

## 400Gb/s QSFP-DD SR8 100m Optical Transceiver

### Features

- QSFP-DD MSA compliant
- 8 parallel lanes on 850nm center wavelength
- Compliant to IEEE 802.3bs Specification
- Maximum link length of 70m on OM3 and 100m on OM4
- Operating case temperature: 0 to 70°C
- 8x53.125Gb/s electrical interface (400GAUI-8)
- Data Rate 53.125Gbps (PAM4) per channel
- Maximum power consumption 8W
- MPO-16 connector

### Applications

- 400G Ethernet
- Data Center Interconnect
- Data center Enterprise networking

## General Description

The QDD-400G-SR8 transceiver is a parallel 400Gb/s Quad Small Form Factor Pluggable--double density (QSFP-DD) optical module. It provides increased port density and total system cost savings. The QSFP-DD full- duplex optical module offers 8 independent transmit and receive channels, each capable of 53.125Gb/s operation for an aggregate data rate of 400Gb/s on 100 meters of OM4 multi-mode fiber.

An optical fiber cable with an MTP/MPO-16 connector can be plugged into the QSFP-DD SR8 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 QSFP-DD MSA-compliant edge type connector.

The central wavelengths of all the 8 parallel lanes are 850nm. It contains an optical MPO-16 connector for the optical interface and a 60-pin connector for the electrical interface. Host FEC is required to support up to 70m OM3 multi-mode fiber transmission.

The product is designed with form factor, optical/electrical connection and digital diagnostic interface according to the QSFP-DD Multi-Source Agreement (MSA) Type 2. It has been designed to meet the harshest external operating conditions including temperature, humidity and EMI interference.

## Functional Description

The module incorporates 8 parallel channels, on 850nm Center Wavelength, operating at 50G per channel. The transmitter path incorporates an 8-channel CDR retimer, 2 sets of quad channel VCSEL drivers together with 2 sets of VCSEL arrays. On the receiver path, 2 sets of photo-diode arrays optics are coupled with an 8-channel CDR re-timer. The electrical interface is compliant with IEEE 802.3bs and QSFP-DD MSA in the transmitting and receiving directions, and the optical interface is compliant to QSFP-DD MSA with MPO-16 Optical Connector. Figure 1 shows the functional block diagram of this product.

A single +3.3V power supply is required to power up this product. All the power supply pins are internally connected and should be applied concurrently. As per MSA specifications the module offers seven low speed hardware control pins (including the 2-wire serial interface): ModSelL, SCL, SDA, ResetL, InitMode, ModPrsL and IntL.

Module Select (ModSelL) is an input pin. When held low by the host, this product responds to 2-wire serial communication commands. The ModSelL allows the use of this product on a single 2-wire interface bus – individual ModSelL lines 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 memory map.

The ResetL pin enables a complete reset, returning the 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 it indicates a completion of the reset interrupt. The product 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.

Initialize Mode (InitMode) is an input signal. It is pulled up to Vcc in the QSFP-DD module. The InitMode signal allows the host to define whether the QSFP-DD module will initialize under host software control (InitMode asserted High) or module hardware control (InitMode deasserted Low). Under host software control, the module shall remain in Low Power Mode until software enables the

transition to High Power Mode, as defined in the QSFP-DD Management Interface Specification. Under hardware control (InitMode de-asserted Low), the module may immediately transition to High Power Mode after the management interface is initialized. The host shall not change the state of this signal while the module is present. In legacy QSFP applications, this signal is named LPMode. See SFF-8679 for LPMode signal description.

Module Present (ModPrsL) is a signal local to the host board which, in the absence of a product, is normally pulled up to the host Vcc. When the product 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 its present by setting ModPrsL to a "Low" state.

Interrupt (IntL) is an output pin. "Low" indicates a possible 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.

## Absolute Maximum Ratings

**Table1-Absolute Maximum Ratings**

| Parameter                                    | Symbols | Min. | Typical | Max. | Unit | Notes |
|----------------------------------------------|---------|------|---------|------|------|-------|
| Storage Temperature                          | TSTG    | -40  |         | +85  | °C   |       |
| Operating Relative Humidity (non-condensing) | RH      | 0    |         | 85   | %    |       |
| Supply Voltage                               | VCC     | -0.5 |         | 3.6  | V    |       |
| Damage Threshold, each Lane                  | THd     | 5.5  |         |      | dBm  |       |

