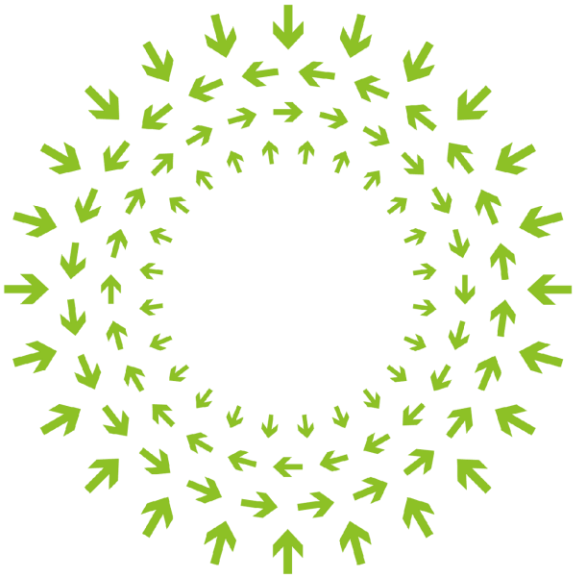


OPEN
Compute Project

Optical Transceiver

100G QSFP28 LR4

OCP Immersion Active Optical Pigtail (iAOP)

Specification V0.1

Product Specification
Effective July 15th, 2025

Author: Eric Chen, FormericaOE

Compliance with OCP Tenants

Openness

By migrating the Immersion Active Optical Cable & Pigtail Specifications to the Open Compute foundation, they become open to all to review and implement. In addition, the broad membership of the OCP is able to contribute to the future development of the specification.

Efficiency

The purpose of the Immersion Active Optical Cable Specification is to drive commonality in implementations of iAOCs/iAOPs in order to reduce friction in adoption users. This directly reduces opex in the form of qualifications and firmware work to adapt to different iAOC/iAOP implementations.

Impact

Immersion Active Optical Cables or Pigtails have proven to be essential components of hyperscale and service provider networks in order to enable high speed, low cost, low power and highly reliable networks. Migrating this specification to OCP drives commonality in these implementations and a broader membership base to widen impact.

Scale

Multiple hyperscalers have deployed or are planning to deploy Active Optical Cables. Soon they shall be deployed in immersion cooling.
Similarly to optical connectors in Air/DLC, the CMIS/DDMI monitoring functions ensure the Data Center Fabric is performing at its optimal.

Sustainability

Active Optical Cables & Pigtails ease fabric connection complexity. Immersion Active Optical Cables & Pigtails allows the fabric to function in immersion cooling, which lowers PUE of data centers for AI/ML/HPC.

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Scope and Overview

1.1 Scope

This document defines the technical specifications for the 100G QSFP28 LR4 OCP Immersion Active Optical Pigtail (iAOP) used in large-scale data center applications.

1.2 Overview

The 100G QSFP28 LR4 iAOP OCP optical specification is based on 100GBASE-LR4 as defined in IEEE 802.3 ba.

This optimization involves the adoption of coolant-compatible materials, preservation of optical path integrity, and validated thermal performance to ensure reliable operation in immersion liquid-cooling environments. Considering the characteristics of liquid cooling fluid and the operation mode of the cooling system, temperature specifications of the product have been relaxed. The temperature range shall be relaxed from 0-70°C to RT-70°C. (Note, the RT value depends on dew point of the air).

While this specification is focused on 100G operation, the module shall be compliant to the IEEE 802.3 ba.

2 Common Terms

The following terms are used in this document

2.1 Parameter related

AOP - Average Optical Power
OMA - Optical Modulation Amplitude
TDECQ - Transmitter Dispersion Eye Closure Quaternary
ER - Extinction Ratio
SMSR - Side Mode Suppression Ratio
BER - Bit Error Rate
FEC - Forward Error Correction
PAM4 - 4-level Pulse Amplitude Modulation
Gbps - Gigabit per second
GBd - Gigabaud

2.2 Product related

iAOP - Immersion Active Optical Pigtail
iAOC - Immersion Active Optical Cable
AOC - Active Optical Cable
CT - Commercial Temperature
IT - Industrial Temperature
LPMode - Low Power Mode
I2C - Inter-Integrated Circuit
SR - Short reach
LR - Long reach

2.3 Fiber

MMF - Multi-Mode Fiber
SMF - Single-Mode Fiber
OM3 - Optical Multimode 3
PC - Physical Contact
APC - Angled Physical Contact
MPO - Multiple-Fiber Push-On

2.4 Standard

CWDM - Coarse Wavelength Division Multiplex
IEEE - Institute for Electrical and Electronics Engineers
MSA - Multi-Source Agreement
SFF - Small Form Factor
QSFP - Quad Small Form Factor Pluggable
QSFP112 - Quad Small Form Factor Pluggable Module 112
QSFP-DD - QSFP–Double Density
OSFP - Octal Small Form Factor Pluggable Module
OSFP-RHS - OSFP-Riding Heat Sink
CMIS - Common Management Interface Specification

