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# OP-QSFP-DD-FR4
# 400G QSFP-DD FR4 Optical Transceiver

This product is a 400Gb/s QSFP-DD optical module designed for 2km optical communication applications. The module converts 8 channels of 50Gb/s (PAM4) electrical input data to 4 channels of CWDM optical signals and multiplexes them into a single channel for 400Gb/s optical transmission.
On the receiver side, the module optically de-multiplexes a 400Gb/s optical input into 4 channels of CWDM optical signals and converts them to 8 channels of 50Gb/s (PAM4) electrical output data.
The central wavelengths of the 4 CWDM channels are 1271, 1291, 1311 and 1331 nm.
Host FEC is required to support up to 2km fiber transmission.

## Applications
- 400G BASE-FR4 Ethernet
- Data Center Interconnect
- Infiniband Interconnect
- Enterprise Networking

## Features
- Compliant to QSFP-DD MSA
- 4 CWDM lanes MUX/DEMUX design
- 100G Lambda MSA 400G-FR4 Specification compliant
- Maximum power consumption 10W

# 1.General Description
- Compliant with IEEE Std 802.3cu
- Compliant with 400G-FR4 optical specifications
- Compliant with QSFP-DD MSA
- Compliant with CMIS4.0 Management interface specifications
- 8x53.125Gb/s electrical interface (400GAUI-8)
- Up to 2km transmission on single mode fiber (SMF) with FEC
- Single +3.3V power supply
- Case temperature range: 0 ~ +70°C
- Maximum power consumption 12W
- Duplex LC connector
- RoHS complaint

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# 2. Absolute Maximum Ratings

| Parameter | Symbol | Min | Max | Units |
|---|---|---|---|---|
| Storage Temperature Range | $T_{STG}$ | -40 | +85 | °C |
| Supply Voltage | $V_{CC}$ | -0.5 | 3.6 | V |
| Relative Humidity | RH | 10% to 90% non-condensing | | |

# 3. Operating Conditions

| Parameter | Symbol | Min | Max | Unit |
|---|---|---|---|---|
| Case Temperature- Operating | $T_{CASE}$ | 0 | 70 | °C |
| Supply Voltage | Vcc | 3.135 | 3.465 | V |
| Power Consumption | $P_{DISS}$ | | 12 | W |
| Pre-FEC Bit Error Ratio | | | $2.4x10^{-4}$ | |
| Link Distance over SMF | | 0.5 | 2000 | M |

# 4. Transmitter Optical Specifications

| Transmitter Parameter | Lane | Min | Typical | Max | Units |
|---|---|---|---|---|---|
| Lane Wavelength Range | Lane 0 | 1264.5 | 1271 | 1277.5 | nm |
| | Lane 1 | 1284.5 | 1291 | 1297.5 | nm |
| | Lane 2 | 1304.5 | 1311 | 1317.5 | nm |
| | Lane 3 | 1324.5 | 1331 | 1337.5 | nm |
| Average launch Power per lane | | -3.2 | | 4.4 | dBm |
| Total Average launch power | | | | 10.4 | dBm |
| Outer Optical Modulation Amplitude (OMAouter), each lane, for TDECQ <1.4 dB<br>for 1.4 dB ⩽ TDECQ ⩽ 3.4 dB | | -0.2<br>-1.6 + TDECQ | | 3.7 | dBm |
| Difference in launch power between any two lanes (OMAouter) | | | | 3.9 | dB |
| Average Launch Power per Lane @ TX Off State | | | | -16 | dBm |
| Launch Power in OMAouter minus TDECQ, each Lane<br>for ER ⩾ 4.5dB<br>for ER < 4.5dB | | -1.7<br>-1.6 | | | dBm |
| Transmitter and Dispersion Eye Closure for PAM4, each Lane | | | | 3.4 | dB |
| Extinction Ratio | | 3.5 | | | dB |
| Relative Intensity Noise (OMA) | | | | -136 | dB/Hz |
| Side-Mode Suppression Ration (SMSR) | | 30 | | | dB |
| Optical Return Loss Tolerance | | | | 17.1 | dB |
| Transmitter Reflectance | | | | -26 | dB |
| Transmitter Output Power Monitoring Accuracy | | -3 | | 3 | dB |
| TDECQ – 10* log10(Ceq), each Lane | | | | 3.4 | dB |
| Transmitter transition time | | | | 17 | ps |

