400G-BD4.2 Multimode Fiber 8x50Gbps Technical Specifications

As Defined by the "400G BiDi MSA"

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The following companies were members of the 400G BiDi MSA at the release of this specification:

Company
Alibaba
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Corning Incorporated
Foxconn Interconnect Technology
InnoLight Technology
Inphi Corporation
Sumitomo Electric

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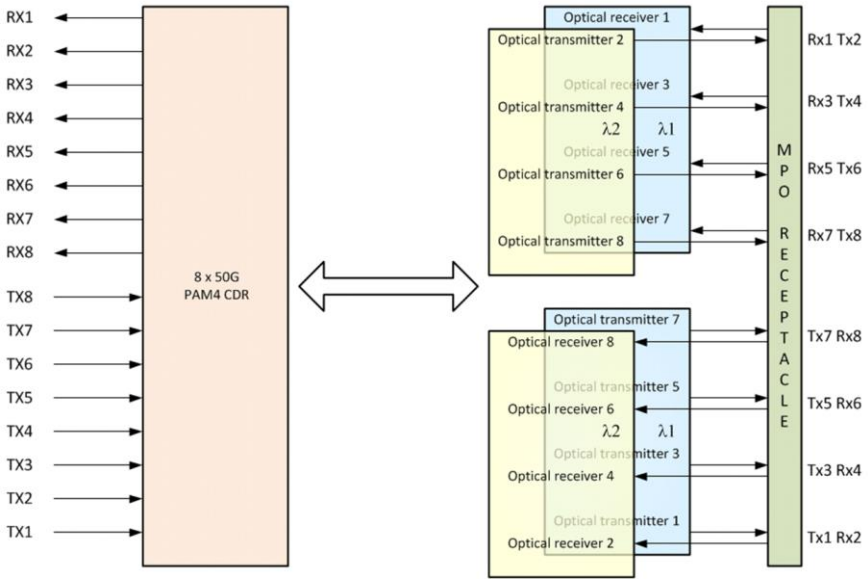
1 GENERAL

1.1 SCOPE

This Specification defines the 400G-BD4.2 8x50 Gbps MMF optical interface for Ethernet applications. Using the 400G-BD4.2 specification, two transceivers communicate over multimode optical fibers (MMF) of lengths from 0.5 meters to 70 meters (OM3), 100m (OM4) and 150m (OM5). The transceiver electrical interface is not defined in this specification, but is typically deployed using eight lanes in each direction with a PAM4 encoded, nominal signaling rate of 26.5625 GBd (53.125 Gbps) in each direction (400GAUI-8 C2M per IEEE Std 802.3™-2018 Annex 120E). Forward error correction (FEC) is required to be implemented by the host in order to ensure reliable system operation and is accommodated in the nominal signaling rate.

A variety of form factors for 400G-BD4.2 transceivers are possible (such as QSFP-DD and OSFP) and none are precluded by this MSA.

1.2 400G-BD4.2 MODULE BLOCK DIAGRAM



NOTE – Specification of the CDR function is beyond the scope of this specification.
NOTE: See Table 3-1 and Figure 3-1 for Electrical to Optical Lane Mapping for MPO Receptacle

Figure 1-1: Block Diagram for 400G-BD4.2 Transmit and Receive Paths

1.3 FUNCTIONAL DESCRIPTION

400G-BD4.2 modules comply with the requirements of this document and have the following common features: eight optical transmitters and eight optical receivers in a bi-directional optical configuration (four of the transmitters using a wavelength range of 844nm to 863nm, λ_1, and four of the transmitters using a wavelength range of 900nm to 918nm, λ_2), a signal detect for each optical receiver and a twelve channel MPO fiber optic connector (only eight fibers total are required) using multimode optical fiber.

1.4 MODULE HARDWARE SIGNALING PINS

Hardware signals and associated contact assignments are specified in the respective form factor specifications (such as QSFP-DD or OSFP).

1.5 MODULE MANAGEMENT AND LOW SPEED ELECTRICAL INTERFACE

The module management and low speed electrical interface is specified in the respective form factor specifications (such as QSFP-DD or OSFP).

1.6 HOST FEC REQUIREMENTS

The host system is required to enable FEC for the module electrical interface in accordance with IEEE Std 802.3™-2018 Clause 122.1.1 and IEEE Std 802.3™-2018 Annex 120E (400GAUI-8). The option to disable the host FEC correction function is not addressed in this specification.

Use of supplemental FEC capability within the optical module is not addressed in this specification.

1.7 MODULE HIGH SPEED ELECTRICAL CHARACTERISTICS

The detailed high speed electrical characteristics are not defined in this specification. The module electrical interface is intended to be in accordance with IEEE Std 802.3™-2018 Annex 120E (400GAUI-8).

1.8 MODULE MECHANICAL DIMENSIONS AND REQUIREMENTS

Module mechanical dimensions and requirements are specified in the respective form factor specifications (such as QSFP-DD or OSFP).

