International Photonics & Electronics Committee

400G eSR4 & 800G eSR8 Implementation Agreement

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400G eSR4&800G eSR8 Implementation Agreement

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400G eSR4&800G eSR8 Implementation Agreement

Summary

The objective of this document is to define 400 Gb/s and 800G Gb/s PMD for operation over multi-mode fibers (MMF) with lengths up to at least 150 m.

Keywords

400G eSR4, 800G eSR8, eSR, MMF, PAM4

Working Group: PMD

TITLE: 400G eSR4&800G eSR8 Implementation Agreement

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Revision History

Rev	Date	Description
V1.0	2026-04-13	Updated the member list and version to V1.0.
D0.3	2026-01-08	Add requirements for RMS and fiber EMB specifications, and made some editorial revisions.
D0.2	2025-12-01	Revision of chapter 6 optical interface
D0.1	2025-09-29	Initial release of this IA.

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1 Introduction

This Implementation Agreement (IA) specifies physical layer specifications and parameters for 400 Gb/s and 800 Gb/s optical interfaces.

The objective of this document is to define 400 Gb/s and 800 Gb/s Physical Medium Dependent (PMD) sublayer for operation over multi-mode fibers (MMF) with lengths up to at least 150 m.

1.1 Scope

This IA defines an optical interface for 400 Gb/s and 800 Gb/s optical transceivers in Ethernet applications. Forward error correction (FEC) is required to be implemented by the host to ensure reliable system operation. The transceiver communicates over MMF of lengths from 2 meters up to at least 150 meters. The transceiver's electrical interface is not specified by this IA.

A variety of form factors for the transceivers are possible and none are precluded by this IA.

1.2 Hardware Signaling Pins

Hardware signaling pins are specified in the multi-source agreements (MSAs) of respective module form factors.

1.3 Module Management Interface

The contents of the various ID registers shall comply with the requirements of the module MSAs.

1.4 High-Speed Electrical Characteristics

The detailed high-speed electrical characteristics are not defined by this IA. The defined modules should be implemented in compliance with applicable electrical interface specifications.

1.5 FEC Requirements

400GE links rely on the host system implementing the 400GBASE-R PCS layer in accordance with clauses from the IEEE Std 802.3-2022™ and IEEE Std 802.3ck-2022™.

1.6 Mechanical Dimensions

Mechanical dimensions are defined in the MSA specifications of module form factors. This IA does not specify the use of a specific form factor.

Figure 1 shows the block diagrams of 400G eSR4 and 800G eSR8 modules.

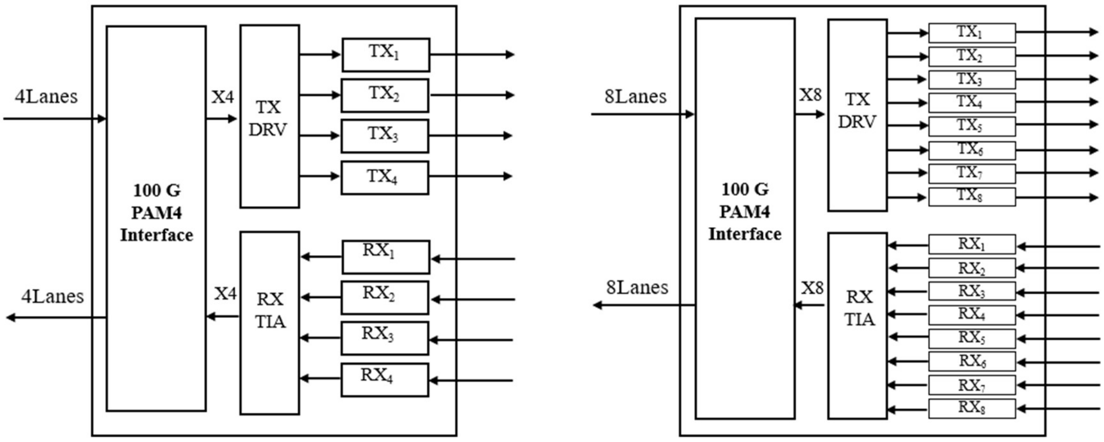

Figure 1 400G eSR4&800G eSR8 module block diagram

2 400G eSR4&800G eSR8 Optical Specifications

This IA defines the 100G/Lane MMF optical interface for 400 Gb/s&800Gb/s optical transceivers. The following tables show the common parameters: operating range, optical transmit characteristics, optical receive characteristics and optical link budget.

