

## 400 Gb/s QSFP-DD FR4 2 km Transceiver

### QSFP-DD Series



- **Compliant to QSFP-DD MSA**
- **Support 4 CWDM lanes  
MUX/DEMUX design**
- **Up to 2km transmission on  
single mode fiber (SMF) with  
FEC**
- **Support 8x53.125Gb/s  
electrical interface (400GAUI-  
8)**
- **Maximum power consumption  
10.5W**
- **RoHS compliant**

Ascent's QDD-400G-FR4-02 is a 400Gb/s Quad Small Form Factor Pluggable-double density (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. Reversely, 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.

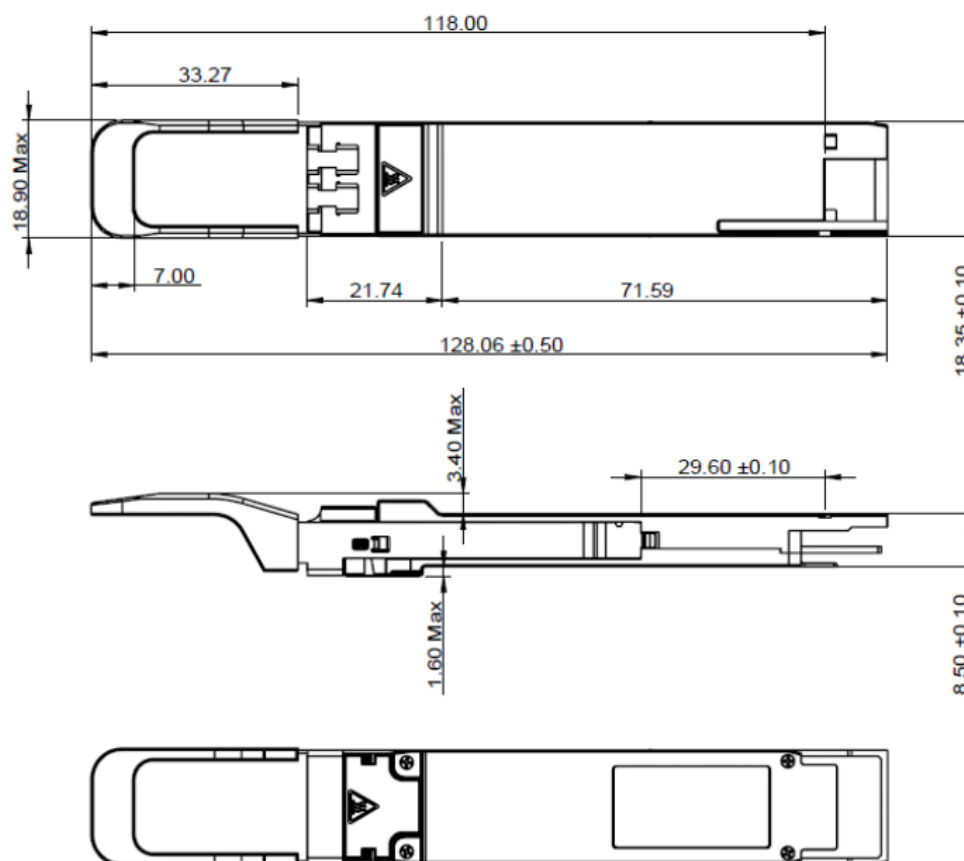
The central wavelengths of the 4 CWDM channels are 1271, 1291, 1311 and 1331 nm as members of the CWDM wavelength grid defined in ITU-T G.694.2. It contains a duplex LC connector for the optical interface and a 76-pin connector for the electrical interface. To minimize the optical dispersion in the long-haul system, single-mode fiber (SMF) has to be applied in this module. Host FEC is required to support up to 2km 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.

