



## Features:

- ✧ 4 independent full-duplex channels
- ✧ Up to 28Gb/s data rate per channel
- ✧ Hot pluggable QSFP28 MSA form factor
- ✧ Compliant to IEEE 802.3bm

100GBASE-PSM4

- ✧ Up to 2km reach for G.652 SMF
- ✧ Maximum power consumption 3.5W
- ✧ Single +3.3V power supply
- ✧ Operating case temperature: 0~70°C
- ✧ RoHS-6 compliant

## Applications:

- ✧ 100G Ethernet Links
- ✧ Infiniband QDR and DDR interconnects
- ✧ Datacenter and Enterprise networking

### Part Number Ordering Information

|          |   |
|----------|---|
| OPQE02-4 | QSFP28 IR4 2km optical transceiver with full real-time digital diagnostic monitoring and pull tab |
|----------|---|

## 1. General Description

This product is a parallel 100Gb/s Quad Small Form-factor Pluggable (QSFP28) optical module. It provides increased port density and total system cost savings. The QSFP28 full-duplex optical module offers 4 independent transmit and receive channels, each capable of 25Gb/s operation for an aggregate data rate of 100Gb/s on 2km of single mode fiber.

An optical fiber ribbon cable with an MTP/MPO connector can be plugged into the QSFP28 module receptacle. Proper alignment is ensured by the guide pins inside the receptacle. The cable usually cannot be twisted for proper channel to channel alignment. Electrical connection is achieved through an MSA-compliant 38-pin edge type connector.

The module operates with single +3.3V power supply. LVCMOS/LVTTL global control signals, such as Module Present, Reset, Interrupt and Low Power Mode, are available with the modules. A 2-wire serial interface is available to send and receive more complex control signals, and to receive digital diagnostic information. Individual channels can be addressed and unused channels can be shut down for maximum design flexibility.

The product is designed with form factor, optical/electrical connection and digital diagnostic interface according to the QSFP28 Multi-Source Agreement (MSA). It has been designed to meet the harshest external operating conditions including temperature, humidity and EMI interference. The module can be managed through the I2C two-wire serial interface.

## 2. Functional Description

This product is a QSFP28 parallel single mode optical transceiver with an MTP/MPO fiber ribbon connector. The transmitter module accepts electrical input signals compatible with Common Mode Logic (CML) levels. All input data signals are differential and internally terminated. The receiver module converts parallel optical input signals via a photo detector array into parallel electrical output signals. The receiver

module outputs electrical signals are also voltage compatible with Common Mode Logic (CML) levels. All data signals are differential and support a data rates up to 25Gb/s per channel. Figure 1 shows the functional block diagram of this product.

A single +3.3V power supply is required to power up the module. Both power supply pins VccTx and VccRx are internally connected and should be applied concurrently. Per MSA the module offers 7 low speed hardware control pins (including the 2-wire serial interface): ModSelL, SCL, SDA, ResetL, LPMode, ModPrsL and IntL.

Module Select (ModSelL) is an input pin. When held low by the host, the module responds to 2-wire serial communication commands. The ModSelL allows the use of multiple QSFP28 modules on a single 2-wire interface bus – individual ModSelL lines for each QSFP28 module must be used.

Serial Clock (SCL) and Serial Data (SDA) are required for the 2-wire serial bus communication interface and enable the host to access the QSFP28 memory map.

The ResetL pin enables a complete module reset, returning module settings to their default state, when a low level on the ResetL pin is held for longer than the minimum pulse length. During the execution of a reset the host shall disregard all status bits until the module indicates a completion of the reset interrupt. The module indicates this by posting an IntL (Interrupt) signal with the Data\_Not\_Ready bit negated in the memory map. Note that on power up (including hot insertion) the module should post this completion of reset interrupt without requiring a reset.

Low Power Mode (LPMode) pin is used to set the maximum power consumption for the module in order to protect hosts that are not capable of cooling higher power modules, should such modules be accidentally inserted.

Module Present (ModPrsL) is a signal local to the host board which, in the absence of a module, is normally pulled up to the host Vcc. When a module is inserted into the connector, it completes the path to ground through a resistor on the host board and asserts the signal. ModPrsL then indicates a module is present by setting ModPrsL to a “Low” state.

Interrupt (IntL) is an output pin. Low indicates a possible module operational fault or a status critical to the host system. The host identifies the source of the interrupt using the 2-wire serial interface. The IntL pin is an open collector output and must be pulled to the Host Vcc voltage on the Host board.