Table 1 400G eSR4&800G eSR8 operating range

PMD Type	Required Operating Range
400G eSR4&800G eSR8	2 m to 150 m for OM4

Table 2 400G eSR4&800G eSR8 optical transmit characteristics

Description	Value	Unit
Signaling rate (range)	53.125±50 ppm	GBd
Modulation format	PAM4	-
Wavelength (range)	844 to 863	nm
RMS spectral width	0.45	nm
Average launch power, each lane (max)	4	dBm
Average launch power, each lane (min)	-4.1	dBm
Outer optical modulation amplitude (OAMouter) (max)	3.5	dBm

Outer optical modulation amplitude (OMAouter) (min) for TDECQ < 1.8 dB for 1.8 dB ≤ TDECQ ≤ 4.4 dB	-2.1 -3.9+TDECQ	dBm
Transmitter and dispersion eye closure for PAM4 (TDECQ) (max)	4.4	dB
Transmitter eye closure for PAM4 (TECQ), each lane (max)	4.4	dB
Average launch power of OFF transmitter (max)	-30	dBm
Extinction ratio (min)	2.5	dB
Transmitter transition time (max)	17	ps
$RIN_{12}OMA$ (max)	-132	dB/Hz
Optical return loss tolerance (max)	14	dB
Encircled flux, each lane	≥ 86% @ 19 µm ≤ 30% @ 4.5 µm	

Table 3 400G eSR4&800G eSR8 optical receive characteristics

Description	Value	Unit
Signaling rate (range)	53.125±50 ppm	GBd
Modulation format	PAM4	-
Wavelengths (range)	842 to 948	nm
Damage threshold, each lane	5	dBm
Average receive power, each lane(max)	4	dBm
Average receive power, each lane (min)	-6.4	dBm
Receive power (OMAouter), each lane (max)	3.5	dBm
Receiver reflectance (max)	-15	dB
Receiver sensitivity (OMAouter) (max)	RS = max (-4.6, TECQ – 6.4)	dBm
Stressed receiver sensitivity (OMAouter) (max)	-2	dBm
Conditions of stressed receiver sensitivity test:		
Stressed eye closure for PAM4 (SECQ)	4.4	dB
OMAouter of each aggressor lane	3.5	dBm

Table 4 400G eSR4&800G eSR8 optical link budget

Description	Value	Unit
Effective modal bandwidth at 850 nm[a]	4700	MHz.km
Power budget (for max TDECQ):	6.9	dB
Operating distance	0.5 to 150	m
Channel insertion loss[b]	2.3	dB
Maximum discrete reflectance	-35	dB
Allocation for penalties (for max TDECQ):	4.6	dB
Additional insertion loss allowed	0	dB

[a] Per IEC 60793-2-10.

[b] The channel insertion loss is calculated using the maximum distance specified in Table 1 with a cabled optical fiber attenuation of 3.5 dB/km at 850 nm plus a 1.7 dB allocation for total connection and splice loss.

2.1 400G eSR4&800G eSR8 Illustrative Link Power Budget

Figure 2 shows 400G eSR4&800G eSR8 optical link budget and sensitivity mask.