## Recommended Operating Conditions

**Table2-Recommended Operating Conditions**

| Parameter                  | Symbols | Min.  | Typical | Max.                 | Unit | Notes |
|----------------------------|---------|-------|---------|----------------------|------|-------|
| Operating Case Temperature | Top     | 0     |         | +70                  | °C   |       |
| Power Supply Voltage       | VCC     | 3.135 | 3.3     | 3.465                | V    |       |
| Data Rate, each Lane       |         |       | 26.5625 |                      | GBd  | PAM4  |
| Data Rate Accuracy         |         | -100  |         | 100                  | ppm  |       |
| Pre-FEC Bit Error Ratio    |         |       |         | $2.4 \times 10^{-4}$ |      |       |
| Post-FEC Bit Error Ratio   |         |       |         | $1 \times 10^{-12}$  |      | 1     |
| Link Distance with OM4     | D       | 0.5   |         | 100                  | m    | 2     |

Notes:

[1] EC provided by host system.

[2] FEC required on host system to support maximum transmission distance.

## Electrical Characteristic

**Table3-Electrical Characteristic**

| Parameter                                     | Symbol          | Min.                             | Typical | Max. | Unit | Notes |
|-----------------------------------------------|-----------------|----------------------------------|---------|------|------|-------|
| Supply current                                | I <sub>cc</sub> |                                  |         | 3.63 | A    |       |
| Power Consumption                             |                 |                                  |         | 8    | W    |       |
| Optical Transmitter Characteristics           |                 |                                  |         |      |      |       |
| Signaling Rate, each Lane                     | TP1             | 26.5625 ± 100 ppm                |         |      | GBd  |       |
| Differential pk-pk Input Voltage Tolerance    | TP1a            | 900                              |         |      | mVpp | 1     |
| Differential Termination Mismatch             | TP1             |                                  |         | 10   | %    |       |
| Differential Input Return Loss                | TP1             | IEEE 802.3-2015 Equation (83E-5) |         |      | dB   |       |
| Differential to Common Mode Input Return Loss | TP1             | IEEE 802.3-2015 Equation (83E-6) |         |      | dB   |       |
| Module Stressed Input Test                    | TP1a            | See IEEE 802.3bs 120E.3.4.1      |         |      |      | 2     |
| Single-ended Voltage Tolerance Range (Min)    | TP1a            | -0.4 to 3.3                      |         |      |      |       |
| DC Common Mode Input Voltage                  | TP1             | -350                             |         | 2850 | mV   | 3     |
| Optical Receiver Characteristics              |                 |                                  |         |      |      |       |
| Signaling Rate, each lane                     | TP4             | 26.5625 ± 100 ppm                |         |      | GBd  |       |
| Differential Peak-to-Peak                     | TP4             |                                  |         | 900  | mVpp |       |
| Output Voltage                                |                 |                                  |         |      |      |       |
| AC Common Mode Output Voltage, RMS            | TP4             |                                  |         | 17.5 | mV   |       |
| Differential Termination Mismatch             | TP4             |                                  |         | 10   | %    |       |
| Differential Output Return Loss               | TP4             | IEEE 802.3-2015 Equation (83E-2) |         |      |      |       |
| Transition Time, 20% to 80%                   | TP4             | 9.5                              |         |      | ps   |       |
| Near-end Eye Symmetry Mask                    | TP4             |                                  | 0.265   |      | UI   |       |

|                                           |     |      |     |      |    |   |
|-------------------------------------------|-----|------|-----|------|----|---|
| Width (ESMW)                              |     |      |     |      |    |   |
| Near-end Eye Height,<br>Differential      | TP4 | 70   |     |      | mV |   |
| Far-end Eye Symmetry Mask<br>Width (ESMW) | TP4 |      | 0.2 |      | UI |   |
| Far-end Eye Height,<br>Differential       | TP4 | 30   |     |      | mV |   |
| Far-end Pre-cursor ISI Ratio              | TP4 | -4.5 |     | 2.5  | %  |   |
| Common Mode Output<br>Voltage (Vcm)       | TP4 | -350 |     | 2850 | mV | 3 |

Notes:

[1] With the exception to IEEE 802.3bs 120E.3.1.2 that the pattern is PRBS31Q or scrambled idle.

[2] Meets BER specified in IEEE 802.3bs 120E.1.1.

[3] DC common mode voltage generated by the host. Specification includes effects of ground offset voltage.