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# 5. Receiver Optical Specifications

| Receiver Parameter | Lane | Min | Typical | Max | Units |
|---|---|---|---|---|---|
| Lane Wavelength Range | Lane 0 | 1264.5 | 1271 | 1277.5 | nm |
| | Lane 1 | 1284.5 | 1291 | 1297.5 | nm |
| | Lane 2 | 1304.5 | 1311 | 1317.5 | nm |
| | Lane 3 | 1324.5 | 1331 | 1337.5 | nm |
| Damage Threshold | | 5.4 | | | dBm |
| Average Receive Power, each lane | | -7.2 | | 4.4 | dBm |
| Receiver Power, each lane (OMA) | | | | 3.7 | dBm |
| Receiver Reflectance | | | | -26.0 | dB |
| Difference in receive Power between any Two Lanes($OMA_{outer}$) | | | | 4.1 | dBm |
| Receiver Sensitivity each lane ($OMA_{outer}$) | | | | max(-4.6,SECQ-6.0) | dBm |
| Stressed Receiver Sensitivity ($OMA_{outer}$), each | | | | -2.6 | dBm |
| Stressed Conditions for Stress Receiver Sensitivity | | | | | |
| Stressed Eye Closure for PAM4 (SECQ),Lane under Test | | | 3.4 | | dB |
| SECQ – 10*log10(Ceq), lane under test | | | 3.4 | | dB |
| OMAouter of each Aggressor Lane | | | 1.5 | | dBm |

# 6. Receiver Thresholds for Loss of Signal (LOS)

| Parameter | Min | Typical | Max | Units |
|---|---|---|---|---|
| RX_LOS_Assert Min/Max | -24.0 | | | dBm |
| RX_LOS_De-Assert Min/Max | | | -13 | dBm |
| RX_LOS_Hysteresis | 0.5 | | | dB |

# 7. Digital Diagnostic Monitoring Specifications

| Parameters | Unit | Specification |
|---|---|---|
| Temperature Monitor absolute error | ° C | ± 3 |
| Supply Voltage Monitor absolute error | % | ± 5 |
| I_bias Monitor absolute error | % | ± 10 |
| Received Power (Rx) Monitor absolute error | dB | ± 3.0 |
| Transmit Power (Tx) Monitor absolute error | dB | ± 3.0 |

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# 8. Low Speed Electrical signal

| Parameter | Symbol | Min | Max | Units | Condition |
|---|---|---|---|---|---|
| SCL and SDA | VOL | 0 | 0.4 | V | IOL(max)=3.0mA for fast mode,20mA for Fast-mode plus |
| | VOH | Vcc-0.5 | Vcc+0.3 | V | |
| SCL and SDA | VIL | -0.3 | Vcc*0.3 | V | |
| | VIH | Vcc*0.7 | Vcc +0.5 | V | |
| Capacitance for SCL and SDA I/O pin | Ci | | 14 | pF | |
| Total bus cpacitive load for SCL and SDA | Cb | | 100 | pF | 3.0k Ohms Pull up resistor,max |
| | | | 200 | pF | 1.6k Ohms Pull up resistor,max |
| LPMode/TxDis,Reset and ModeSelL | VIL | -0.3 | 0.8 | V | \|Iin\| </= 125uA for Vin < Vcc |
| | VIH | 2 | Vcc + 0.3 | V | |
| IntL/RxLOS | VOL | 0 | 0.4 | V | IOL=2.0mA |
| | VOH | VCC - 0.5 | VCC + 0.3 | V | 10k ohms pull-up to Host Vcc |
| ModPrsL | VOL | 0 | 0.4 | % | IOL=2.0mA |
| | VOH | | | dB | ModPrsL can be implemented as a short-circuit to GND on the module |

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# 9. High Speed Electrical signal

