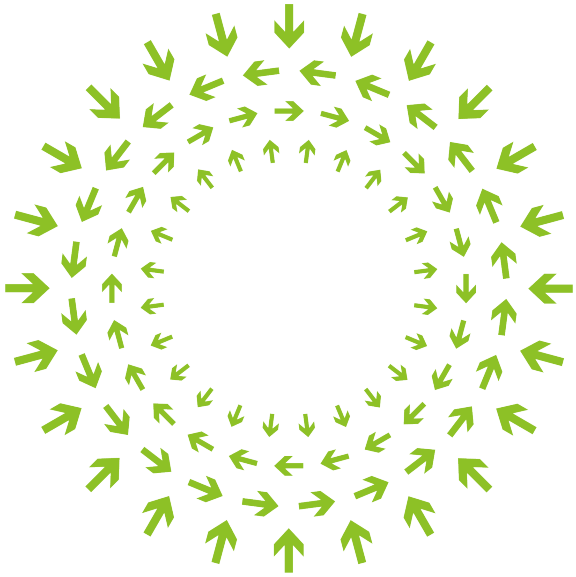


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400G-FR4 QSFP-DD OCP Optical Transceiver Specification

Rev 0.1

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2. Scope & Overview

2.1 Scope

This document defines the technical specifications for the 400G-FR4 optical transceivers in QSFP-DD form-factor used in large-scale data center applications.

2.2 Overview

The 400G-FR4 OCP optical specification is based on IEEE 400GBASE-FR4 specification as defined in IEEE 802.3 cu. Similar to 200G-FR4 OCP specification, it is optimized considering both the practical operating conditions of data centers, the overall cost/yield of the optical transceiver modules and the backward compatibility. The optimization is done in four areas: reach, temperature, wavelength and link budget. First, the reach is increased to 3km to address the longest intra-DC links. Second, most data centers operate under a well-controlled thermal environment, allowing the operating case temperature of the 400G FR4 optical transceivers to be relaxed from 0-70°C to 15-70°. The operating wavelength range can be reduced from +/-6.5nm to +/-5.75nm around the center wavelengths.
While this specification is focused on 400G operation, the module shall be compliant to the 200G-FR4 QSFP56 OCP Technical Specifications Rev 0.2, when operating in 200G mode. The customized lane mapping is implemented to fully support backward compatibility.

3. Common Terms

The following terms are used in this document

- QSFP56 –Quad Small Form-factor Pluggable (QSFP) at 4x 26Gbaud PAM4, used for 200GBE
- QSFP-DD –Quad Small Form-factor Pluggable Double Density at 8x 56Gbps, used for 400GE
- BER – Bit Error Rate
- ER – Extinction Ratio
- SMSR – Side Mode Suppression Ratio
- OMA – Optical Modulation Amplitude
- AOP – Average Optical Power
- TDECQ – Transmitter and Dispersion Eye Closure Quaternary
- TECQ – Transmitter Eye Closure Quaternary
- SECQ – Stressed Eye Closure Quaternary
- SNR - Signal to Noise Ratio
- PRBS- pseudorandom binary sequence
- CMIS – Common Management Interface Specification

4. References

The following documents are referenced in this specification:

- IEEE 802.3 cu
- OIF-CEI-4.0
- QSFP-DD Hardware Specification, Rev 4.0
- OCP 200G FR4 Optical Transceiver Specification
- Common Management Interface Specification, Rev 4.0
- Telcordia GR-468-CORE, issue 2

5. Operating Conditions

Parameter	Symbol	Min	Typical	Max	Unit	Note
Electrical signaling rate, each lane			26.5625		GBaud	+/-100ppm
Optical signaling rate, each lane		26.5625	53.125		GBaud	+/-100ppm
Modulation format			PAM4			
Power supply voltage	Vcc	3.135	3.3	3.465	V	
Operating case temperature	Tcase	15		70	°C	
Power consumption	P			10.5	W	400G mode
				7.0		200G mode
Power consumption, low power mode	P_LP			1.5	W	

Table 1 - Operating Conditions

6. Optical Specifications

6.1 Optical Transmitter Characteristics

The optical transmitter characteristics and measurement methodologies are based on IEEE 400GBASE-FR4 as defined in IEEE 802.3 cu, with the following change:

A. Wavelength range is reduced.

When this specification and IEEE 802.3 cu do not agree, this spec will take precedence.

