-1. A channel may contain additional connectors as long as the optical characteristics of the channel (such as attenuation, modal dispersion, reflections and losses of all connectors and splices) meet the specifications. Insertion loss measurements of installed fiber cables are made in accordance with IEC 61280-4-1:2009. As OM4 and OM5 (TIA-492AAAE) optical fiber meet the requirements for OM3, a channel compliant to the “OM3” column may use OM4 or OM5 (TIA-492AAAE) optical fiber, or a combination of OM3, OM4 and OM5 (TIA-492AAAE). 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.

Table 4-1 and characteristics in 4.2.1. A PMD that exceeds the required operating range while meeting all other optical specifications is considered compliant (e.g., operating at 500 m on OM5 fiber meets the operating range requirement of 2 m to 440 m).

**Table 2-2: 40G-SWDM4 operating range**

MMF type	Required operating range
OM3	2 to 240 m
OM4	2 to 350 m
OM5	2 to 440 m

# 40G-SWDM4 MSA Technical Specifications Rev 2

## 2.2.1 40G-SWDM4 transmitter optical specifications

The SWDM4 transmitter shall meet the specifications defined in Table 2-3.

**Table 2-3: 40G-SWDM4 transmit characteristics**

Description	Value		Unit	
Signaling rate, each lane (range) 40GE	10.3125 ± 100 ppm		GBd	
Lane wavelengths (range)	L0	844 to 858	nm	
	L1	874 to 888		
	L2	904 to 918		
	L3	934 to 948		
RMS spectral width (max) [1]	L0	0.53	nm	
	L1	0.59		
	L2	0.59		
	L3	0.59		
Average launch power, each lane (max)	[2]		dBm	
Average launch power, each lane (min)	-7.5		dBm	
Optical Modulation Amplitude (OMA), each lane (max)	3		dBm	
Optical Modulation Amplitude (OMA), each lane (min) [3]	-5.5		dBm	
Difference in launch power between any 2 lanes (OMA) (max)	4.5		dB	
Launch power in OMA minus TDEC, each lane (min)	L0	-6.4	dBm	
	L1	-6.0		
	L2	-6.5		
	L3	-7.0		
Transmitter and dispersion eye closure (TDEC) and measured TDEC (TDECm), each lane (max) [4]		TDECm	TDEC	dB
	L0	5.1	3.7	
	L1		4.0	
	L2		4.5	
	L3		5.0	
Average launch power of OFF transmitter, each lane (max)	-30		dBm	
Extinction ratio (min)	2		dB	
Optical return loss tolerance (max)	12		dB	
Encircled flux [5]	≥ 86% at 19 μm ≤ 30% at 4.5 μm			
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3} Hit ratio 5x10 <sup>-5</sup> hits per sample	{0.23, 0.34, 0.43, 0.27, 0.35, 0.4}			

**Notes:**

1. RMS spectral width is the standard deviation of the spectrum.
2. Average launch power, each lane (max) shall be the lower of Average receive power (max) or, a value that in combination with all other lanes is less than class 1M eye safety limits per IEC 60825.
3. The normative lowest value of OMA for a compliant transmitter is 'Launch power in OMA minus TDEC, each lane (min)' plus the actual value of 'TDEC', but with a value of at least 'OMA, each lane (min)'.
4. TDEC is calculated from the measured TDECm using the methods in 3.6. TDECm is measured following the method in IEEE 802.3 clause 95.8.5 but using a 3.1 GHz bandwidth reference receiver for all lanes.
5. If measured into type A1a.2 or type A1a.3 50 μm fiber in accordance with IEC 61280-1-4.

# 40G-SWDM4 MSA Technical Specifications Rev 2

## 2.2.2 40G-SWDM4 receive optical specifications

The SWDM4 receiver shall meet the specifications defined in Table 2-4.