## Optical Characteristics

#### Table4-Optical Characteristics

| Parameter                                                             | Symbols                | Min.                              | Typical | Max. | Unit | Notes     |
|-----------------------------------------------------------------------|------------------------|-----------------------------------|---------|------|------|-----------|
| Center Wavelength                                                     | $\lambda_c$            | 840                               | 850     | 860  | nm   |           |
| Transmitter                                                           |                        |                                   |         |      |      |           |
| Data Rate, each Lane                                                  |                        | 26.5625±100ppm                    |         |      | GBd  |           |
| Modulation Format                                                     |                        | PAM4                              |         |      |      |           |
| RMS Spectral Width                                                    | $\Delta \lambda_{rms}$ |                                   |         | 0.6  | nm   | Modulated |
| Average Launch Power, each Lane                                       | $P_{AVG}$              | -6.5                              |         | 4    | dBm  | 1         |
| Outer Optical Modulation Amplitude (OMA <sub>outer</sub> ), each Lane | $P_{OMA}$              | -4.5                              |         | 3    | dBm  | 2         |
| Launch Power in OMA <sub>outer</sub> minus TDECQ, each Lane           |                        | -5.9                              |         |      | dB   |           |
| Transmitter and Dispersion Eye Closure for PAM4, each Lane            | TDECQ                  |                                   |         | 4.5  | dB   |           |
| Extinction Ratio                                                      | ER                     | 3                                 |         |      | dB   |           |
| Optical Return Loss Tolerance                                         | TOL                    |                                   |         | 12   | dB   |           |
| Average Launch Power of OFF Transmitter, each Lane                    | $P_{off}$              |                                   |         | -30  | dBm  |           |
| Encircled Flux                                                        |                        | ⌈ 86% at 19 μm<br>⌋ 30% at 4.5 μm |         |      |      |           |
| Receiver                                                              |                        |                                   |         |      |      |           |

|                                                                         |      |                   |   |      |     |   |
|-------------------------------------------------------------------------|------|-------------------|---|------|-----|---|
| Data Rate, each Lane                                                    |      | 26.5625 ± 100 ppm |   |      | GBd |   |
| Modulation Format                                                       |      | PAM4              |   |      |     |   |
| Damage Threshold, each Lane                                             | THd  | 5                 |   |      | dBm | 3 |
| Average Receive Power, each Lane                                        |      | -7.9              |   | 4    | dBm | 4 |
| Receive Power (OMA <sub>outer</sub> ), each Lane                        |      |                   |   | 3    | dBm |   |
| Receiver Sensitivity (OMA <sub>outer</sub> ), each Lane                 | SEN  |                   |   | -6.5 | dBm | 5 |
| Stressed Receiver Sensitivity (OMA <sub>outer</sub> ), each Lane        | SRS  |                   |   | -3   | dBm | 6 |
| Receiver Reflectance                                                    | RR   |                   |   | -12  | dB  |   |
| LOS Assert                                                              | LOSA | -30               |   |      | dBm |   |
| LOS De-assert                                                           | LOSD |                   |   | -12  | dBm |   |
| LOS Hysteresis                                                          | LOSH | 0.5               |   |      | dB  |   |
| <b>Stressed Conditions of Stress Receiver Sensitivity Test (Note 7)</b> |      |                   |   |      |     |   |
| Stressed Eye Closure for PAM4 (SECQ), Lane under Test                   |      |                   | 4 |      | dB  |   |
| OMA <sub>outer</sub> of each Aggressor Lane                             |      |                   | 3 |      | dBm |   |

Notes:

- [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] Even if the TDECQ < 1 dB, the OMA<sub>outer</sub> (min) must exceed the minimum value specified here.
- [3] The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level.
- [4] 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.
- [5] Receiver Sensitivity OMA<sub>outer</sub>, each lane (max) is informative and is defined for a BER of 2.4x10<sup>-4</sup>.
- [6] Measured with conformance test signal at receiver input for the BER of 2.4x10<sup>-4</sup>.
- [7] These test conditions are for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

## Digital Diagnostic Functions

**Table5-Digital Diagnostic Functions**

| Parameter                             | Symbols   | Min. | Max. | Unit | 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        |
| Supply Voltage Monitor                | DMI_RX_Ch | -2   | 2    | dB   | 1                                |

|                              |              |      |     |    |   |
|------------------------------|--------------|------|-----|----|---|
| Absolute Error               |              |      |     |    |   |
| Channel Bias Current Monitor | DMI_Ibias_Ch | -10% | 10% | mA |   |
| Channel TX Power Monitor     | DMI_TX_Ch    | -2   | 2   | dB | 1 |
| Absolute Error               |              |      |     |    |   |

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.

