800G-VR4.2, 800G-SR4.2, 1.6T-VR8.2, and 1.6T-SR8.2 Multimode Fiber Technical Specifications

As Defined by the "Terabit BiDi MSA"

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1 GENERAL

1.1 Scope

This Specification defines the 8×100 Gb/s and 16×100 Gb/s multimode fiber (MMF) optical interfaces for Ethernet applications. Four Physical Medium Dependent (PMD) sublayers are defined, namely, 800G-VR4.2, 800G-SR4.2, 1.6T-VR8.2, and 1.6T-SR8.2. Two transceivers can communicate over MMF of lengths specified in Table 1 using the PMD specifications.

Table 1: Operating range

PMD type	OM3 operating range	OM4 operating range	OM5 operating range
800G-VR4.2 1.6T-VR8.2	0.5 m to 30 m	0.5 m to 50 m	0.5 m to 70 m
800G-SR4.2 1.6T-SR8.2	0.5 m to 45 m	0.5 m to 70 m	0.5 m to 100 m

The transceiver electrical interface is not defined in this specification, but is typically deployed using eight lanes in each direction with a PAM4 encoded signal for 800G-VR4.2 and 800G-SR4.2, and sixteen lanes in each direction with a PAM4 encoded signal for 1.6T-VR8.2 and 1.6T-SR8.2. The nominal signaling rate is 53.125 GBd (106.25 Gb/s) in each direction (800GAUI-8 C2M for 800G-VR4.2 and 800G-SR4.2 as defined by IEEE Draft[1] P802.3df™/D1.1 Annex 120G, and 2×800GAUI-8 C2M for 1.6T-VR8.2 and 1.6T-SR8.2). 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 800G-VR4.2/800G-SR4.2 and 1.6T-VR8.2/1.6T-SR8.2 transceivers are possible (such as QSFP-DD and OSFP) and none are precluded by this MSA.

1.2 Module Block Diagram

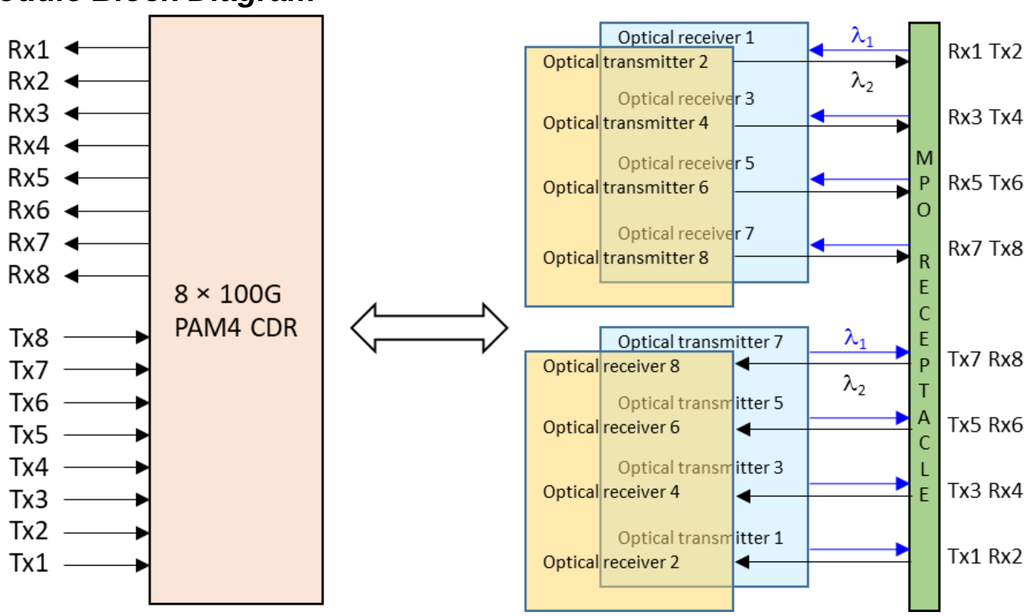

Figure 1: Block diagram for 800G-VR4.2 / 800G-SR4.2 transmit and receive paths

[1] Specifications referring to IEEE Draft 802.3df™ will be updated if the reference becomes incorrect.