## High Speed Electrical Specifications

| Parameter | Min | Typical | Max | Units | Notes |
|---|---|---|---|---|---|
| **Receiver electrical output characteristics at TP4** | | | | | |
| Signaling rate per lane | | 26.5625 | | GBd | |
| AC common-mode output voltage(RMS) | | - | 17.5 | mV | |
| Differential peak-to-peak output voltage | | | 900 | mV | |
| Near-end ESMW (Eye symmetry mask width) | | 0.265 | | UI | |
| Near-end Eye height, differential | 70 | | | mV | |
| Far-end ESMW (Eye symmetry mask width) | | 0.2 | | UI | |
| Far-end Eye height, differential | 30 | | | mV | |
| Far-end pre-cursor ISI ratio | -4.5 | | 2.5 | % | |
| Differential output return loss | 9.5 - 0.37f | | | dB | 0.01 – 8 GHz |
| | 4.75 -7.4log 10 (f/14) | | | dB | 8 – 19 GHz |
| Common to differential mode conversion return loss | 22-20(f/25.78) | | | dB | 0.01 -12.89GHz |
| | 15 -6log 10 (f/25.78) | | | dB | 12.89 – 19 GHz |
| Differential termination mismatch | | | 10 | % | |
| Transition time (min, 20%to 80%) | 9.5 | | | ps | |
| DC common mode voltage | -350 | | 2850 | mV | |
| **Transmitter electrical input characteristics at TP1** | | | | | |
| Signaling rate, per lane | | 26.5625 | | GBd | |
| Differential pk-pk input voltage tolerance | 900 | | | mV | |
| Differential input return loss | 9.5 - 0.37f | | | dB | 0.01 – 8 GHz |
| | 4.75 -7.4log 10 (f/14) | | | dB | 8 – 19 GHz |
| Differential to common mode input return loss | 22-20(f/25.78) | | | dB | 0.01 -12.89GHz |
| | 15 -6log 10 (f/25.78) | | | dB | 12.89 – 19 GHz |
| Differential termination mismatch | | | 10 | % | |
| Module stressed input test | Per Section 120E.3.4.1, IEEE802.3bs | | | | |
| Single-ended voltage tolerance range | -0.4 | | 3.3 | V | |
| Common-mode voltage | -350 | | 2850 | mV | |

# 10. QSFP-DD Edge Connector and Pinout Description

The electrical pinout of the QSFP-DD module is shown in Figure 2 below.