Parameter	Symbol	Min	Typ.	Max	Unit	Note	Dev.
Center wavelength 0	WL0	1265.25	1271	1276.75	nm		A
Center wavelength 1	WL1	1285.25	1291	1296.75	nm		A
Center wavelength 2	WL2	1305.25	1311	1316.75	nm		A
Center wavelength 3	WL3	1325.25	1331	1336.75	nm		A
Side-mode suppression ratio	SMSR	30			dB		
Total average launch power				9.5	dBm		
Average launch power per lane	AOP	-3.2		3.5	dBm	Note 1	
Outer optical modulation amplitude, each lane	OMAouter	-0.2		3.7	dBm	Note 2	
		-1.6+TDECQ				Note 3	
Difference in launch power between any two lanes (OMAouter)				4.0	dB		

Parameter	Symbol	Min	Typ.	Max	Unit	Note	Dev.
Transmitter and dispersion eye closure quaternary (TDECQ), each lane	TDECQ			3.4	dB		
Transmitter eye closure quaternary (TECQ), each lane	TECQ			3.4	dB		
|TECQ-TDECQ|				2.5	dB		
Transmitter transition time				17	ps		
Transmitter over/undershoot				22	%		
Transmitter peak-to-peak power				4.5	dBm		
Average launch power of OFF transmitter, each lane	Toff			-30	dBm		
Extinction ratio, each lane (min)	ER	3.5			dB		
RIN17.1OMA	RIN_OMA			-136	dB/Hz	Note 4	
Optical return loss tolerance	ORL			17.1	dB		
Transmitter reflectance	Tx_Ref			-26	dB	Note 5	
Note: 1. 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. 2. For Tx with TDECQ < 1.4 dB 3. For Tx with 3.4 dB ≥ TDECQ ≥ 1.4 dB 4. RIN on OMA measured with 17.1dB return loss. 5. Transmitter reflectance is defined looking into the transmitter.							

Table 2 - Optical Transmitter Characteristics

6.2 Optical Receiver Characteristics

The optical receive characteristics are based on IEEE 400GBASE-FR4 as defined in IEEE 802.3 cu section 151.7.2, with the following changes.

A. Wavelength range is reduced
B. Bit error ratio floor is added

When this specification and IEEE 802.3 cu do not agree, this spec will take precedence.

Parameter	Symbol	Min	Typical	Max	Unit	Note	Deviation
Center wavelength 0	WL0	1265.25	1271	1276.75	nm		A
Center wavelength 1	WL1	1285.25	1291	1296.75	nm		A
Center wavelength 2	WL2	1305.25	1311	1316.75	nm		A
Center wavelength 3	WL3	1325.25	1331	1336.75	nm		A
Damage threshold, each lane		4.5					
Average receive power, each lane	AOP	-7.2		3.5	dBm	Note 1	
Difference in receive power between any two lane (OMAouter)				4.1	dB		
Receiver reflectance	Rx_Ref			-26	dB		
Receive outer optical modulation amplitude, each lane	OMAouter			3.7	dBm		
Receiver sensitivity (OMA outer), each lane	RxSens			-4.6	dBm	Note 2	
				-6+TECQ		Note 3	
Stressed receiver sensitivity (OMA outer), each lane	SRS			-2.6	dBm	Note 4	
Bit error ratio floor	BER_FL			3.4E-6		Note 5	B

Note:
1. 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.
2. For Tx with TDECQ < 1.4 dB
3. For Tx with 3.4 dB ≥ TDECQ ≥ 1.4 dB
4. Measured with conformance test signal at TP3 for the BER = 2.4E-4. The stressed conditions are shown in Table 4.
5. Measured with a reference transmitter to produce SECQ greater than or equal to 2dB. The BER at receiver must stay within the specified limit over an OMA range of (-4.9 + TDECQ) dBm to 3.7dBm.