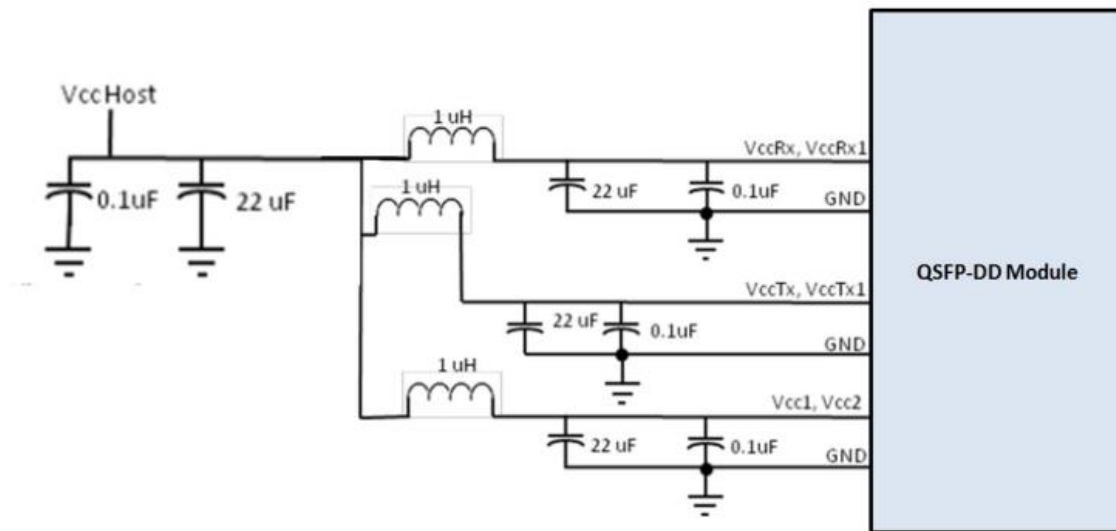
## Key Features

- QSFP-DD MSA compliant
- 4 CWDM lanes MUX/DEMUX design
- 100G Lambda MSA 400G-FR4 Specification compliant
- Up to 2km transmission on single mode fiber (SMF) with FEC
- Operating case temperature: 0 to 70°C
- 8x53.125Gb/s electrical interface (400GAUI-8)
- Data Rate 106.25Gbps (PAM4) per channel
- Maximum power consumption 10.5W
- Duplex LC connector
- RoHS compliant