### 3. Transceiver Block Diagram

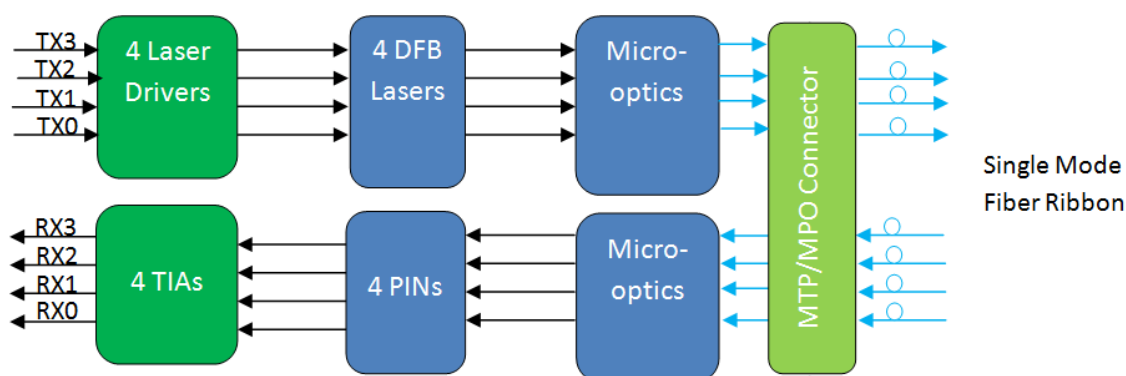


Figure 1. Transceiver Block Diagram

### 4. Pin Assignment and Description

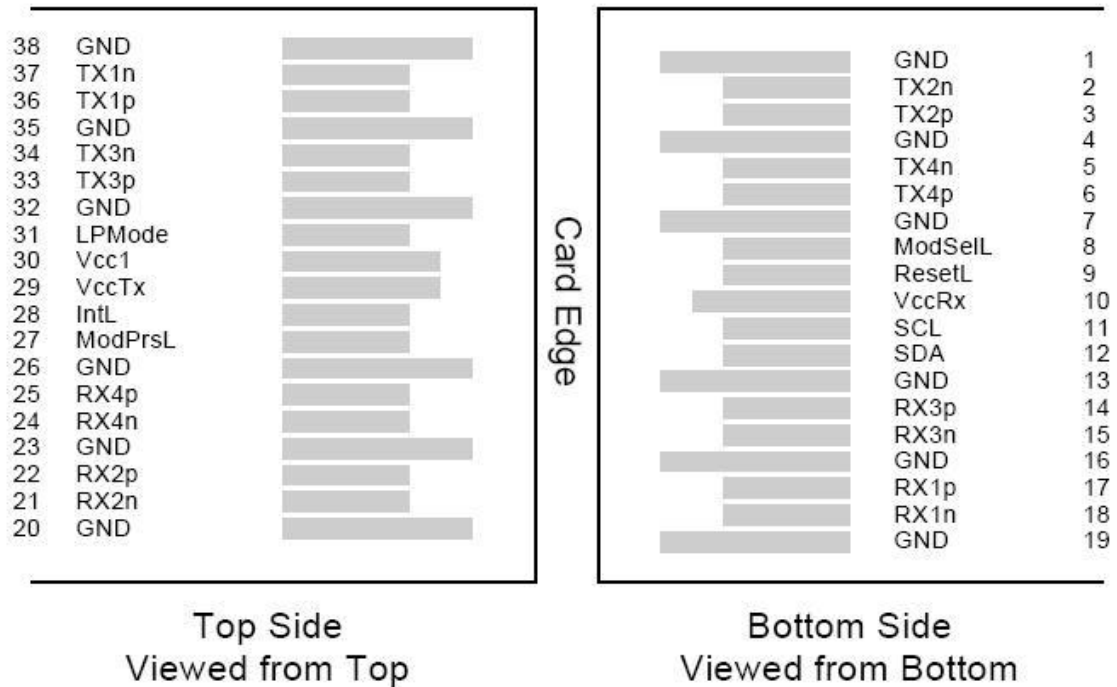


Figure 2. QSFP28 Transceiver Electrical Connector Layout

### Pin Definition

| PIN | Logic       | Symbol  | Name/Description                     | Notes |
|-----|-------------|---------|--------------------------------------|-------|
| 1   |             | GND     | Ground                               | 1     |
| 2   | CML-I       | Tx2n    | Transmitter Inverted Data Input      |       |
| 3   | CML-I       | Tx2p    | Transmitter Non-Inverted Data output |       |
| 4   |             | GND     | Ground                               | 1     |
| 5   | CML-I       | Tx4n    | Transmitter Inverted Data Input      |       |
| 6   | CML-I       | Tx4p    | Transmitter Non-Inverted Data output |       |
| 7   |             | GND     | Ground                               | 1     |
| 8   | LVTTLL-I    | ModSelL | Module Select                        |       |
| 9   | LVTTLL-I    | ResetL  | Module Reset                         |       |
| 10  |             | VccRx   | +3.3V Power Supply Receiver          | 2     |
| 11  | LVC MOS-I/O | SCL     | 2-Wire Serial Interface Clock        |       |
| 12  | LVC MOS-I/O | SDA     | 2-Wire Serial Interface Data         |       |
| 13  |             | GND     | Ground                               |       |
| 14  | CML-O       | Rx3p    | Receiver Non-Inverted Data Output    |       |
| 15  | CML-O       | Rx3n    | Receiver Inverted Data Output        |       |
| 16  |             | GND     | Ground                               | 1     |
| 17  | CML-O       | Rx1p    | Receiver Non-Inverted Data Output    |       |
| 18  | CML-O       | Rx1n    | Receiver Inverted Data Output        |       |

|    |         |         |                                     |   |
|----|---------|---------|-------------------------------------|---|