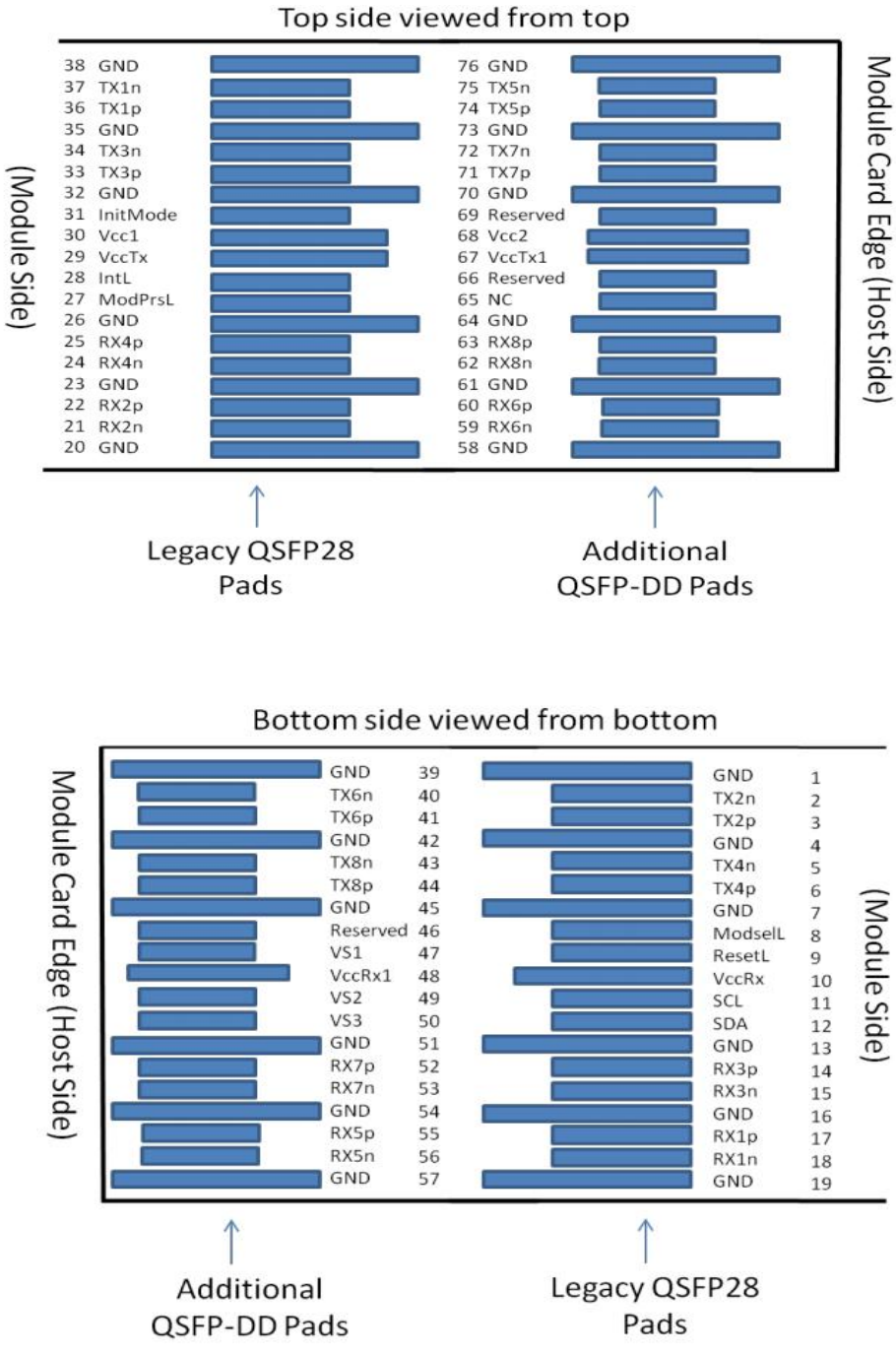


**Figure 1. Host PCB QSFP-DD pad assignment top view**

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| Pin No. | Symbol | Description | Note |
|---|---|---|---|
| 1 | GND | Ground | 1 |
| 2 | Tx2n | Transmitter Inverted Data Input | |
| 3 | Tx2p | Transmitter Non-Inverted Data output | |
| 4 | GND | Ground | 1 |
| 5 | Tx4n | Transmitter Inverted Data Input | |
| 6 | Tx4p | Transmitter Non-Inverted Data output | |
| 7 | GND | Ground | 1 |
| 8 | ModSelL | Module Select | |
| 9 | ResetL | Module Reset | |
| 10 | VccRx | 3.3V Power Supply Receiver | 2 |
| 11 | SCL | 2-Wire serial Interface Clock | |
| 12 | SDA | 2-Wire serial Interface Data | |
| 13 | GND | Ground | 1 |
| 14 | Rx3p | Receiver Non-Inverted Data Output | |
| 15 | Rx3n | Receiver Inverted Data Output | |
| 16 | GND | Ground | 1 |
| 17 | Rx1p | Receiver Non-Inverted Data Output | |
| 18 | Rx1n | Receiver Inverted Data Output | |
| 19 | GND | Ground | 1 |
| 20 | GND | Ground | 1 |
| 21 | Rx2n | Receiver Inverted Data Output | |
| 22 | Rx2p | Receiver Non-Inverted Data Output | |
| 23 | GND | Ground | 1 |
| 24 | Rx4n | Receiver Inverted Data Output | |
| 25 | Rx4p | Receiver Non-Inverted Data Output | |
| 26 | GND | Ground | 1 |
| 27 | ModPrsL | Module Present | |
| 28 | IntL | Interrupt | |
| 29 | VccTx | 3.3V power supply transmitter | 2 |
| 30 | Vcc1 | 3.3V power supply | 2 |
| 31 | Init Mode | Initialization mode | |
| 32 | GND | Ground | 1 |
| 33 | Tx3p | Transmitter Non-Inverted Data Input | |
| 34 | Tx3n | Transmitter Inverted Data Output | |
| 35 | GND | Ground | 1 |
| 36 | Tx1p | Transmitter Non-Inverted Data Input | |
| 37 | Tx1n | Transmitter Inverted Data Output | |
| 38 | GND | Ground | 1 |