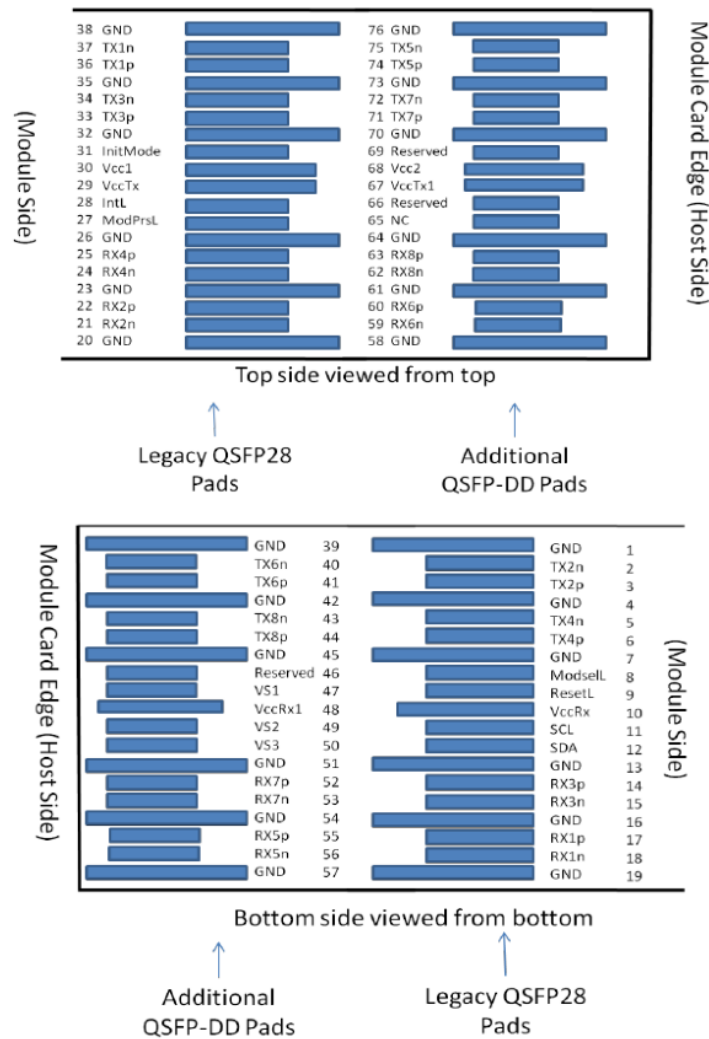
## Outline Dimensions



## Recommended Power Supply Filter



## Pin Assignment



| Pin | Logic       | Symbol   | Definition                                                                          | Plug Seq. |
|-----|-------------|----------|-------------------------------------------------------------------------------------|-----------|
| 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   | LVTTTL-I    | ModSelL  | Module Select                                                                       | 3B        |
| 9   | LVTTTL-I    | ResetL   | Module Reset                                                                        | 3B        |
| 10  |             | VccRx    | +3.3 V Power Supply Receiver                                                        | 2B        |
| 11  | LVC MOS-I/O | SCL      | 2-Wire Serial Interface Clock                                                       | 3B        |
| 12  | LVC MOS-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  | LVTTTL-O    | ModPrsL  | Module Present                                                                      | 3B        |
| 28  | LVTTTL-O    | IntL     | Interrupt                                                                           | 3B        |
| 29  |             | VccTx    | +3.3 V Power Supply Transmitter                                                     | 2B        |
| 30  |             | Vcc1     | +3.3 V Power Supply                                                                 | 2B        |
| 31  | LVTTTL-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 Non-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        |

| Pin | Logic | Symbol   | Definition                          | Plug Seq. |
|-----|-------|----------|-------------------------------------|-----------|
| 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        |

## Specifications

### 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. | Typ. | Max. | Unit | Note |
|--------------------------------------|-----------------|------|------|------|------|------|
| Storage Temperature                  | T <sub>S</sub>  | -40  |      | 85   | °C   |      |
| Operating Case Temperature           | T <sub>OP</sub> | 0    |      | 70   | °C   |      |
| Power Supply Voltage                 | V <sub>CC</sub> | -0.5 |      | 3.6  | V    |      |
| Relative Humidity (non-condensation) | RH              | 0    |      | 85   | %    |      |
| Damage Threshold, each Lane          | TH <sub>d</sub> | 4.5  |      |      | dBm  |      |

### Recommended Operating Conditions and Power Supply Requirements

| Parameter                  | Symbol          | Min.  | Typ.    | Max.                 | Unit | Note |
|----------------------------|-----------------|-------|---------|----------------------|------|------|
| Operating Case Temperature | T <sub>OP</sub> | 0     |         | 70                   | °C   |      |
| Power Supply Voltage       | V <sub>CC</sub> | 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    |                 |       |         | 2.4x10 <sup>-4</sup> |      |      |
| Post-FEC Bit Error Ratio   |                 |       |         | 1x10 <sup>-12</sup>  |      | 1    |
| Link Distance              | D               | 0.002 |         | 2                    | km   | 2    |