**Table 2-4: 40G-SWDM4 receive characteristics**

Description	Value		Unit
Signaling rate, each lane (range) 40GE	10.3125 ± 100 ppm		GBd
Lane wavelengths (range)	L0	844 to 858	nm
	L1	874 to 888	
	L2	904 to 918	
	L3	934 to 948	
Damage threshold, each lane (min) [1]	3.8		dBm
Average receive power, each lane (max)	2.4		dBm
Average receive power, each lane (min) [2]	L0	-12.9	dBm
	L1	-12.5	
	L2	-12.2	
	L3	-11.9	
Receive power, each lane (OMA) (max)	3		dBm
Difference in receive power between any two lanes (OMA) (max)	5		dB
Receiver reflectance (max)	-12		dB
Stressed receiver sensitivity (OMA), each lane (max) [4]	L0	TBD	dBm
	L1	TBD	
	L2	TBD	
	L3	TBD	
Conditions of stressed receiver sensitivity test:			
Stressed eye closure (SEC), lane under test	L0	TBD	dB
	L1	TBD	
	L2	TBD	
	L3	TBD	
Stressed eye J2 Jitter, lane under test	0.39		UI
Stressed eye J4 Jitter, lane under test	0.53		UI
OMA of each aggressor lane relative to lane under test	+5		dB
Stressed receiver eye mask definition { X1, X2, X3, Y1, Y2, Y3} Hit ratio 5x10 <sup>-5</sup> hits per sample	{0.28, 0.5, 0.5, 0.33, 0.33, 0.3}		
Notes:			
1. The receiver shall be able to tolerate, without damage, continuous exposure to an optical signal having this average power level			
2. 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.			
3. Measured with conformance test signal at TP3 (see 3.9) for BER = 5x10 <sup>-5</sup> .			
4. Stressed eye closure, stressed eye J2 Jitter, stressed eye J4 Jitter, and SRS eye mask definition are test conditions for measuring stressed receiver sensitivity. They are not characteristics of the receiver.			



## 40G-SWDM4 MSA Technical Specifications Rev 2

### 2.2.3 40G-SWDM4 illustrative link power budget

An illustrative power budget and penalties for 40G-SWDM4 are shown in Table 2-5.

**Table 2-5: 40G-SWDM4 illustrative power budget**

Parameter	Lane	OM3	OM4	OM5	Unit
Effective modal bandwidth (min) [1]	L0	2108	4606	4700	MHz.km
	L1	1782	3294	3700	
	L2	1523	2480	2880	
	L3	1319	1981	2500	
Power budget at max TDEC	L0	6.4			dB
	L1	7.3			
	L2	7.5			
	L3	7.7			
Operating distance		0.5 to 240	0.5 to 350	0.5 to 440	m
Channel insertion loss (max) [2]	L0	2.4	2.8	2.9	dB
	L1	2.3	2.6	2.7	
	L2	2.2	2.5	2.6	
	L3	2.1	2.5	2.5	
Allocation for penalties (for max TDEC) [3]	L0	2.9	3.7	3.6	dB
	L1	3.3	3.7	3.9	
	L2	3.8	4	4.5	
	L3	4.6	4.9	5	
Additional insertion loss allowed		1	0	0	dB
Notes:					
<ol style="list-style-type: none"> <li>1. Per IEC 60793-2-10</li> <li>2. The channel insertion loss is calculated using the maximum distance specified in Table 2-2 and cabled fiber attenuation of 3.5 dB/kmat 850 nm plus an allocation for connection and splice loss given in 4.2.3.</li> <li>3. Link penalties are used for linkbudget calculations. They are not requirements and are not meant to be tested.</li> </ol>					

### 3 DEFINITION OF OPTICAL PARAMETERS AND MEASUREMENT METHODS

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

#### 3.1 TEST PATTERNS FOR OPTICAL PARAMETERS

Table 3-1: Patterns for optical parameter testing

Parameter	Pattern	Sub-clause [1]
Wavelength, spectral width	PRBS31	3.3
Average optical power	PRBS31	3.4
Optical modulation amplitude (OMA)	Square wave	3.5
Transmitter and dispersion eye closure (TDEC)	PRBS31	3.6
Extinction ratio	PRBS31	3.7
Transmitter optical waveform	PRBS31	3.8
Stressed receiver sensitivity	PRBS31	3.9
Stressed eye closure (SEC), calibration	PRBS31	3.9
Notes: 1. These sub-clauses make reference to relevant clauses of IEEE Std 802.3™. 2. Note that the PRBS pattern generator and pattern checker are defined in IEEE Std 802.3 clauses 49.2.9 and 49.2.12 respectively.		

##### 3.1.1 Square wave pattern definition

A pattern consisting of eight ones followed by an equal run of zeroes may be used as a square wave.

#### 3.2 SKEW AND SKEW VARIATION

Refer to IEEE Std 802.3™ Clause 87.8.2. SWDM4 MSA transceivers shall comply with the skew and skew variation limits of clause 88.3.2.

#### 3.3 WAVELENGTH AND SPECTRAL WIDTH

Measure per TIA/EIA-455-127-A or IEC 61280-1-3.

#### 3.4 AVERAGE OPTICAL POWER

Measure using the methods given in IEC 61280-1-1 with all channels not being measured turned off.

#### 3.5 OPTICAL MODULATION AMPLITUDE (OMA)

Refer to IEEE Std 802.3 Clause 52.9.5. OMA is measured with a square wave (8 ones, 8 zeros) test pattern. Each lane may be tested individually with all other lanes turned off, or by using an optical filter as defined in 3.6 if the other lanes are active.