Table 3 - Optical Receiver Characteristics

Parameter	Value
Stressed eye closure for PAM4 (SECQ), lane under test (dB)	3.4
OMAouter of each aggressor lane (dBm)	1.5

Table 4 - Stressed Receiver Sensitivty Test Conditions

6.3 Optical Fiber Link Model

The reference optical fiber link model is based on 3km SMF-28 fiber. The total link loss and dispersion budget are shown in Table 5. Refer to IEEE 802.3 bs, section 122.11.2.2 for the return loss budget.

Parameter	Symbol	Min	Typical	Max	Unit	Note
Total fiber link loss	IL			4.0	dB	
Dispersion	CD	-17.81		9.84	ps/nm	

Table 5 - Fiber Optical Link Budget

7. Form Factor and Low Speed Pins

QSFP-DD form factor is used. Refer to QSFP-DD Hardware Specification, Rev 4.0 section 4.1 about the description and specification of the following low speed pins for control and status: ModSelL, ResetL, LPMode, ModPrsL, and IntL.

8. High Speed Signals

8.1 Electrical Specification

The High-speed PIN electrical specification is based on CEI-56G-VSR-PAM4 in OIF-CEI-4.0 section 16, table 16-2 and table 16-4. Module vendors need to comply to the module input and output interface defined in these tables.

8.2 Electrical to Optical Lane Mapping

To support 200G backward compatibility requirement, the mapping of high-speed electrical input/output lanes from QSFP-DD connector to optical wavelengths of the 400G-FR4 module is defined as in Table 6.

Electrical signal	Wavelength
Tx0	Tx0
Tx4	
Tx1	Tx1
Tx5	
Tx2	Tx2
Tx6	
Tx3	Tx3
Tx7	
Rx0	Rx0
Rx4	
Rx1	Rx1
Rx5	
Rx2	Rx2
Rx6	
Rx3	Rx3
Rx7	

Table 6 - Electrical Input/ Output to Wavelength Mapping in 400G Mode

Electrical signal	Wavelength
Tx0	Tx0
Tx1	Tx1
Tx2	Tx2
Tx3	Tx3
Tx4 (turned off)	
Tx5 (turned off)	
Tx6 (turned off)	
Tx7 (turned off)	
Rx0	Rx0
Rx1	Rx1
Rx2	Rx2
Rx3	Rx3
Rx4 (turned off)	
Rx5 (turned off)	
Rx6 (turned off)	
Rx7 (turned off)	

Table 7 - Electrical Input/ Output to Wavelength Mapping in 200G Mode

In the 200G mode, four electrical lanes 4-7 shall be turned off. Four remaining electrical lanes (0-3) shall be modulated onto four CWDM4 optical wavelengths. The lane mapping for module in 200G mode is defined in Table 7.

9. Management Interface

The module is compliant to Common Management Interface Specification (CMIS) Rev. 4.0.

10. Labels and Marking

The label shall not interfere with the mechanical, thermal, or EMI features.

Parameter	Value
Pull tab color	Purple (Pantone code: Medium Purple C; RGB: 78/0/142)
Pull tab marking	“400G-FR4” embossed
Label information	Part number, serial number, optical wavelength, operating data rate, interface standard supported, link length supported, manufacturing country

Table 8 - Label and Marking

11. EMC

Vendor will provide an EMC report from a certified test lab. Module EMC report will include the following tests.

1. Radiated emissions
2. Electrostatic discharge immunity
3. Radiated EM field immunity

Testing must be conducted on a minimum of two modules and may be tested in a vendor-designed, 1-up test fixture. For testing on an individual module, radiated emissions must comply with CISPR 22 (EN55022) for class B products. ESD and radiated immunity must comply with CISPR 24 (EN55024).
For ESD immunity, test level 4 is to be used.
In addition to module-level EMC testing, it might be required that the vendor's modules are compliant in fully-loaded switch-level testing with OCP switches as well.

12. Quality and Reliability

This product should come with proper Quality Control Plan after the reliability test passes. Customer may reserve the right to keep their own quality control plan. The product should at least meet Telcordia GR-468-CORE issue 2.

13. Revisions

Revision	Date	Description
0.1	09/13/2021	Initial draft for review