#### Notes:

1. FEC provided by host system.
2. FEC required on host system to support maximum distance.

### Optical Characteristics

| Parameter                                                                   | Symbol           | Min.   | Typ.             | Max.   | Unit | Note |
|-----------------------------------------------------------------------------|------------------|--------|------------------|--------|------|------|
| Wavelength Assignment                                                       | L0               | 1264.5 | 1271             | 1277.5 | nm   |      |
|                                                                             | L1               | 1284.5 | 1291             | 1297.5 | nm   |      |
|                                                                             | L2               | 1304.5 | 1311             | 1317.5 | nm   |      |
|                                                                             | L3               | 1324.5 | 1331             | 1337.5 | nm   |      |
| <b>Transmitter</b>                                                          |                  |        |                  |        |      |      |
| Data Rate, each Lane                                                        |                  |        | 53.125 ± 100 ppm |        | GBd  |      |
| Modulation Format                                                           |                  |        | PAM4             |        |      |      |
| Side-mode Suppression Ratio                                                 | SMSR             | 30     |                  |        | dB   |      |
| Total Average Launch Power                                                  | P <sub>T</sub>   |        |                  | 9.3    | dBm  |      |
| Average Launch Power, each Lane                                             | P <sub>AVG</sub> | -3.3   |                  | 3.5    | dBm  | 1    |
| Outer Optical Modulation Amplitude (OMAO <sub>outer</sub> ), each Lane      | P <sub>OMA</sub> | -0.3   |                  | 3.7    | dBm  | 2    |
| Launch Power in OMAO <sub>outer</sub> Minus TDECQ, each Lane for ER ≥ 4.5dB |                  | -1.7   |                  |        | dB   |      |
| Launch Power in OMAO <sub>outer</sub> Minus TDECQ, each Lane for ER < 4.5dB |                  | -1.6   |                  |        | dB   |      |
| Transmitter and Dispersion Eye Clouser for PAM4, each Lane                  | TDECQ            |        |                  | 3.4    | dB   |      |