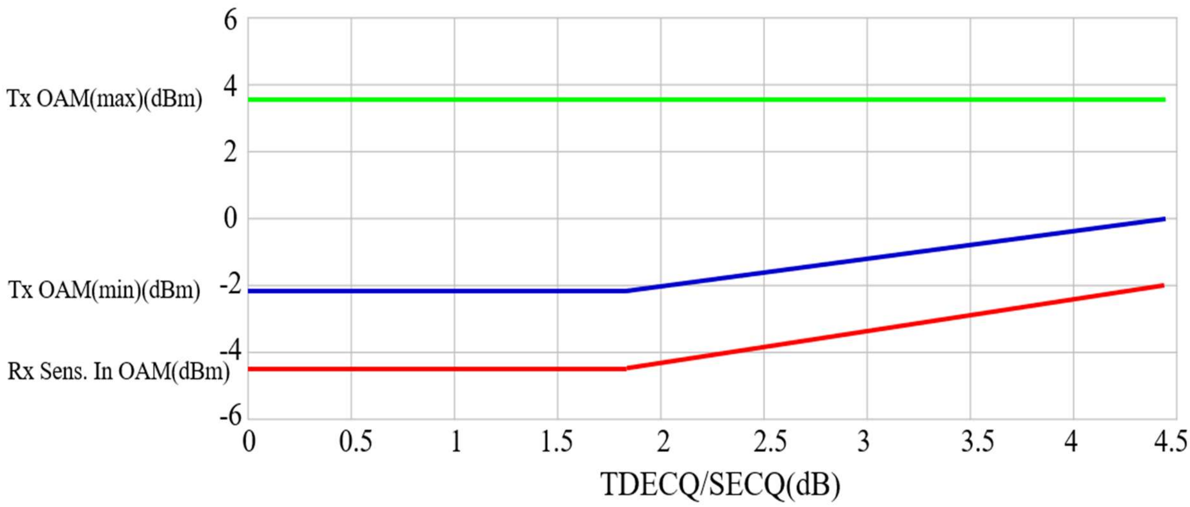

Figure 2 400G eSR4&800G eSR8 optical link budget and sensitivity mask

3 Definition of Optical Parameters and Measurement Methods

The specific test patterns are defined in Table 138-11 of IEEE Std 802.3-2022 [1].

3.1 Test Patterns for Optical Parameters

Detailed information on the test patterns for optical parameters is available in Clause 138.8.1 of IEEE Std 802.3-2022 [2].

3.2 Skew and Skew Variation

The skew and skew variation are available in Clause 138.3 of IEEE Std 802.3-2022 [1].

3.3 Wavelength and Spectral Width

The center wavelength and RMS spectral width of each optical lane shall be within the range given in Table 3 if measured per IEC 61280-1-3. The lane under test should be modulated using test patterns specified in Clause 3.1.

3.4 Average Optical Power

The specific average optical power shall be within the limit given in Table 2 if measured per IEC 61280-1-1 and using one of the test patterns specified in Clause 3.1.

3.5 Optical Modulation Amplitude (OMAouter)

The specific definition of OMAouter is defined in Clause 121.8.4 of IEEE Std 802.3-2022 [1].

3.6 Transmitter and Dispersion Eye Closure for PAM4 (TDECQ)

The methodology of TDECQ is specified in Clause 167.8.6 of IEEE Std 802.3-2022 [2].

3.6.1 TDECQ Reference Equalizer

The TDECQ reference equalizer is defined in Clause 167.8.7 of IEEE Std 802.3-2022 [2].

3.7 Extinction Ratio

The test method of extinction ratio is defined in Clause 121.8.6 of IEEE Std 802.3-2022 [1]. The extinction ratio of each lane shall be compliant to the limit listed in Table 2.

3.8 Transmitter Transition Time

The test method of transmitter transition time is defined in Clause 138.8.7 of IEEE Std 802.3-2022 [1]. The transmitter transition time of each lane shall be compliant to the limit listed in Table 2.

3.9 Relative Intensity Noise ($RIN_{12}OMA$)

The test method of $RIN_{12}OMA$ is defined in Clause 138.8.8 of IEEE Std 802.3-2022 [1]. $RIN_{12}OMA$ of each lane shall be compliant to the limit listed in Table 2.