3 Operating Conditions

Recommended Operating Conditions		
Parameters	**Value**	**Unit**
Case Operating Temperature	**RT ~ 70** **Note1**	℃
Power Supply Voltage (Typical)	3.3	V
Power Consumption (Max)	4	W
Data Rate per Channel (Typical)	25.78125 +/- 100ppm	Gb/s

Note1: RT (Room Temp) value depends on dew point of the air

4 Specifications

4.1 Electrical Transmitter Characteristic

Electrical Transmitter Characteristics		
Parameters	**Value**	**Unit**
Differential Input Voltage Swing	180 ~ 900	mV
Tx Differential Input Impedance	100	Ohm
Differential input return loss	IEEE 802.3 ba	dB
Common mode input return loss	IEEE 802.3 ba	dB

4.2 Electrical Receiver Characteristic

Electrical Receiver Characteristics		
Parameters	**Value**	**Unit**
Differential Output Voltage Swing	300 ~ 900	mV
Rx Differential Output Impedance	100	Ohm
Differential input return loss	IEEE802.3 ba	dB
Common mode output return loss	IEEE 802.3 ba	dB

4.3 Optical Transmitter Characteristic

Optical Transmitter Characteristics		
Parameters	**Value**	**Unit**
Center Wavelength (range)	CH1 1294.53 ~ 1296.59	nm
	CH2 1299.02 ~ 1301.09	
	CH3 1303.54 ~ 1305.63	
	CH4 1308.09 ~ 1310.19	
Average Launch Optical Power, each lane	-4.3 ~ 4.5	dBm
Total Average Launch Power (max)	10.5	dBm
Average Lunch Power of OFF transmitter, each lane (max)	-30	dBm
OMA, each lane	-1.3 ~ 4.5	dBm
ER (min)	4	dB
Side Mode Suppression Ratio	30	dB
Optical Return Loss Tolerance (max)	20	dB
Transmit Reflectance (max)	-12	dB

4.4 Optical Receiver Characteristics

Optical Receiver Characteristics		
Parameters	**Value**	**Unit**
Center Wavelength (range)	CH1 1294.53 ~ 1296.59	nm
	CH2 1299.02 ~ 1301.09	
	CH3 1303.54 ~ 1305.63	
	CH4 1308.09 ~ 1310.19	
Damage Threshold (min)	5.5	dBm
Receiver Sensitiity (OMA), each lane (max)	-8.6 note 1	dBm
Average Receive Power, each lane	-10.6 ~ 4.5	dBm
Receiver Power, each lane (OMA) (max)	4.5	dBm

Note1: Sensitivity is specified at BER = 1E-12

4.5 Optical Fiber Link Model

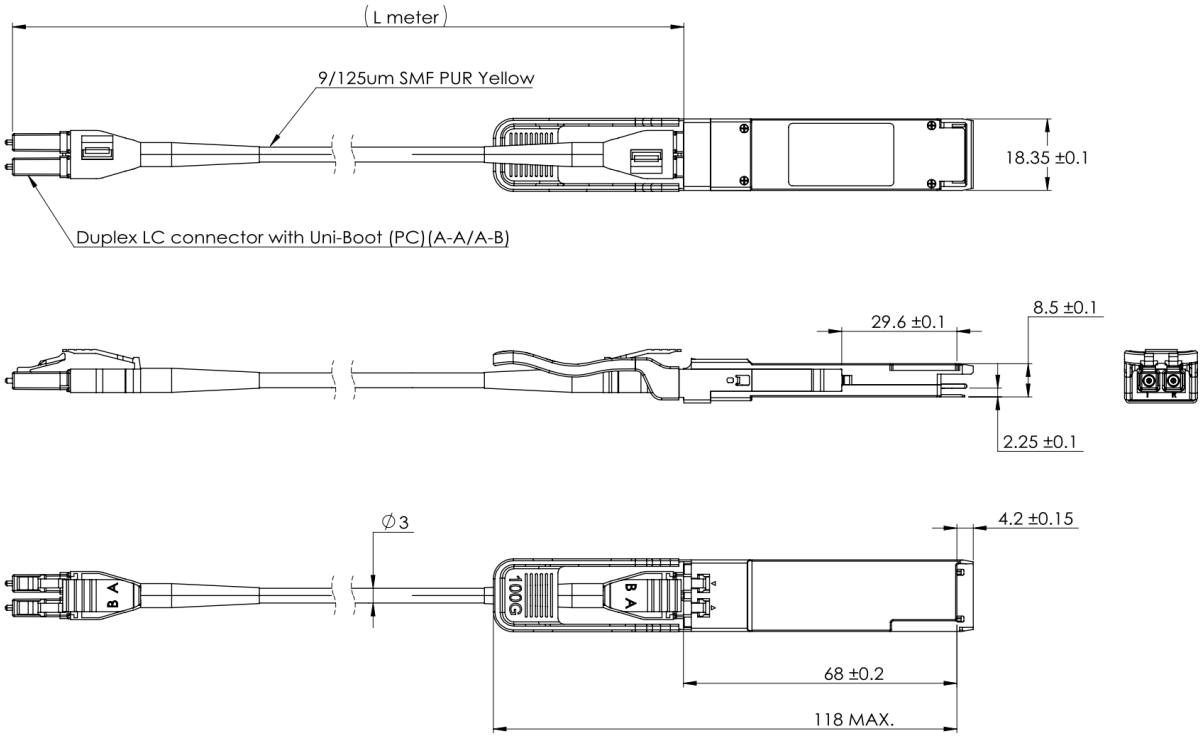
The reference optical fiber link model is based on SMF fiber. The distance. Refer to IEEE 802.3 ba.