## Pin Description

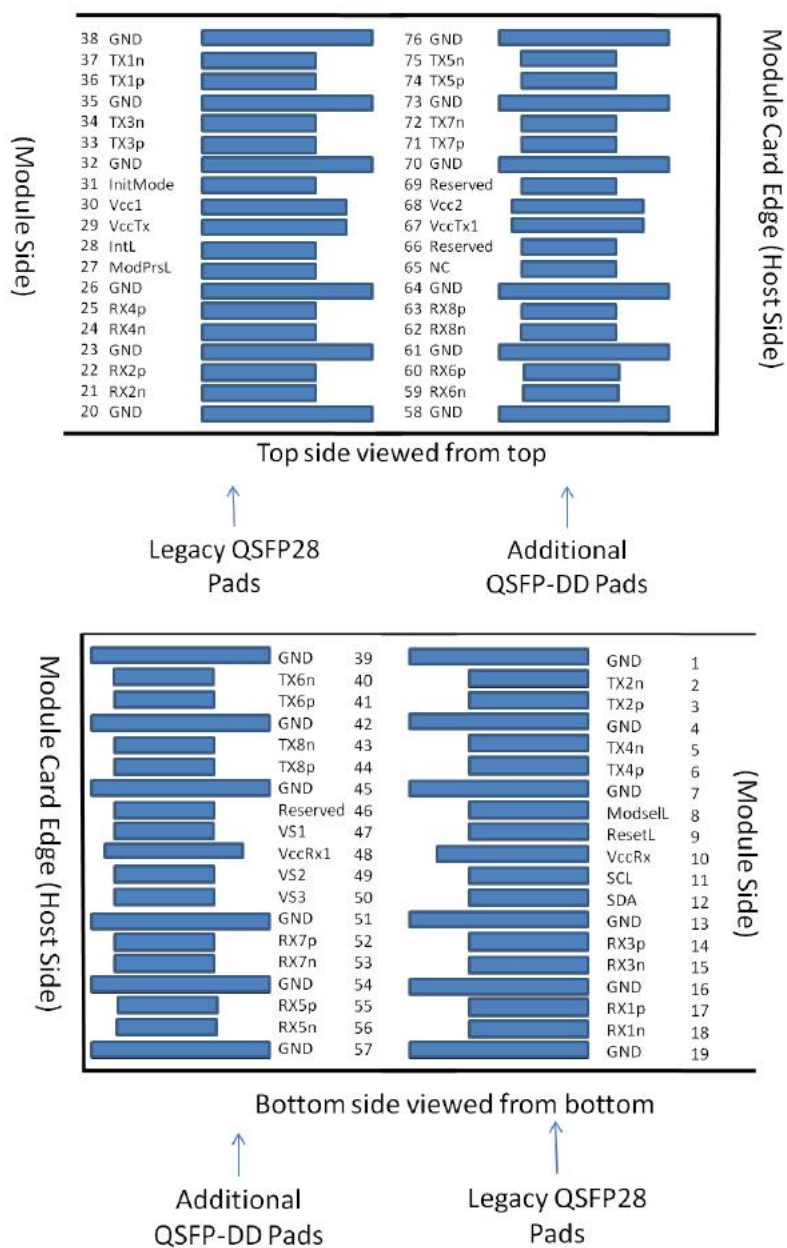


Figure 1 Pin view

## Pin Function Definitions

**Table6-Pin Function Definitions**

| Pin | Logic      | Symbol      | Description                                                                          | Notes |
|-----|------------|-------------|--------------------------------------------------------------------------------------|-------|
| 1   |            | GND         | Ground                                                                               | 1B    |
| 2   | CML-I      | Tx2n        | Transmitter Inverted Data Input                                                      | 3B    |
| 3   | CML-I      | Tx2p        | Transmitter Non-Inverted Data Input                                                  | 3B    |
| 4   |            | GND         | Ground                                                                               | 1B    |
| 5   | CML-I      | Tx4n        | Transmitter Inverted Data Input                                                      | 3B    |
| 6   | CML-I      | Tx4p        | Transmitter Non-Inverted Data Input                                                  | 3B    |
| 7   |            | GND         | Ground                                                                               | 1B    |
| 8   | LVTTL-I    | ModSelL     | Module Select                                                                        | 3B    |
| 9   | LVTTL-I    | ResetL      | Module Reset                                                                         | 3B    |
| 10  |            | Vcc Rx      | +3.3V Power Supply Receiver                                                          | 2B    |
| 11  | LVCMOS-I/O | SCL         | 2-wire serial interface clock                                                        | 3B    |
| 12  | LVCMOS-I/O | SDA         | 2-wire serial interface data                                                         | 3B    |
| 13  |            | GND         | Ground                                                                               | 1B    |
| 14  | CML-O      | Rx3p        | Receiver Non-Inverted Data Output                                                    | 3B    |
| 15  | CML-O      | Rx3n        | Receiver Inverted Data Output                                                        | 3B    |
| 16  |            | GND         | Ground                                                                               | 1B    |
| 17  | CML-O      | Rx1p        | Receiver Non-Inverted Data Output                                                    | 3B    |
| 18  | CML-O      | Rx1n        | Receiver Inverted Data Output                                                        | 3B    |
| 19  |            | GND         | Ground                                                                               | 1B    |
| 20  |            | GND         | Ground                                                                               | 1B    |
| 21  | CML-O      | Rx2n        | Receiver Inverted Data Output                                                        | 3B    |
| 22  | CML-O      | Rx2p        | Receiver Non-Inverted Data Output                                                    | 3B    |
| 23  |            | GND         | Ground                                                                               | 1B    |
| 24  | CML-O      | Rx4n        | Receiver Inverted Data Output                                                        | 3B    |
| 25  | CML-O      | Rx4p        | Receiver Non-Inverted Data Output                                                    | 3B    |
| 26  |            | GND         | Ground                                                                               | 1B    |
| 27  | LVTTL-O    | ModPrsL     | Module Present                                                                       | 3B    |