3.10 Receiver Sensitivity

The test method of $RIN_{12}OMA$ is defined in Clause 138.8.8 of IEEE Std 802.3-2022 [1]. $RIN_{12}OMA$ of each lane shall be compliant to the limit listed in Table 2.

3.11 Stressed Receiver Sensitivity

The test method of stressed receiver sensitivity is defined in Clause 138.8.10 of IEEE Std 802.3-2022 [1].

4 Fiber Optic Cabling Model

The fiber optic cabling model of 400G eSR4&800G eSR8 is shown in **Figure 3**.

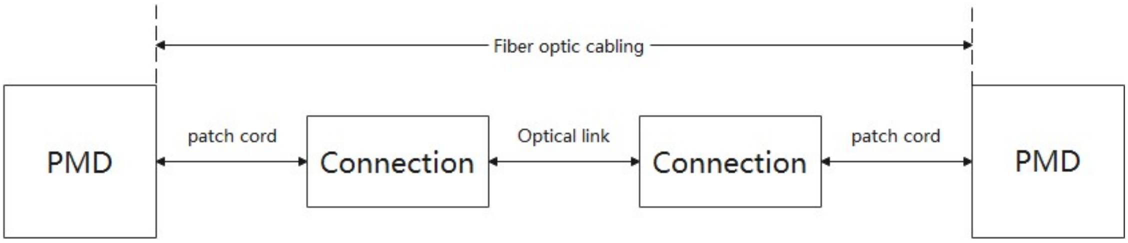

Figure 3 Fiber optic cabling model

5 Characteristics of the Fiber Optic Cabling (Channel)

The channel insertion loss is calculated using the maximum distance specified in Table 1 with a cabled optical fiber attenuation of 3.5 dB/km at 850 nm plus a 1.7 dB allocation for total connection and splice loss. The fiber optic cabling requirements for 400G eSR4&800G eSR8 are specified in Table 5

Table 5 Fiber optic cabling characteristics (channel) for 400G eSR4&800G eSR8

Description	400G eSR4&800G eSR8	Unit
Operating distance (max)	150	m
Channel insertion loss[a] (max)	2.3	dB
Cabling skew (max)	79	ns
Cabling skew variation	4.8	ns
Discrete reflectance (max)	-35	dB
Additional loss allowed	0	dB

[a] The channel insertion loss includes connectors, splices etc.

6 Optical Interfaces

This specification defines two mandatory Media Dependent Interfaces (MDIs). The spatial alignment of transmit (Tx) and receive (Rx) optical lanes shall comply with the geometric configurations defined in Figure 4 , Figure 5 and figure 6 when viewed with the connector keying feature oriented in the upward position.

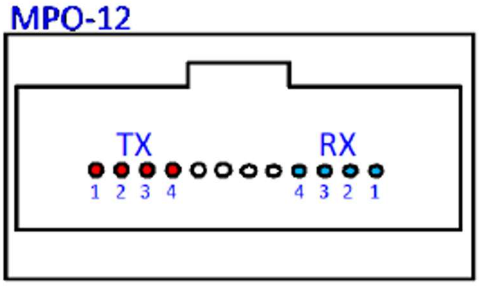

Figure 4 MPO-12 MDI

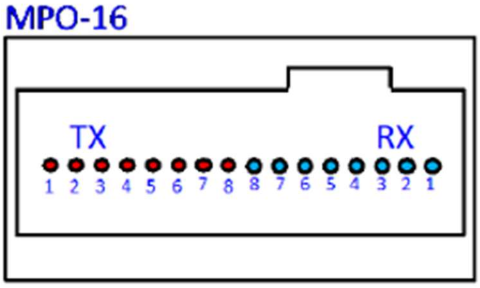

Figure 5 MPO-16 MDI

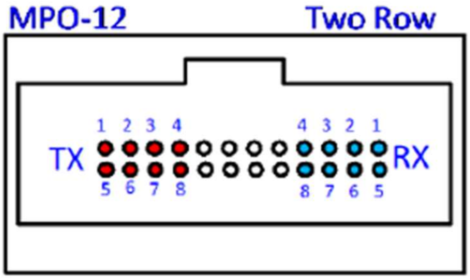

Figure 6 MPO-12 Two Row MDI

MPO (Multi-fiber Push-On) connectors utilize rectangular ferrules to align and secure optical fibers in standardized arrays (e.g., 16, or 24 fibers see Figure 8&9). Connector keying and polarization shall comply with IEC 61754-7 and TIA-604-5 specifications, ensuring consistent Tx/Rx channel assignment per predefined fiber sequences.