| 19 |         | GND     | Ground                              | 1 |
| 20 |         | GND     | Ground                              | 1 |
| 21 | CML-O   | Rx2n    | Receiver Inverted Data Output       |   |
| 22 | CML-O   | Rx2p    | Receiver Non-Inverted Data Output   |   |
| 23 |         | GND     | Ground                              | 1 |
| 24 | CML-O   | Rx4n    | Receiver Inverted Data Output       | 1 |
| 25 | CML-O   | Rx4p    | Receiver Non-Inverted Data Output   |   |
| 26 |         | GND     | Ground                              | 1 |
| 27 | LVTTL-O | ModPrsL | Module Present                      |   |
| 28 | LVTTL-O | IntL    | Interrupt                           |   |
| 29 |         | VccTx   | +3.3 V Power Supply transmitter     | 2 |
| 30 |         | Vcc1    | +3.3 V Power Supply                 | 2 |
| 31 | LVTTL-I | LPMoDe  | Low Power Mode                      |   |
| 32 |         | GND     | Ground                              | 1 |
| 33 | CML-I   | Tx3p    | Transmitter Non-Inverted Data Input |   |
| 34 | CML-I   | Tx3n    | Transmitter Inverted Data Output    |   |
| 35 |         | GND     | Ground                              | 1 |
| 36 | CML-I   | Tx1p    | Transmitter Non-Inverted Data Input |   |
| 37 | CML-I   | Tx1n    | Transmitter Inverted Data Output    |   |
| 38 |         | GND     | Ground                              | 1 |

**Notes:**

1. GND is the symbol for signal and supply (power) common for QSFP28 modules. All are common within the QSFP28 module and all module voltages are referenced to this potential unless otherwise noted. Connect these directly to the host board signal common ground plane.
2. VccRx, Vcc1 and VccTx are the receiver and transmitter power suppliers and shall be applied concurrently. Recommended host board power supply filtering is shown in Figure 3 below. Vcc Rx, Vcc1 and VccTx may be internally connected within the QSFP28 transceiver module in any combination. The connector pins are each rated for a maximum current of 1000mA.