| 28  | LVTTL-O    | IntL/RxLOSL | Interrupt. Optionally configurable as RxLOSL via the management interface (SFF-8636) | 3B    |
| 29  |            | VccTx       | +3.3V Power supply transmitter                                                       | 2B    |
| 30  |            | Vcc1        | +3.3V Power supply                                                                   | 2B    |
| 31  | LVTTL-I    | InitMode    | Initialization mode; In legacy QSFP applications, the InitMode pad is called LPMODE  | 3B    |
| 32  |            | GND         | Ground                                                                               | 1B    |
| 33  | CML-I      | Tx3p        | Transmitter Non-Inverted Data Input                                                  | 3B    |
| 34  | CML-I      | Tx3n        | Transmitter Inverted Data Input                                                      | 3B    |
| 35  |            | GND         | Ground                                                                               | 1B    |



|    |       |          |                                     |    |
|----|-------|----------|-------------------------------------|----|
| 36 | CML-I | Tx1p     | Transmitter Non-Inverted Data Input | 3B |
| 37 | CML-I | Tx1n     | Transmitter Inverted Data Input     | 3B |
| 38 |       | GND      | Ground                              | 1B |
| 39 |       | GND      | Ground                              | 1A |
| 40 | CML-I | Tx6n     | Transmitter Inverted Data Input     | 3A |
| 41 | CML-I | Tx6p     | Transmitter Non-Inverted Data Input | 3A |
| 42 |       | GND      | Ground                              | 1A |
| 43 | CML-I | Tx8n     | Transmitter Inverted Data Input     | 3A |
| 44 | CML-I | Tx8p     | Transmitter Non-Inverted Data Input | 3A |
| 45 |       | GND      | Ground                              | 1A |
| 46 |       | Reserved | For future use                      | 3A |
| 47 |       | VS1      | Module Vendor Specific 1            | 3A |
| 48 |       | VccRx1   | 3.3V Power Supply                   | 2A |
| 49 |       | VS2      | Module Vendor Specific 2            | 3A |
| 50 |       | VS3      | Module Vendor Specific 3            | 3A |
| 51 |       | GND      | Ground                              | 1A |
| 52 | CML-O | Rx7p     | Receiver Non-Inverted Data Output   | 3A |
| 53 | CML-O | Rx7n     | Receiver Inverted Data Output       | 3A |
| 54 |       | GND      | Ground                              | 1A |
| 55 | CML-O | Rx5p     | Receiver Non-Inverted Data Output   | 3A |
| 56 | CML-O | Rx5n     | Receiver Inverted Data Output       | 3A |
| 57 |       | GND      | Ground                              | 1A |
| 58 |       | GND      | Ground                              | 1A |
| 59 | CML-O | Rx6n     | Receiver Inverted Data Output       | 3A |
| 60 | CML-O | Rx6p     | Receiver Non-Inverted Data Output   | 3A |
| 61 |       | GND      | Ground                              | 1A |
| 62 | CML-O | Rx8n     | Receiver Inverted Data Output       | 3A |
| 63 | CML-O | Rx8p     | Receiver Non-Inverted Data Output   | 3A |
| 64 |       | GND      | Ground                              | 1A |
| 65 |       | NC       | No Connect                          | 3A |
| 66 |       | Reserved | For future Use                      | 3A |
| 67 |       | VccTx1   | 3.3V Power Supply                   | 2A |
| 68 |       | Vcc2     | 3.3V Power Supply                   | 2A |
| 69 |       | Reserved | For future Use                      | 3A |
| 70 |       | GND      | Ground                              | 1A |
| 71 | CML-I | Tx7p     | Transmitter Non-Inverted Data Input | 3A |
| 72 | CML-I | Tx7n     | Transmitter Inverted Data Input     | 3A |
| 73 |       | GND      | Ground                              | 1A |
| 74 | CML-I | Tx5p     | Transmitter Non-Inverted Data Input | 3A |
| 75 | CML-I | Tx5n     | Transmitter Inverted Data Input     | 3A |
| 76 |       | GND      | Ground                              | 1A |