Figure 1 shows the block diagram for 800G bidirectional modules. The center wavelength range for λ_1 and λ_2 is specified in Table 2. The electrical-to-optical lane mapping is specified in Table 7 and Figure 2. The specification of the clock and data recovery (CDR) function is beyond the scope of this document.

The block diagram for 1.6T bidirectional modules would be analogous to Figure 1 with 16 transmitters and 16 receivers. The electrical-to-optical lane mapping is specified in Table 8 and Figure 3.

1.3 Functional Description

800G-VR4.2 and 800G-SR4.2 interfaces comply with the requirements of this document and have the following common features: eight optical transmitters and eight optical receivers in a bidirectional optical configuration (four of the transmitters using a wavelength λ_1 and four of the transmitters using a wavelength λ_2, see Table 2 for the center wavelength range), a signal detect for each optical receiver and either an eight channel MPO-8 fiber optic connector or a twelve channel MPO-12 fiber optic connector (only eight fibers total are required; MPO-8 is an MPO-12 with the middle four fibers depopulated) using multimode optical fiber.

1.6T-VR8.2 and 1.6T-SR8.2 interfaces comply with the requirements of this document and have the following common features: 16 optical transmitters and 16 optical receivers in a bidirectional optical configuration (eight of the transmitters using a wavelength λ_1 and eight of the transmitters using a wavelength λ_2, see Table 2 for the center wavelength range), a signal detect for each optical receiver and a sixteen channel MPO-16 fiber optic connector using multimode optical fiber.

A 1.6T capable module that supports 1.6T-VR8.2 or 1.6T-SR8.2 implemented with either dual MPO-8 or dual MPO-12 fiber optic connectors to support breakout applications of dual 800G-VR4.2 or 800G-SR4.2 is not precluded. Care should be taken to minimize cable length differences in this case if operating in 1.6 TbE mode.

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™-2022 Clause 122.1.1 and IEEE Draft P802.3df™/D1.1 Annex 120G (800GAUI-8). The option to disable the host FEC correction function is not addressed in this document.

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

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 Draft P802.3df™/D1.1 Annex 120G (800GAUI-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 OPTICAL SPECIFICATION

2.1 Optical Specifications

The operating ranges for 800G-VR4.2, 800G-SR4.2, 1.6T-VR8.2, and 1.6T-SR8.2 are defined in Table 1. A compliant PMD operates on multimode fibers according to the specifications in Table 4 for 800G-VR4.2 and 1.6T-VR8.2, and Table 5 for 800G-SR4.2 and 1.6T-SR8.2. A PMD that exceeds the required link distance operating range while meeting all optical specifications is considered compliant.

The bit error ratio (BER) when processed by the Physical Media Attachment (PMA) sublayer (IEEE Draft P802.3df™/D1.1 Clause 173) 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 Physical Coding Sublayer (PCS) (IEEE Draft P802.3df™/D1.1 Clause 172). 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 Transmit Optical Specifications

Each lane of an 800G-VR4.2, 800G-SR4.2, 1.6T-VR8.2, and 1.6T-SR8.2 transmitter shall meet the specifications in Table 2. The optical transmit signal is defined at the output end of a multimode fiber patch cord (TP2) as illustrated in Figure 150-2 for 400GBASE-SR4.2 in IEEE Std 802.3™-2022.

Two TxRx pair types (combination of Tx and Rx type that connect to a single fiber) are defined:

— TxRx pair type TR comprises a transmitter that uses the wavelength range of 842 nm to 868 nm and a receiver that uses the wavelength range of 900 nm to 916 nm.
— TxRx pair type RT comprises a transmitter that uses the wavelength range of 900 nm to 916 nm and a receiver that uses the wavelength range of 842 nm to 868 nm.