**5. Recommended Power Supply Filter**

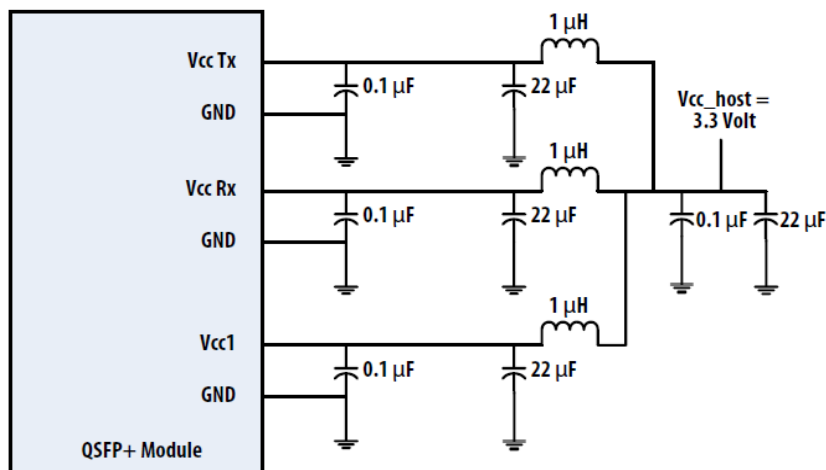


Figure 3. Recommended Power Supply Filter

## 6. Absolute Maximum Ratings

It has to be noted that the operation in excess of any individual absolute maximum ratings might cause permanent damage to this module.

| Parameter                            | Symbol   | Min  | Max | Units | Note |
|--------------------------------------|----------|------|-----|-------|------|
| Storage Temperature                  | $T_S$    | -40  | 85  | degC  |      |
| Operating Case Temperature           | $T_{OP}$ | 0    | 70  | degC  |      |
| Power Supply Voltage                 | $V_{CC}$ | -0.5 | 3.6 | V     |      |
| Relative Humidity (non-condensation) | RH       | 0    | 85  | %     |      |
| Damage Threshold, each Lane          | $TH_d$   | 4.5  |     | dBm   |      |

## 7. Recommended Operating Conditions and Power Supply Requirements

| Parameter                  | Symbol   | Min   | Typical  | Max      | Units |
|----------------------------|----------|-------|----------|----------|-------|
| Operating Case Temperature | $T_{OP}$ | 0     |          | 70       | degC  |
| Power Supply Voltage       | $V_{CC}$ | 3.135 | 3.3      | 3.465    | V     |
| Data Rate, each Lane       |          |       | 25.78125 |          | Gb/s  |
| Control Input Voltage High |          | 2     |          | $V_{CC}$ | V     |
| Control Input Voltage Low  |          | 0     |          | 0.8      | V     |
| Link Distance with G652    | D        | 0.002 |          | 2        | km    |

## 8. Electrical Characteristics

The following electrical characteristics are defined over the Recommended Operating Environment unless otherwise specified.

| Parameter                           | Symbol   | Min | Typical | Max  | Units | Notes |
|-------------------------------------|----------|-----|---------|------|-------|-------|
| Power Consumption                   |          |     |         | 3.5  | W     |       |
| Supply Current                      | $I_{CC}$ |     |         | 1.1  | A     |       |
| Transceiver Power-on Initialization |          |     |         | 2000 | ms    | 1     |

| Time  |              |      |     |     |      |                           |
|---|--------------|------|-----|-----|------|---------------------------|
| <b>Transmitter (each Lane)</b>                |              |      |     |     |      |                           |
| Single Ended Input Voltage Tolerance (Note 2) |              | -0.3 |     | 4.0 | V    |                           |
| AC Common Mode Input Voltage Tolerance        |              | 15   |     |     | mV   | RMS                       |
| Differential Input Voltage Swing Threshold    |              | 50   |     |     | mVpp | LOSA Threshold            |
| Differential Input Voltage Swing              | $V_{in,pp}$  | 190  |     | 700 | mVpp |                           |
| Differential Input Impedance                  | $Z_{in}$     | 90   | 100 | 110 | Ohm  |                           |
| <b>Receiver (each Lane)</b>                   |              |      |     |     |      |                           |
| Single Ended Output Voltage                   |              | -0.3 |     | 4.0 | V    | Referred to signal common |
| AC Common Mode Output Voltage                 |              |      |     | 7.5 | mV   | RMS                       |
| Differential Output Voltage Swing             | $V_{out,pp}$ | 300  |     | 850 | mVpp |                           |
| Differential Output Impedance                 | $Z_{out}$    | 90   | 100 | 110 | Ohm  |                           |

**Notes:**

- 1.Power-on Initialization Time is the time from when the power supply voltages reach and remain above the minimum recommended operating supply voltages to the time when the module is fully functional.
- 2.The single ended input voltage tolerance is the allowable range of the instantaneous input signals.