## Transceiver Block Diagram

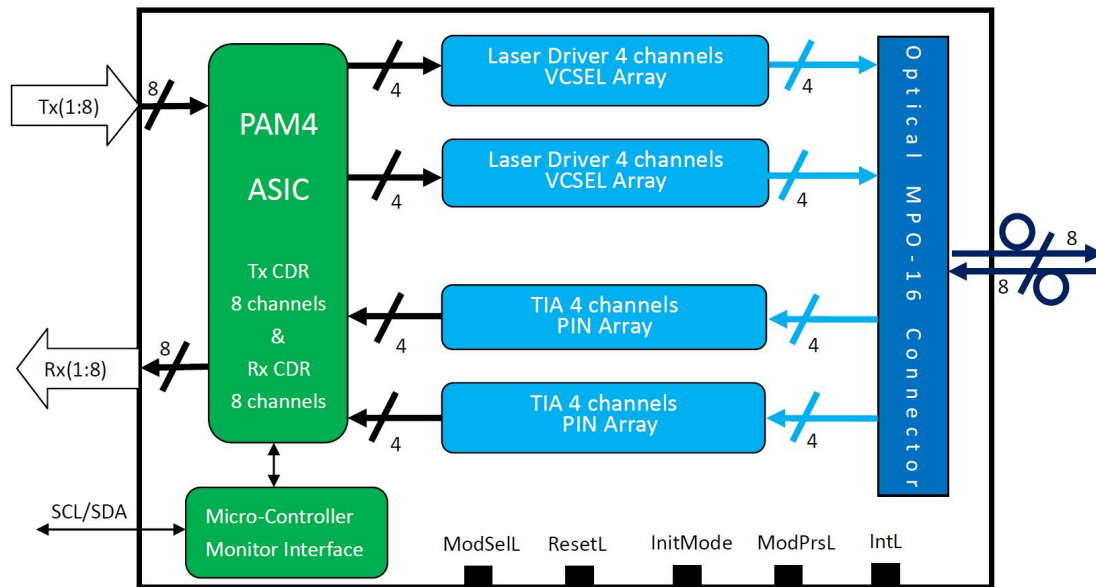
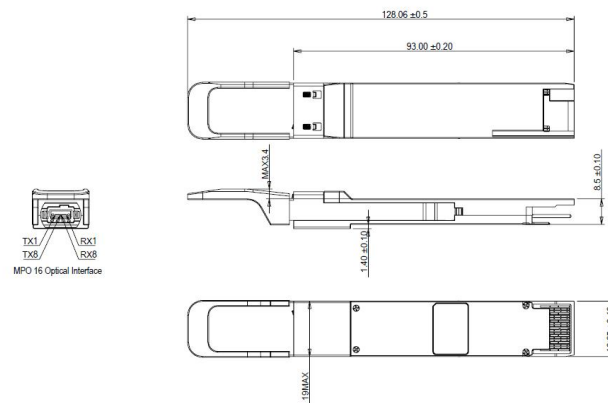


Figure 2 Transceiver Block Diagram

## Mechanical Dimensions



## QSFP- DD SR8 MPO 16 Optical Interface Outline



Figure3 Mechanical Outline

### ESD

This transceiver is specified as ESD threshold 1kV for high speed data pins and 2kV for all other 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.

### 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.