#### 3.6 TRANSMITTER AND DISPERSION EYE CLOSURE (TDEC)

TDEC shall be as defined in IEEE Std 802.3 Clause 95.8.5 with the exception that each optical lane is tested individually using an optical filter to separate the lane under test from the others.

# 40G-SWDM4 MSA Technical Specifications Rev 2

The optical filter pass band ripple shall be limited to 0.5 dB peak-to-peak and the isolation is chosen such that the ratio of the power in the lane being measured to the sum of the powers of all the other lanes is greater than 20 dB (see ITU-T G.959.1 Annex B). The lanes not under test shall be operating with PRBS31 bit streams.

### 3.6.1 TDEC conformance test setup

Refer to IEEE Std 802.3 Cl. 95.8.5.1. The combination of the O/E and the oscilloscope used to measure the optical waveform has fourth-order Bessel-Thomson filter response with a bandwidth of 12.6 GHz. That value was selected to model the effective bandwidth of the worst case fiber used for 100GBASE-SR4 at the specified wavelengths for that PMD. Since the 12.6 GHz bandwidth is built into commercial test equipment, the 40G-SWDM4 PMD can use the same bandwidth and correct the results for the actual properties of the fibers used.

### 3.6.2 Test procedure

The test procedure is as defined in IEEE Std 802.3 Cl. 95.8.5.2. Each lane is tested individually using an optical filter to separate the lane under test from the others, and the BER of  $5 \times 10^{-5}$  is for the lane under test on its own. The measured value is equal to TDEC<sub>m</sub> and the final value of TDEC is obtained by conversion as follows:

$$\text{TDEC} = \text{TDEC}_m + \text{TDEC}_{\text{adj}}$$

Where TDEC<sub>adj</sub> is the adjustment required for the worst case fiber type at each wavelength as listed in Table 3-2.

Table 3-2: TDEC<sub>adj</sub> versus optical lane

Lane	TDEC <sub>adj</sub>
L0	TBD
L1	TBD
L2	TBD
L3	TBD

### 3.7 EXTINCTION RATIO

Extinction ratio is measured using the methods specified in IEC 61280-2-2, with the lanes not under test turned off.

### 3.8 TRANSMITTER OPTICAL WAVEFORM (TRANSMIT EYE)

Refer to IEEE Std 802.3 Cl. 95.8.7.

### 3.9 STRESSED RECEIVER SENSITIVITY

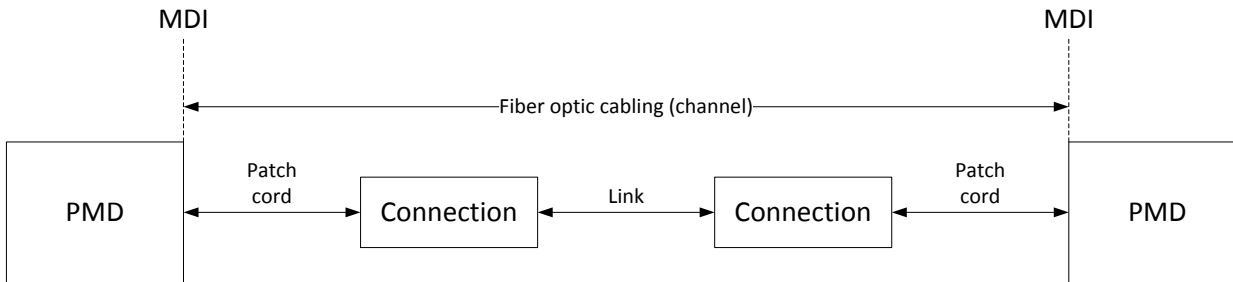
Use the method of IEEE Std 802.3 Cl. 95.8.8 with the following exceptions:

- The limits and test conditions for stressed receiver sensitivity are in Table 2-4.
- The attenuated stressed receiver conformance test signal for the lane under test and the three aggressor lanes are combined using a 4:1 optical multiplexer before application to the PMD receiver under test at TP3.

## 4 FIBER OPTIC CABLING MODEL

### 4.1 FIBER OPTIC CABLING MODEL

The fiber optic cabling model is shown in Figure 4-1.



**Figure 4-1: Fiber optic cabling model**

The channel insertion loss is given in Table 4-1. A channel may contain additional connectors as long as the optical characteristics of the channel (such as attenuation, modal dispersion, reflections and losses of all connectors and splices) meet the specifications. Insertion loss measurements of installed fiber cables are made in accordance with IEC 61280-4-1:2009. As OM4 and OM5 (TIA-492AAAE) optical fiber meet the requirements for OM3, a channel compliant to the “OM3” column may use OM4 or OM5 (TIA-492AAAE) optical fiber, or a combination of OM3, OM4 and OM5 (TIA-492AAAE). 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.