**9. Optical Characteristics**

| Parameter   | Symbol        | Min  | Typical | Max                                | Unit  | Notes |
|---|---------------|------|---------|------------------------------------|-------|-------|
| <b>Transmitter</b>  |               |      |         |                                    |       |       |
| Center Wavelength   | $\lambda_c$   | 1260 | 1310    | 1355                               | nm    |       |
| Side Mode Suppression Ratio   | SMSR          | 30   |         |                                    | dB    |       |
| Total Average Launch Power  | $P_T$         |      |         | 9.5                                | dBm   |       |
| Average Launch Power, each Lane   | $P_{AVG}$     | 1.0  |         | 3.5                                | dBm   |       |
| Optical Modulation Amplitude , each Lane                                      | $P_{OMA}$     | 2.0  |         | 4.5                                | dBm   | 1     |
| Difference in Launch Power between any Two Lanes (OMA)                        | $P_{tx,diff}$ |      |         | 5                                  | dB    |       |
| Launch Power in OMA minus Transmitter and Dispersion Penalty (TDP), each Lane |               | 1.0  |         |                                    | dBm   |       |
| TDP, each Lane  | TDP           |      |         | 3.2                                | dB    |       |
| Extinction Ratio  | ER            | 3.5  |         |                                    | dB    |       |
| Relative Intensity Noise  | RIN           |      |         | -128                               | dB/Hz |       |
| Optical Return Loss Tolerance   | TOL           |      |         | 12                                 | dB    |       |
| Transmitter Reflectance   | $R_T$         |      |         | -12                                | dB    |       |
| Average Launch Power OFF Transmitter, each Lane                               | $P_{off}$     |      |         | -30                                |       |       |
| Eye Mask{X1, X2, X3, Y1, Y2, Y3}  |               |      |         | {0.25, 0.4, 0.45, 0.25, 0.28, 0.4} |       |       |
| <b>Receiver</b>   |               |      |         |                                    |       |       |
| Center Wavelength   | $\lambda_c$   | 1260 | 1310    | 1355                               | nm    |       |
| Damage Threshold, each Lane   | $TH_d$        | 4.5  |         |                                    | dBm   | 2     |
| Average Receive Power, each Lane  |               | -9.0 |         | 3.5                                | dBm   |       |

|  |          |     |  |      |     |  |
|--|----------|-----|--|------|-----|--|
| Receiver Reflectance   | $R_R$    |     |  | -12  | dB  |  |
| Receive Power (OMA), each Lane                                 |          |     |  | 4.5  | dBm |  |
| Receiver Sensitivity (OMA), each Lane                          | SEN      |     |  | -9.0 | dBm |  |
| Difference in Receive Power between any Two Lanes(OMA)         | Prx,diff |     |  | 5.5  | dB  |  |
| LOS Assert   | LOSA     |     |  | -18  | dBm |  |
| LOS De-assert  | LOSD     |     |  | -15  | dBm |  |
| LOS Hysteresis   | LOSH     | 0.5 |  |      | dB  |  |
| Receiver Electrical 3 dB upper Cutoff Frequency, each Lane     | Fc       |     |  | 31   | GHz |  |
| <b>Conditions of Stress Receiver Sensitivity Test (Note 5)</b> |          |     |  |      |     |  |
| Vertical Eye Closure Penalty, each Lane                        |          |     |  | 1.8  | dB  |  |
| Stressed Eye J2 Jitter, each Lane                              |          |     |  | 0.3  | UI  |  |
| Stressed Eye J9 Jitter, each Lane                              |          |     |  | 0.47 | UI  |  |

**Notes:**

1. Even if the TDP<1dB, the OMA min must exceed the minimum value specified here.
2. The receiver shall be able to tolerate, without damage, continuous exposure to a modulated optical input signal having this power level on one lane. The receiver does not have to operate correctly at this input power.

**11. Digital Diagnostic Functions**

The following digital diagnostic characteristics are defined over the Recommended Operating Environment unless otherwise specified.

| Parameter                               | Symbol       | Min  | Max | Units | Notes                            |
|---|--------------|------|-----|-------|----------------------------------|
| Temperature monitor absolute error      | DMI_Temp     | -3   | 3   | degC  | Over operating temperature range |
| Supply voltage monitor absolute error   | DMI_VCC      | -0.1 | 0.1 | V     | Over full operating range        |
| Channel RX power monitor absolute error | DMI_RX_Ch    | -2   | 2   | dB    | 1                                |
| Channel Bias current monitor            | DMI_Ibias_Ch | -10% | 10% | mA    | Ch1~Ch4                          |
| Channel TX power monitor absolute error | DMI_TX_Ch    | -2   | 2   | dB    | 1                                |

**Notes:**

1. Due to measurement accuracy of different single mode fibers, there could be an additional +/-1 dB fluctuation, or a +/- 3 dB total accuracy.