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

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# 11. Module Block Diagram

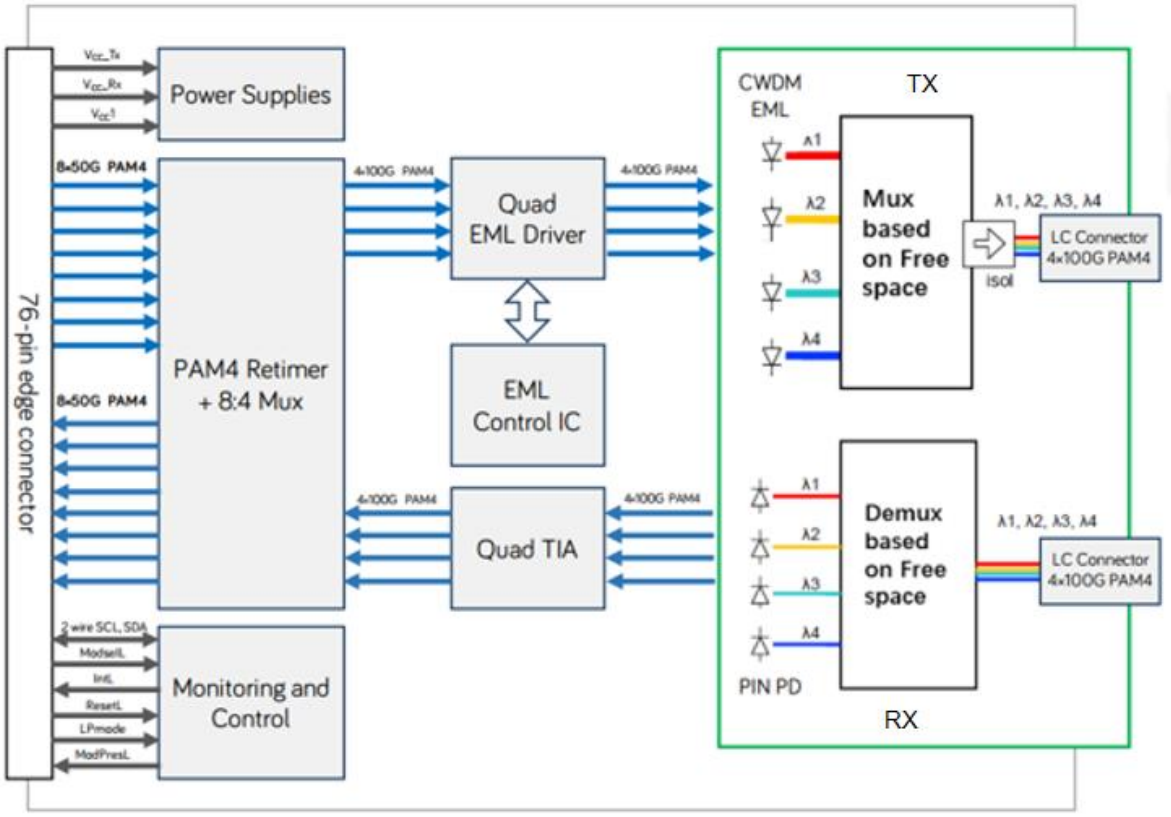
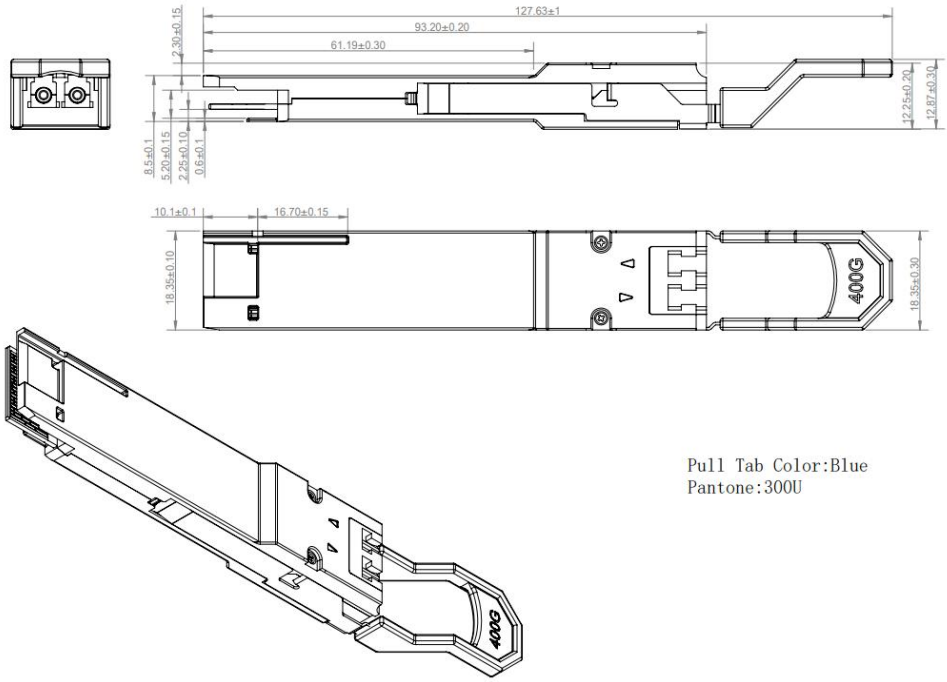



**Figure 2. Module Block Diagram**

# 12. Mechanical Specifications



# 13. Ordering Information

| Part Number | Description |
|---|---|
| OP-QSFP-DD-FR4 | 400G QSFP-DD FR4 Optical Transceiver |