**Table 4-1: Fiber optic cabling (channel) characteristics for 40G-SWDM4**

Description	OM3	OM4	OM5	Unit
Operating distance (max)	240	350	440	m
Channel insertion loss <sup>a</sup> (max)	2.4	2.8	2.9	dB
Channel insertion loss (min)	0			dB

a) These channel loss values include cable loss plus 1.5 dB allocated for connection and splice loss over the wavelength range 844 to 948 nm.

## 4.2 CHARACTERISTICS OF THE FIBER OPTIC CABLING (CHANNEL)

The SWDM4 fiber optic cabling shall meet the specifications defined in The channel insertion loss is given in Table 4-1. A channel may contain additional connectors as long as the optical characteristics of the channel (such as attenuation, modal dispersion, reflections and losses of all connectors and splices) meet the specifications. Insertion loss measurements of installed fiber cables are made in accordance with IEC 61280-4-1:2009. As OM4 and OM5 (TIA-492AAAE) optical fiber meet the requirements for OM3, a channel compliant to the “OM3” column may use OM4 or OM5 (TIA-492AAAE) optical fiber, or a combination of OM3, OM4 and OM5 (TIA-492AAAE). 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.

Table 4-1. The fiber optic cabling consists of one or more sections of fiber optic cable and any intermediate connections required to connect sections together.

### 4.2.1 Optical fiber cable

The fiber contained within the fiber optic cabling shall comply with the specifications and parameters of Table 4-2. A variety of multimode cable types may satisfy these requirements, provided the resulting channel also meets the specifications of Table 4-1.

**Table 4-2: Optical fiber and cable characteristics**

Description	OM3 <sup>a</sup>	OM4 <sup>b</sup>	OM5 <sup>c</sup>	Unit
Nominal core diameter	50			μm
Nominal fiber specification wavelength	850			nm
Effective modal bandwidth (min) <sup>d</sup>	2000	4700		MHz.km
Cabled optical fiber attenuation (max)	3.5			dB/km
Zero dispersion wavelength ( $\lambda_0$ )	$1295 \leq \lambda_0 \leq 1340$		$1297 \leq \lambda_0 \leq 1328$	nm
Chromatic dispersion slope (max) ( $S_0$ )	0.105 for $1295 \leq \lambda_0 \leq 1310$ and $0.000375 \times (1590 - \lambda_0)$ for $1310 \leq \lambda_0 \leq 1340$		$-412 / (840(1 - (\lambda_0/840)^4))$	ps/nm <sup>2</sup> km

a IEC 60793-2-10 type A1a.2

b IEC 60793-2-10 type A1a.3

c TIA-492AAAE

d When measured with launch conditions in Table 2-3

### 4.2.2 Optical fiber connection

An optical fiber connection, as shown in Figure 4-1, consists of a mated pair of optical connectors.

### 4.2.3 Connection insertion loss

The maximum link distance is based on an allocation of 1.5 dB total connection and splice loss. For example, this allocation supports three connections with an average insertion loss per connection of 0.5 dB. Connections with

## 40G-SWDM4 MSA Technical Specifications Rev 2

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lower loss characteristics may be used provided the requirements of Table 4-1 are met. However, the loss of a single connection shall not exceed 0.75 dB.

### 4.2.4 Maximum discrete reflectance

The maximum discrete reflectance shall be less than -20 dB.

### 4.3 MEDIUM DEPENDENT INTERFACE (MDI)

The 40G-SWDM4 PMD is coupled to the fiber optic cabling at the MDI. The MDI is the interface between the PMD and the “fiber optic cabling” (as shown in Figure 4-1). Examples of an MDI include the following:

- a) PMD with a connectorized fiber pigtail plugged into an adapter,
- b) PMD receptacle

NOTE---Transmitter compliance testing is performed at TP2 i.e. after a 2-5 meter patch cord, not at the MDI.

#### 4.3.1 MDI requirements for 40G-SWDM4

The MDI shall optically mate with the compatible plug on the fiber optic cabling. For 40G-SWDM4 when the MDI is a connector plug and receptacle connection, it shall meet the interface performance specifications of IEC 61753-1 and IEC 61753-022-2 for performance grade Bm/2m.

## 5 SWDM4 MODULE COLOR CODING

Transceiver modules compliant to the SWDM4 MSA Specifications use a color code to indicate the application. This color code can be on a module bail latch, pull tab, or other visible feature of the module when installed in a system. The color code scheme is specified in Table 5-1.

**Table 5-1: SWDM4 Module Color Coding**

Color Code	Application
Gray	40 Gb/s SWDM4

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