Figure 7 MPO-12 One row optical connector and module receptacle

Figure 8 MPO-16 One row optical connector and module receptacle

Figure 9 MPO-12 Two rows optical connector and module receptacle

This specification introduces two additional Media Dependent Interfaces (MDIs) that utilize Very Small Form Factor (VSFF) connectors, offering further flexibility in optical module design and deployment.
Figure 10 shows channel orientation when a SN-MT connector with 16 fibers is used in a transceiver module

Figure 11 shows channel orientation when a SN-MT connector with 2x12 fibers is used in a transceiver module

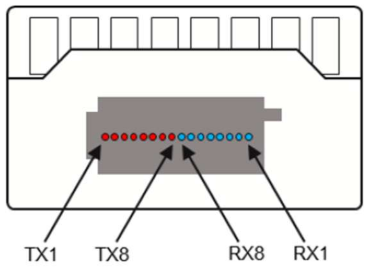

Figure 10 SN-MT-16 MDI

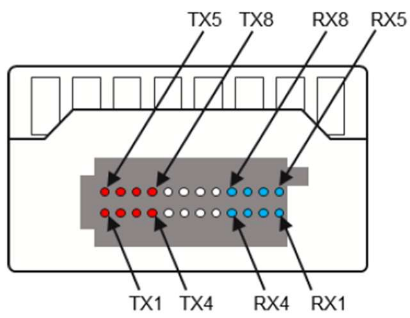

Figure 11 SN-MT-12 Two Row MDI

VSFF (Very Small Form Factor) connectivity is to deliver twice as many optical channels within the standard footprint of transceivers, utilizing smaller rectangular ferules to align and secure optical fibers in standardized arrays (e.g., 16, or 24 fibers see Figure 12&13).

Figure 12 SN-MT-16 One Row Connector

Figure 13 SN-MT-12 Two Row Connector

7 References

7.1 Normative References

1. IEEE Std 802.3-2022: IEEE Standard for Ethernet
2. IEEE Std 802.3db-2022: IEEE Standard for Ethernet Amendment 3: Physical Layer Specifications and Management Parameters for 100 Gb/s, 200 Gb/s, and 400 Gb/s Operation over Optical Fiber Using 100 Gb/s Signaling
3. IEEE Std 802.3ck-2022™ IEEE Standard for Ethernet Amendment 4: Physical Layer Specifications and Management Parameters for 100 Gb/s, 200 Gb/s, and 400 Gb/s Electrical Interfaces Based on 100 Gb/s Signaling

8 Appendix A: Abbreviations and Acronyms

The following abbreviations and acronyms are used in this IA:

DeMUX	Demultiplexer
DGD	Differential Group Delay
DRV	Driver
FEC	Forward Error Correction
IA	Implementation Agreement
MSA	Multisource Agreement
MUX	Multiplexer
OMA	Optical Modulation Amplitude
OMAouter	Outer Optical Modulation Amplitude
PCS	Physical Coding Sublayer
PMA	Physical Medium Attachment
PMD	Physical Medium Dependent

PRBS	Pseudo-Random Bit Sequence
QSFP	Quad Small Form Factor Pluggable
RIN	Relative Intensity Noise
RX	Receiver
SECQ	Stressed Eye Closure for PAM4
SMF	Single Mode Fiber
SMSR	Side-Mode Suppression Ratio
SSPRQ	Short Stress Pattern Random Quaternary
TDECQ	Transmitter and Dispersion Eye Closure for PAM4
TIA	Transimpedance Amplifier
TX	Transmitter

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