Optical Fiber Link Model	
100GBase-LR4	2m to 10Km for SMF

5 Form Factor

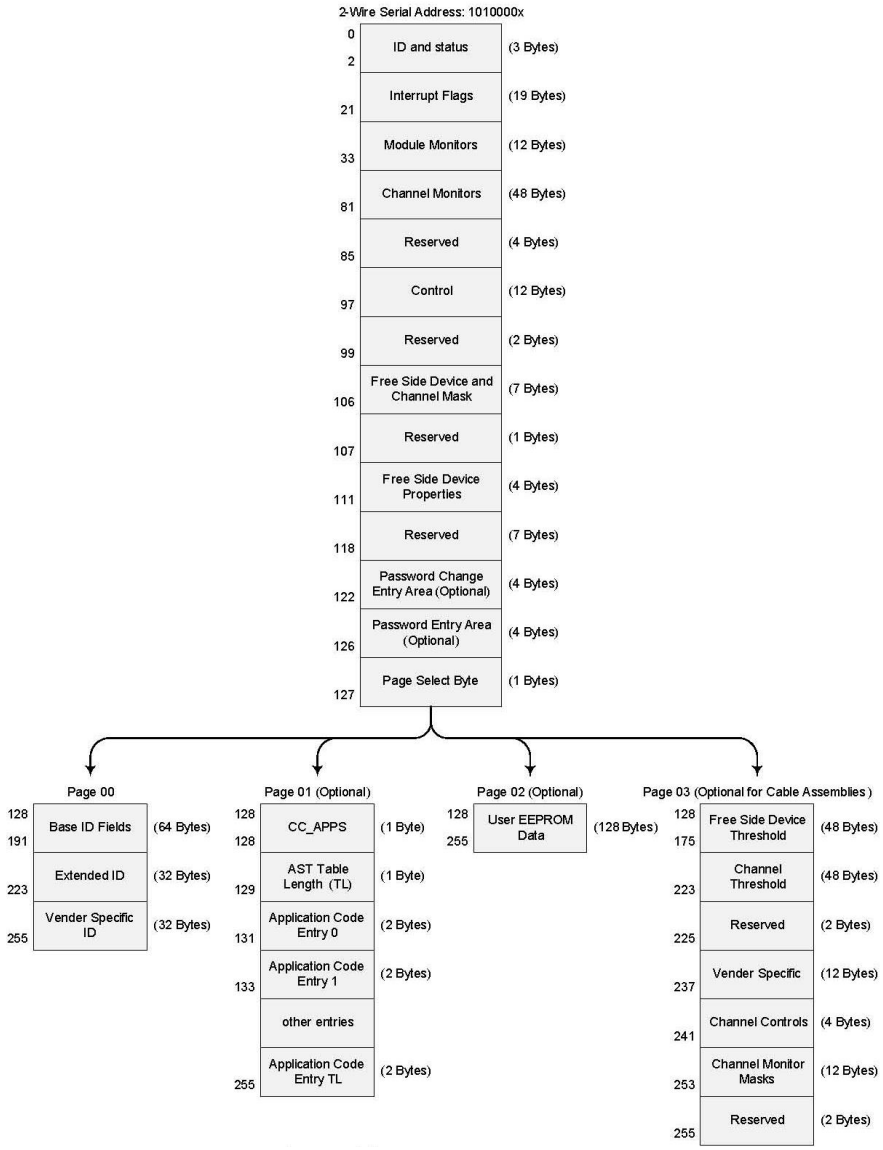
The QSFP28 form factor described in SFF-8665 shall be used. This form factor is commonly referred to as QSFP28 for 100G applications.

5.1 Mechanical Drawing



6 Management Interface

The module is compliant to SFF-8636.



7 Immersion Cooling Requirements

Immersion products must be materially compatible with the immersion fluid and perform equal or better in the immersion fluid.

This involves utilizing the testing conditions specified in the OCP “Material Compatibility in Immersion Cooling” guideline (80°C, 0.8L, 336 hours) and adhering to the acceptance criteria to determine if the material is compatible (< 10% change in weight, length, diameter, etc. before and after test).

Only compatible materials should be used in immersion products.

8 References

The following documents are referenced in this specification:

IEEE 802.3 ba
SFF-8636
SFF-8665
SFF-8661
SFF-8662
SFF-8679
OCP Material Compatibility in Immersion Cooling Rev 1.0
OCP Immersion Requirements Rev 2.1

9 Revisions

Rev	Date	Description
0.1	July 15th, 2025	Initial Release