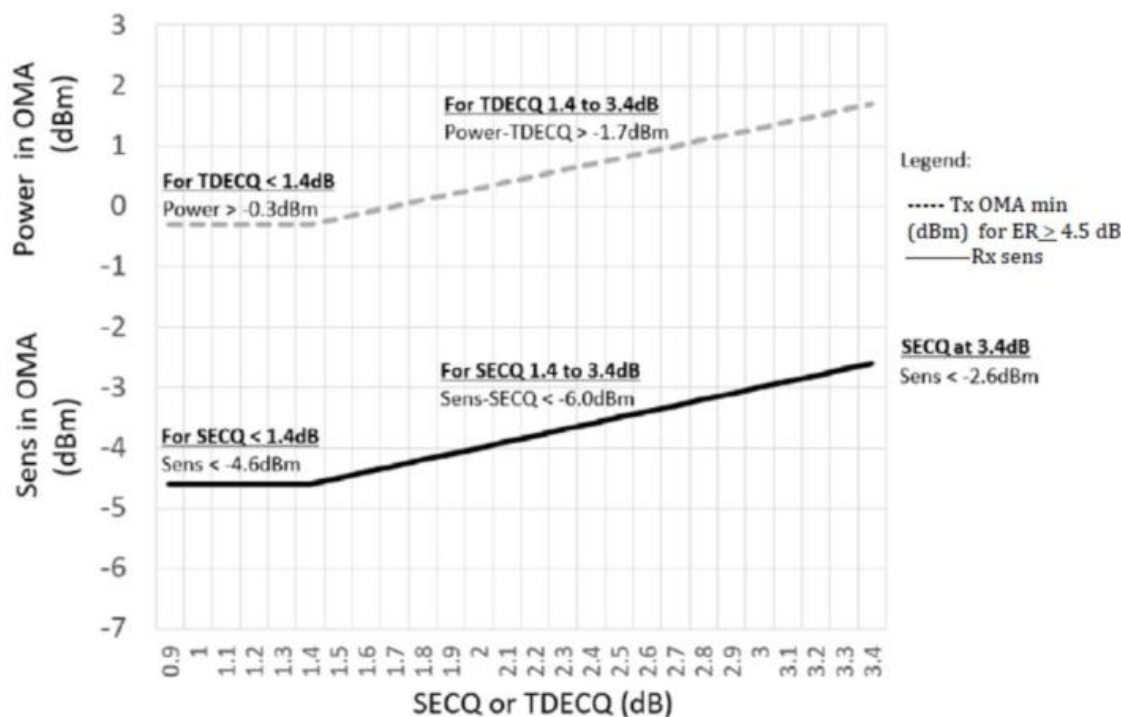
| Parameter                                                            | Symbol | Min. | Typ.             | Max.         | Unit  | Note |
|----------------------------------------------------------------------|--------|------|------------------|--------------|-------|------|
| TDECQ – $10 \cdot \log_{10} (C_{eq})$ , each Lane                    |        |      |                  | 3.4          | dB    | 3    |
| Extinction Ratio                                                     | ER     | 3.5  |                  |              | dB    |      |
| Difference in Launch Power between any Two Lanes ( $OMA_{outer}$ )   |        |      |                  | 4            | dB    |      |
| $RIN_{17.1OMA}$                                                      | RIN    |      |                  | -136         | dB/Hz |      |
| Optical Return Loss Tolerance                                        | TOL    |      |                  | 17.1         | dB    |      |
| Transmitter Reflectance                                              | $R_T$  |      |                  | -26          | dB    |      |
| Transmitter Transition Time                                          |        |      |                  | 17           | ps    |      |
| Average Launch Power of OFF Transmitter, each Lane                   | Poff   |      |                  | -20          | dBm   |      |
| <b>Receiver</b>                                                      |        |      |                  |              |       |      |
| Data Rate, each Lane                                                 |        |      | 53.125 ± 100 ppm |              | GBd   |      |
| Modulation Format                                                    |        |      | PAM4             |              |       |      |
| Damage Threshold, each Lane                                          | $TH_d$ | 4.5  |                  |              | dBm   | 4    |
| Average Receive Power, each Lane                                     |        | -7.3 |                  | 3.5          | dBm   | 5    |
| Receive Power ( $OMA_{outer}$ ), each Lane                           |        |      |                  | 3.7          | dBm   |      |
| Difference in Receiver Power between any Two Lanes ( $OMA_{outer}$ ) |        |      |                  | 4.1          | dB    |      |
| Receiver Sensitivity ( $OMA_{outer}$ ), each Lane                    | SEN    |      |                  | Equation (1) | dBm   | 6    |
| Stressed Receiver Sensitivity ( $OMA_{outer}$ ), each Lane           | SRS    |      |                  | -2.6         | dBm   | 7    |
| Receiver Reflectance                                                 | $R_R$  |      |                  | -26          | dB    |      |
| LOS Assert                                                           | LOSA   | -20  |                  |              | dBm   |      |
| LOS De-assert                                                        | LOSD   |      |                  | -10.3        | dBm   |      |
| LOS Hysteresis                                                       | LOSH   | 0.5  |                  |              | dB    |      |
| <b>Stressed Conditions for Stress Receiver Sensitivity (Note 8)</b>  |        |      |                  |              |       |      |
| Stressed Eye Closure for PAM4 (SECQ), Lane under Test                |        |      | 3.4              |              | dB    |      |
| SECQ – $10 \cdot \log_{10} (C_{eq})$ , Lane under Test               |        |      |                  | 3.4          | dB    |      |
| $OMA_{outer}$ of each Aggressor Lane                                 |        |      | 1.5              |              | 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 < 1.4 dB for an extinction ratio of  $\geq 4.5$  dB or TDECQ < 1.3 dB for an extinction ratio of < 4.5 dB, the  $OMA_{outer}$  (min) must exceed the minimum value specified here.
3.  $C_{eq}$  is a coefficient defined in IEEE Std 802.3-2018 clause 121.8.5.3 which accounts for reference equalizer noise enhancement.
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. The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having this average power level.
6. Receiver sensitivity ( $OMA_{outer}$ ) is informative and is defined for a transmitter with a value of SECQ up to 3.4 dB. Receiver sensitivity should meet Equation (1), which is illustrated in Figure below.

$$RS = \max (-4.6, SECQ - 6.0) \text{ dBm}$$

Where: RS is the receiver sensitivity, and



7. Measured with conformance test signal at TP3 for the BER equal to  $2.4 \times 10^{-4}$ .
8. These test conditions are for measuring stressed receiver sensitivity. They are not characteristics of the receiver.