Table 2: Transmit characteristics

Description	800G-VR4.2 1.6T-VR8.2	800G-SR4.2 1.6T-SR8.2	Unit
Signaling rate, each lane (range)	53.125 ± 50 ppm		GBd
Modulation format	PAM4		—
Center wavelength (range), λ_1 for TxRx pair type RT Center wavelength (range), λ_2 for TxRx pair type TR	842 to 868 900 to 916	844 to 863 900 to 915	nm nm
RMS spectral width[a] (max) for TxRx pair type RT RMS spectral width[a] (max) for TxRx pair type TR	0.65 0.60	0.60 0.58	nm nm
Average launch power, each lane (max)	4		dBm
Average launch power, each lane (min)	–4.6		dBm
Outer optical modulation amplitude (OMA_{outer}), each lane (max)	3.5		dBm
Outer optical modulation amplitude (OMA_{outer}), each lane (min) for max(TECQ, TDECQ) ≤ 1.8 dB for 1.8 < max(TECQ, TDECQ) ≤ 4.4 dB	–2.6 –4.4 + max(TECQ, TDECQ)		dBm dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ), each lane (max)	4.4	4.4	dB
Transmitter eye closure for PAM4 (TECQ), each lane (max)	4.4		dB
Overshoot/undershoot (max)	29		%
Transmitter power excursion, each lane (max)	2.3		dBm
Extinction ratio, each lane (min)	2.5		dB
Transmitter transition time, each lane (max)	17		ps
Average launch power of OFF transmitter, each lane (max)	–30		dBm
$RIN_{14}OMA$, each lane (max)	–132		dB/Hz
Optical return loss tolerance, each lane (max)	14		dB
Encircled flux, each lane[b]	≥ 86% at 19um ≤ 30% at 4.5um		—

[a] RMS spectral width is the standard deviation of the spectrum.
[b] If measured into type A1a.2 or type A1a.3, or type A1a.4, 50 µm fiber, in accordance with IEC 61280-1-4.

2.1.2 Receive Optical Specifications

Each lane of an 800G-VR4.2, 800G-SR4.2, 1.6T-VR8.2, and 1.6T-SR8.2 receiver shall meet the specifications in Table 3. The optical receive signal is defined at the output of the fiber optic cabling (TP3) at the medium dependent interface (MDI) (see section 3) as illustrated in Figure 150-2 for 400GBASE-SR4.2 in IEEE Std 802.3™-2022.

Table 3: Receive characteristics

Description	800G-VR4.2 1.6T-VR8.2	800G-SR4.2 1.6T-SR8.2	Unit
Signaling rate, each lane (range)	53.125 ± 50 ppm		GBd
Modulation format	PAM4		—
Center wavelength (range), λ_1 for TxRx pair type RT Center wavelength (range), λ_2 for TxRx pair type TR	842 to 868 900 to 916		nm nm
Damage threshold, each lane[a] (min)	5		dBm
Average receive power, each lane (max)	4		dBm
Average receive power, each lane[b] (min)	−6.3	−6.4	dBm
Receive power (OMA_{outer}), each lane (max)	3.5		dBm
Receiver reflectance (max)	−15		dB
Receiver sensitivity (OMA_{outer}), each lane (max) for TECQ ≤ 1.8 dB for 1.8 < TECQ ≤ 4.4 dB	 −4.4 −6.2 + TECQ	 −4.6 −6.4 + TECQ	 dBm dBm
Stressed receiver sensitivity (OMA_{outer})[c] (max)	−1.8	−2.0	dBm
Conditions of stressed receiver sensitivity test[d]			
Stressed eye closure (SECQ) for PAM4, lane under test	4.4		dB
OMA_{outer} of each aggressor lane	3.5		dBm

[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 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 for the BER specified in section 2.1.
[d] These test conditions are for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

2.1.3 Illustrative Link Power Budget

An illustrative power budget and penalties for 800G-VR4.2 and 1.6T-VR8.2 channels are shown in Table 4. An illustrative power budget and penalties for 800G-SR4.2 and 1.6T-SR4.2 channels are shown in Table 5.