2 400G-BD4.2 OPTICAL SPECIFICATIONS

2.1 OPTICAL SPECIFICATIONS

The optical link distance operating range for the 400G-BD4.2 is defined in Table 2-1. A compliant PMD operates on multimode fibers according to the specifications in Table 2-4. A PMD that exceeds the required link distance operating range while meeting all optical specifications is considered compliant.

Table 2-1: 400G-BD4.2 Required Optical Link Distance Operating Range

PMD Type	OM3 Operating Range	OM4 Operating Range	OM5 Operating Range
400G-BD4.2	0.5 m to 70 m	0.5 m to 100 m	0.5 m to 150 m

For the 400G-BD4.2 PMD, the bit error ratio (BER) when processed by the PMA (IEEE Std 802.3™-2018 Clause 120) shall be less than 2.4×10^{-4} provided that the error statistics are sufficiently random that this results in a frame loss ratio of less than 1.7×10^{-12} for 64-octet frames with minimum inter-packet gap when additionally processed by the PCS (IEEE Std 802.3™-2018 Clause 119). For a complete Physical Layer, the frame loss ratio may be degraded to 6.2×10^{-11} for 64-octet frames with minimum inter-packet gap due to additional errors from the electrical interfaces. If the error statistics are not sufficiently random to meet this requirement, then the BER shall be less than that required to give a frame loss ratio of less than 1.7×10^{-12} for 64-octet frames with minimum inter-packet gap.

2.1.1 400G-BD4.2 Transmit Optical Specifications

Each lane of a 400G-BD4.2 transmitter shall meet the specifications in Table 2-2.

Table 2-2: 400G-BD4.2 Transmit Characteristics (TP2[e])

Parameter	400G-BD4.2 Value	Unit
Signaling Rate, each lane (range)	26.5625 ± 100 ppm	GBd
λ_1 Center Wavelength [Tx1, Tx3, Tx5, Tx7], each lane (range)	844 to 863	nm
λ_2 Center Wavelength [Tx2, Tx4, Tx6, Tx8], each lane (range)	900 to 918	nm
Modulation Format	PAM4	
RMS Spectral Width, each lane [a] (max)	0.6	nm
Average Launch Power, each lane (max)	4	dBm
Average Launch Power, each lane (min)	- 6.5	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane (max)	3	dBm
Outer Optical Modulation Amplitude (OMA_{outer}), each lane [b] (min)	- 4.5	dBm
OMA_{outer} - TDECQ, each lane (min)	- 5.9	dBm
Transmitter and Dispersion Eye Closure for PAM4 (TDECQ), each lane max	4.5	dB
TDECQ – $10\log_{10}(C_{eq})$, each lane (max) [c]	4.5	dB
Average Launch Power of OFF Transmitter, each lane (max)	-30	dBm
Extinction Ratio, each lane (min)	3	dB
Transmitter Transition Time, each lane (max)	34	ps
$RIN_{12}OMA$, each lane (max)	-128	dB/Hz
Optical Return Loss Tolerance, each lane (max)	12	dB
Encircled Flux, each lane [d]	≥ 86% at 19um ≤ 30% at 4.5um	

Test methodology is assumed to be based on IEEE P802.3cd™/D3.4 Clause 138.8.

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

[b] Even if the TDECQ < 1.4 dB, the OMA_{outer} (min) must exceed this value.

[c] C_{eq} is a coefficient defined in IEEE Std 802.3™-2018 Clause 121.8.5.8 which accounts for the reference equalizer noise enhancement.

[d] If measured into type A1a.2, or type A1a.3, or type A1a.4, 50 um fiber in accordance with IEC 61280-1-4:2009.

[e] TP2 as defined in IEEE P802.3cd™/D3.4 Figure 138-2.

2.1.2 400G-BD4.2 Receive Optical Specifications

Each lane of a 400G-BD4.2 receiver shall meet the specifications in Table 2-3.

Table 2-3: 400G-BD4.2 Receive Characteristics (TP3[g])

Parameter	400G-BD4.2 Value	Unit
Signaling Rate, each lane (range)	26.5625 ± 100 ppm	GBd
λ_1 Center Wavelength [Rx1, Rx3, Rx5, Rx7], each lane (range)	844 to 863	nm
λ_2 Center Wavelength [Rx2, Rx4, Rx6, Rx8], each lane (range)	900 to 918	nm
Modulation Format	PAM4	
Damage Threshold, each lane [a] (min)	5	dBm
Average Receive Power, each lane (max)	4	dBm
Average Receive Power, each lane [b] (min)	- 8.5	dBm
Receive Power (OMA_{outer}), each lane (max)	3	dBm
Receiver Reflectance, each lane (max)	-12	dB
Stressed Receiver Sensitivity (OMA_{outer}), each lane [c] (max)	-3.5	dBm
Receiver Sensitivity (OMA_{outer}), each lane [d] (max)	max (-6.6, SECQ - 8)	dBm
Conditions of Stressed Receiver Sensitivity Test: [e]		
Stressed Eye Closure (SECQ), lane under test	4.5	dB
SECQ – $10\log_{10}(C_{eq})$, lane under test (max) [f]	4.5	dB
OMA_{outer} of each aggressor lane	3	dBm

Test methodology is assumed to be based on IEEE P802.3cd™/D3.4 Clause 138.8.