## Electrical Characteristics

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

| Parameter                                     | Symbol | Min.                                                               | Typ. | Max. | Unit | Note |
|-----------------------------------------------|--------|--------------------------------------------------------------------|------|------|------|------|
| Power Consumption                             |        |                                                                    |      | 10.5 | W    |      |
| Supply Current                                | Icc    |                                                                    |      | 3.18 | A    |      |
| <b>Transmitter (each Lane)</b>                |        |                                                                    |      |      |      |      |
| Signaling Rate, each Lane                     | TP1    | $26.5625 \pm 100$ 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   |      |
|                                               | VIH    | ModPrsL can be implemented as a short-circuit to GND on the module |      |      |      |      |
| 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                                                        |      |      | V    |      |
| DC Common Mode Input Voltage                  | TP1    | -350                                                               |      | 2850 | mV   | 3    |
| <b>Receiver (each Lane)</b>                   |        |                                                                    |      |      |      |      |
| Signaling Rate, each lane                     | TP4    | $26.5625 \pm 100$ ppm                                              |      |      | GBd  |      |
| Differential Peak-to-Peak Output Voltage      | TP4    |                                                                    |      | 900  | mVpp |      |
| AC Common Mode Output Voltage, RMS            | TP4    |                                                                    |      | 17.5 | mV   |      |



| Parameter                                          | Symbol | Min.                             | Typ.  | Max. | Unit | Note |
|----------------------------------------------------|--------|----------------------------------|-------|------|------|------|
| Differential Termination Mismatch                  | TP4    |                                  |       | 10   | %    |      |
| Differential Output Return Loss                    | TP4    | IEEE 802.3-2015 Equation (83E-2) |       |      |      |      |
| Common to Differential Mode Conversion Return Loss | TP4    | IEEE 802.3-2015 Equation (83E-3) |       |      |      |      |
| Transition Time, 20% to 80%                        | TP4    | 9.5                              |       |      | ps   |      |
| Near-end Eye Symmetry Mask Width (ESMW)            | TP4    |                                  | 0.265 |      | UI   |      |
| Near-end Eye Height, Differential                  | TP4    | 70                               |       |      | mV   |      |
| Far-end Eye Symmetry Mask Width (ESMW)             | TP4    |                                  | 0.2   |      | UI   |      |
| Far-end Eye Height, Differential                   | TP4    | 30                               |       |      | mV   |      |
| Far-end Pre-cursor ISI Ratio                       | TP4    | -4.5                             |       | 2.5  | %    |      |
| Common Mode Output 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.

## Digital Diagnostics

| Parameter                               | Range        | Min  | Max | Units | Notes                            |
|-----------------------------------------|--------------|------|-----|-------|----------------------------------|
| Temperature Monitor Absolute Error      | DMI_Temp     | -3   | 3   | °C    | 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    |                                  |
| 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.

## 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.

## Ordering Information

| Product Name     | Product Description                                                                                                                        |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| QDD-400G-FR4-02  | QSFP-DD PAM4 Plug-in, 400GBASE-FR4 2km, CWDM 1271, 1291, 1311 and 1331nm, SMF Optical Transceiver, LC Duplex, DOM                          |
| JQDD-400G-FR4-02 | QSFP-DD PAM4 Plug-in, 400GBASE-FR4 2km, CWDM 1271, 1291, 1311 and 1331nm, SMF Optical Transceiver, LC Duplex, DOM, Compatible with Juniper |

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