Table 4: Illustrative link power budget for 800G-VR4.2 and 1.6T-VR8.2

Parameter	OM3 value	OM4 value	OM5 value	Unit
Effective modal bandwidth at 850 nm[a]	2000	4700	4700	MHz·km
Effective modal bandwidth at 910 nm	1260[b]	1980[b]	3100[a]	MHz·km
Power budget (for max TDECQ)	6.2			dB
Operating distance	30	50	70	m
Channel insertion loss[c]	1.6	1.7	1.7	dB
Allocation for penalties[d] (for max TDECQ)	4.5			dB
Additional insertion loss allowed	0.1	0	0	dB

[a] Per IEC 60793-2-10.
[b] Guidance is provided for effective modal bandwidth at all wavelengths in the 840 to 953 nm range in IEC 60793-2-10.
[c] The channel insertion loss is calculated using the maximum distance specified and the cabled optical fiber attenuation of 3 dB/km at 850 nm, plus an allocation of 1.5 dB for connection and splice loss (as given in IEEE Std 802.3db™-2022 subclause 167.10.2.2.1).
[d] Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.

Table 5: Illustrative link power budget for 800G-SR4.2 and 1.6T-SR8.2

Parameter	OM3 value	OM4 value	OM5 value	Unit
Effective modal bandwidth at 850 nm[a]	2000	4700	4700	MHz·km
Effective modal bandwidth at 910 nm	1260[b]	1980[b]	3100[a]	MHz·km
Power budget (for max TDECQ)	6.4			dB
Operating distance	45	70	100	m
Channel insertion loss[c]	1.6	1.7	1.8	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] Guidance is provided for effective modal bandwidth at all wavelengths in the 840 to 953 nm range in IEC 60793-2-10.
[c] The channel insertion loss is calculated using the maximum distance specified and the cabled optical fiber attenuation of 3 dB/km at 850 nm, plus an allocation of 1.5 dB for connection and splice loss (as given in IEEE Std 802.3db™-2022 subclause 167.10.2.2.1).
[d] Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.

2.2 Optical Parameter and Measurement Methods

All optical measurements shall be made using the Optical Parameter and Measurement Methods specified in IEEE Std 802.3db™-2022 subclause 167.8, using Table 2 and Table 3 of this technical specification.

2.2.1 Transmitter and Dispersion Eye Closure for PAM4 (TDECQ)

TDECQ is a measure of the optical transmitter's vertical eye closure as described in IEEE Std 802.3db™-2022 subclause 167.8.8. The dispersion of the fiber is emulated using a filter with a fourth-order Bessel-Thomson response whose 3 dB bandwidth is specified in Table 6.

Table 6: The 3 dB bandwidth of the fiber emulation filter for TDECQ measurement

PMD type	TxRx pair type	3 dB bandwidth (GHz)
800G-VR4.2 and 1.6T-VR8.2	RT and TR	25.1
800G-SR4.2 and 1.6T-SR8.2	RT and TR	18.0

3 OPTICAL LANE ASSIGNMENTS AND MEDIUM DEPENDENT INTERFACE

3.1 800G-VR4.2 and 800G-SR4.2 Optical Lane Assignments

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

The lane ordering for MPO-8 and MPO-12 connectors is shown for reference in Table 7 and Figure 2. 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 and Table 3.

Table 7: 800G-VR4.2 and 800G-SR4.2 electrical-to-optical lane mapping for MPO-8 and MPO-12 connectors

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

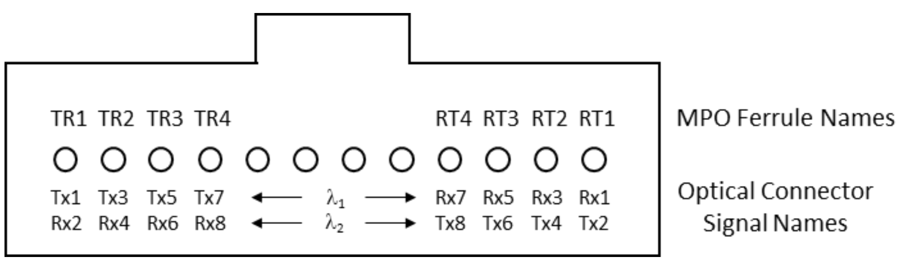

Figure 2: 800G-VR4.2 and 800G-SR4.2 lane ordering for the MPO-12 optical connector. The MPO-8 connector is an MPO-12 connector with the middle four fibers depopulated.