[a] The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level on one lane. The receiver does not have to operate correctly at this input power.

[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] Measured with a conformance test signal at TP3 (see IEEE P802.3cd™/D3.4 Clause 138.8.8) for the BER specified in section 2.1.

[d] Receiver sensitivity is informative and is defined for a transmitter with a value of SECQ up to 4.5dB.

[e] These test conditions are for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

[f] C_{eq} is a coefficient defined in IEEE Std 802.3™-2018 Clause 121.8.5.8 which accounts for the reference equalizer noise enhancement.

[g] TP3 as defined in IEEE P802.3cd™/D3.4 Figure 138-2.

2.1.3 400G-BD4.2 Illustrative Power Budget

An illustrative power budget and penalties for 400G-BD4.2 are shown in Table 2-4.

Table 2-4: 400G-BD4.2 Illustrative Power Budget

Parameter	OM3 Value	OM4 Value	OM5 Value	Unit
Effective Modal Bandwidth at 850nm [a]	2000	4700	4700	MHz km
Effective Modal Bandwidth at 918nm	1210 [b]	1850 [b]	2890 [a]	MHz km
Power Budget (for max TDECQ)	6.6			dB
Operating Distance	70	100	150	m
Channel Insertion Loss [c]	1.8	1.9	2.0	dB
Allocation for Penalties [d] (for max TDECQ)	4.6			dB
Additional Insertion Loss Allowed	0.2	0.1	0	dB

[a] Per IEC 60793-2-10.

[b] Per draft IEC 60793-2-10 (subject to confirmation by TIA and IEC).

[c] The channel insertion loss is calculated using the maximum distance specified and the cabled optical fiber attenuation of 3.5 dB/km at 850 nm, plus an allocation of 1.5 dB for connection and splice loss (as given in IEEE P802.3cd™/D3.4 Clause 138.10.2.2.1).

[d] Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.

3 DEFINITION OF OPTICAL PARAMETERS AND MEASUREMENT METHODS

3.1 400G-BD4.2 Optical Parameter and Measurement Methods

All 400G-BD4.2 optical measurements shall be made using the Optical Parameter and Measurement Methods specified in IEEE P802.3cd™/D3.4 Clause 138.8, using Table 2-2 of this technical specification for the center wavelength and RMS spectral width.

3.2 400G-BD4.2 Optical Lane Assignments

Lane assignments for optical connectors are documented in relevant transceiver specifications (e.g. QSFP-DD and OSFP).

MPO (8 fiber) lane ordering is shown below for reference. Optical lane Tx1 is the output optical signal of transceiver electrical input signals Tx1p and Tx1n; likewise for Tx2 – Tx8. Optical lane Rx1 is the input optical signal for transceiver electrical output signals Rx1p and Rx1n; likewise for Rx2 – Rx8. Optical wavelengths are defined in Table 2-2 and Table 2-3.

Table 3-1: 400G-BD4.2 Electrical to Optical Lane Mapping for MPO Connector

Module Optical I/O		Module Electrical Tx Signals	Module Electrical Rx Signals
Ferrule	Signals		
TR1	Tx1, Rx2	Tx1p/n	Rx2p/n
TR2	Tx3, Rx4	Tx3p/n	Rx4p/n
TR3	Tx5, Rx6	Tx5p/n	Rx6p/n
TR4	Tx7, Rx8	Tx7p/n	Rx8p/n
RT4	Tx8, Rx7	Tx8p/n	Rx7p/n
RT3	Tx6, Rx5	Tx6p/n	Rx5p/n
RT2	Tx4, Rx3	Tx4p/n	Rx3p/n
RT1	Tx2, Rx1	Tx2p/n	Rx1p/n

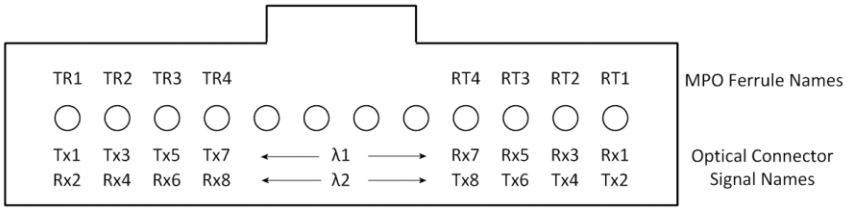


Figure 3-1: 400G-BD4.2 Lane Ordering for MPO Optical Connector

3.3 400G-BD4.2 MDI (Medium Dependent Interface) Requirements

The 400G-BD4.2 MDI shall meet the requirements of IEEE P802.3cd™/D3.4 Clause 138.10.3.3.

4 400G-BD4.2 MODULE COLOR CODING

Transceiver modules compliant to these 400G-BD4.2 specifications shall use a color code to indicate the application. This color code can be on a module latch, pull tab, or other visible feature of the module when installed in a system. The color code scheme is specified in Table 4-1.

Table 4-1: 400G-BD4.2 Module Color Coding

Color Code	Application
Beige	400G-BD4.2