**12. Mechanical Dimensions**

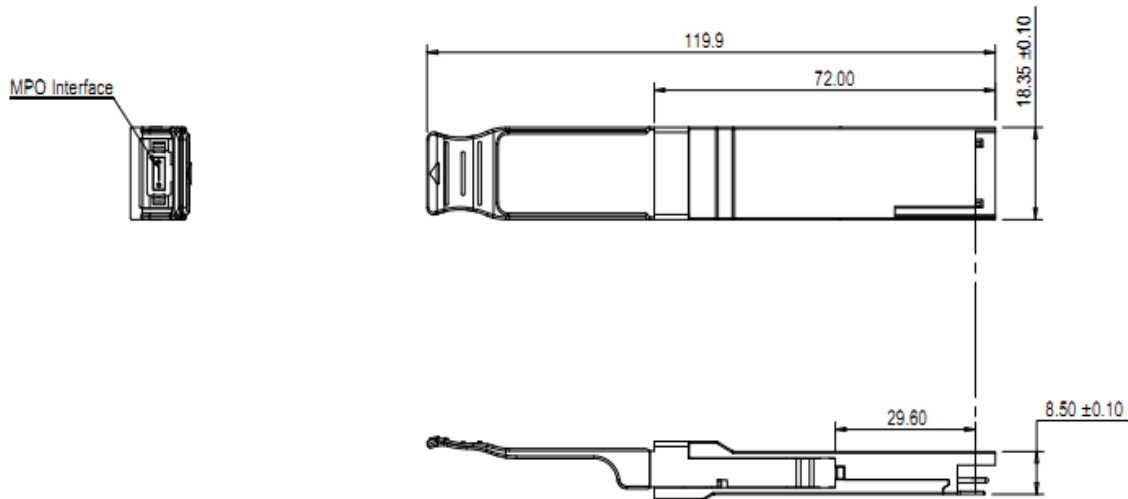


Figure 4. Mechanical Outline

**Attention:** To minimize MPO connection induced reflections, an MPO receptacle with 8-degree angled end-face is utilized for this product. A female MPO connector with 8-degree end-face should be used with this product as illustrated in Figure 5.

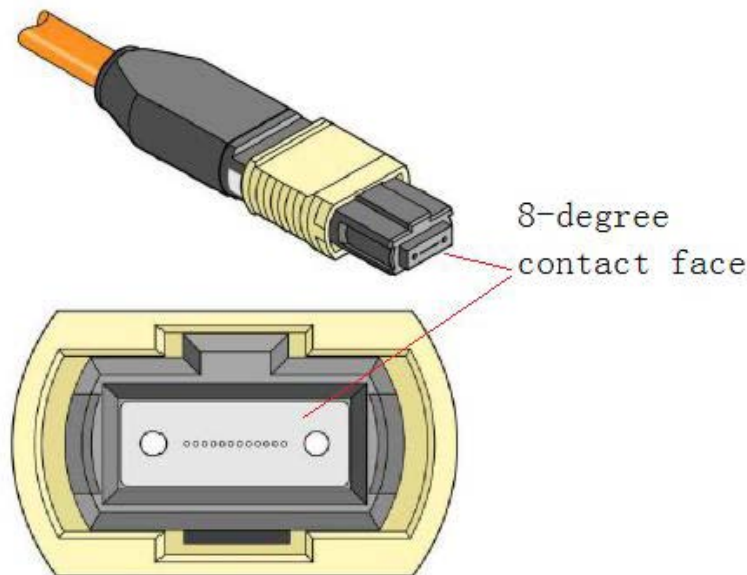


Figure 5. Female MPO Connector with 8-degree End-face

### 13. ESD

This transceiver is specified as ESD threshold 1KV for high speed data pins and 2KV for all others electrical input pins, tested per MIL-STD-883, Method 3015.4 /JESD22-A114-A (HBM). However, normal ESD precautions are still required during the handling of this module. This transceiver is shipped in ESD protective packaging. It should be removed from the packaging and handled only in an ESD protected environment.

### 14. Laser Safety

This is a Class 1 Laser Product according to EN 60825-1:2014. This product complies with 21 CFR 1040.10 and 1040.11 except for deviations pursuant to Laser Notice No. 50, dated (June 24, 2007).

Caution--use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.



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