3.2 800G-VR4.2 and 800G-SR4.2 MDI Requirements

The 800G-VR4.2 and 800G-SR4.2 MDI shall meet the requirements of IEEE Std 802.3db™-2022 subclause 167.10.3.3.

3.3 1.6T-VR8.2 and 1.6T-SR8.2 Optical Lane Assignments

Lane ordering for the MPO-16 connector is shown for reference in Table 8 and Figure 3. Optical lane Tx1 is the output optical signal of transceiver electrical input signals Tx1p and Tx1n; likewise for Tx2 – Tx16. Optical lane Rx1 is the input optical signal for transceiver electrical output signals Rx1p and Rx1n; likewise for Rx2 – Rx16. Optical wavelengths are defined in Table 2 and Table 3.

Table 8: 1.6T-VR8.2 and 1.6T-SR8.2 electrical-to-optical lane mapping for MPO-16 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
TR5	Tx9, Rx10	Tx9p/n	Rx10p/n
TR6	Tx11, Rx12	Tx11p/n	Rx12p/n
TR7	Tx13, Rx14	Tx13p/n	Rx14p/n
TR8	Tx15, Rx16	Tx14p/n	Rx16p/n
RT8	Tx16, Rx15	Tx16p/n	Rx15p/n
RT7	Tx14, Rx13	Tx14p/n	Rx13p/n
RT6	Tx12, Rx11	Tx12p/n	Rx11p/n
RT5	Tx10, Rx9	Tx10p/n	Rx9p/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

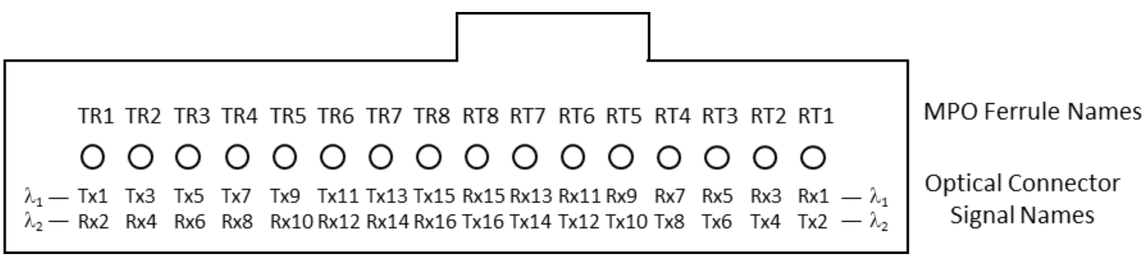

Figure 3: 1.6T-VR8.2 and 1.6T-SR8.2 lane ordering for MPO-16 optical connector

3.4 1.6T-VR8.2 and 1.6T-SR8.2 MDI Requirements

The 1.6T-VR8.2 and 1.6T-SR8.2 MDI shall optically mate with the compatible plug on the optical fiber cabling. The MDI adapter or receptacle shall meet the dimensional specifications for designation FOCIS 18 A-1-0, or designation FOCIS 18 R-1x16-1-8-1-2-2, as defined in ANSI/TIA-604-18-A. The plug terminating the optical fiber cabling shall meet the dimensional specifications of designation FOCIS 18 P-1x16-1-8-2-2-1, as defined in ANSI/TIA-604-18-A. The MPO female plug connector and MDI are structurally similar to those depicted in Figure 167-9 of IEEE Std 802.3db-2022™ subclause 167.10.3.3, but with 16 fibers, an angled interface, an offset keyway, and with different pin diameter and locations. The MDI connection shall meet the interface performance specifications of IEC 63267-1 for performance grade Bm/1m.

4 MODULE COLOR CODING

Transceiver modules compliant to these 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 9.

Table 9: Module color coding

Color code	Application
Beige	800G-VR4.2 800G-SR4.2 1.6T-VR8.2 1.6T-SR8.2