FINISAR

# Product Specification

# Quadwire® 40 Gb/s Parallel Active Optical Cable

# FCCx410QD3Cyy

## PRODUCT FEATURES

- Four-channel full-duplex active optical cable
- Multirate capability: 1.06Gb/s to 10.5Gb/s per channel
- Complies with QSFP MSA high-density form factor
- Round, plenum-rated (OFNP) and riser-rated (OFNR), low smoke zero halogen (LSZH) cables
- Connectivity Diagnostics® ready
- Rigid pull-tab with embedded LED light
- Hot Pluggable
- Low power dissipation: <1.3W per cable end
- Commercial operating case temperature range: 0ºC to 70ºC
- RoHS-6 Compliant



connectivity diagnostics

## APPLICATIONS

- InfiniBand QDR
- 40G Ethernet
- 4G/8G/10G Fibre Channel
- HPC Interconnections
- SATA/SAS3
- PCIe3

## PRODUCT SELECTION (Standard Lengths*)

| FCCx410QD3Cyy | |
|---|---|
| x: | N = Plenum-rated (OFNP) cable jacket<br>R = Riser-rated (OFNR) low smoke zero halogen (LSZH) cable jacket |
| yy*: | 03 = 3m length<br>05 = 5m length<br>10 = 10m length<br>15 = 15m length<br>20 = 20m length<br>30 = 30m length<br>50 = 50m length<br>X0 = 100m length |

*Please contact Finisar for availability of additional cable lengths.

# I. Pin Descriptions

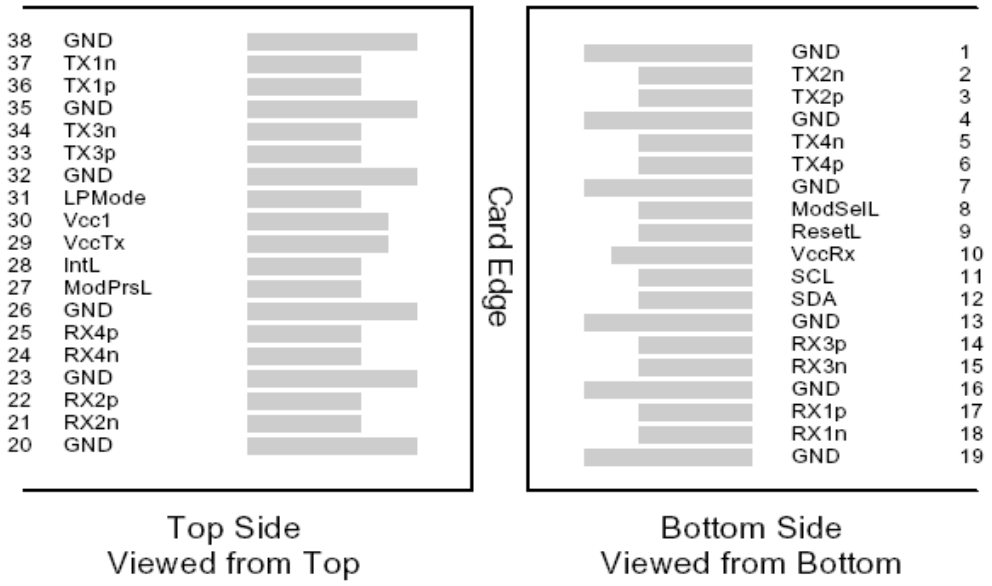



**Figure 1 – QSFP MSA-compliant 38-pin connector**

| Pin | Symbol | Name/Description | Notes |
|---|---|---|---|
| 1 | GND | Ground | 1 |
| 2 | Tx2n | Transmitter Inverted Data Input | |
| 3 | Tx2p | Transmitter Non-Inverted Data Input | |
| 4 | GND | Ground | 1 |
| 5 | Tx4n | Transmitter Inverted Data Input | |
| 6 | Tx4p | Transmitter Non-Inverted Data Input | |
| 7 | GND | Ground | 1 |
| 8 | ModSelL | Module Select | |
| 9 | ResetL | Module Reset | |
| 10 | Vcc Rx | +3.3 V Power supply receiver | |
| 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 | Vcc Tx | +3.3 V Power supply transmitter | |
| 30 | Vcc1 | +3.3 V Power Supply | |
| 31 | LPMode | Low Power Mode | |
| 32 | GND | Ground | 1 |
| 33 | Tx3p | Transmitter Non-Inverted Data Input | |
| 34 | Tx3n | Transmitter Inverted Data Input | |
| 35 | GND | Ground | 1 |
| 36 | Tx1p | Transmitter Non-Inverted Data Input | |
| 37 | Tx1n | Transmitter Inverted Data Input | |
| 38 | GND | Ground | 1 |

Notes
1. Circuit ground is internally isolated from chassis ground.

## II. General Product Characteristics

| Parameter | Value | Unit | Notes |
|---|---|---|---|
| Module Form Factor | QSFP | | |
| Number of Lanes | 4 Tx and 4 Rx | | |
| Maximum Aggregate Data Rate | 42.0 | Gb/s | |
| Maximum Data Rate per Lane | 10.5 | Gb/s | |
| Standard Cable Lengths | 3, 5, 10, 15, 20, 30, 50, 100 | meters | Other lengths may be available upon request (<100) |
| Protocols Supported | Typical applications include InfiniBand, Fibre Channel, 40G Ethernet, SATA/SAS3 | | |
| Electrical Interface and Pin-out | 38-pin edge connector | | Pin-out as defined by the QSFP MSA |
| Standard Optical Cable Type | Multimode fiber cable assembly | | |
| Maximum Power Consumption per End | 1.3 | Watts | Varies with output voltage swing and pre-emphasis settings (see Figure 5) |
| Management Interface | Serial, I2C-based, 400 kHz maximum frequency | | As defined by the QSFP MSA |

| Data Rate Specifications | Symbol | Min | Typ | Max | Units | Ref. |
|---|---|---|---|---|---|---|
| Bit Rate per Lane | BR | 1000 | | 10500 | Mb/sec | 1 |
| Bit Error Ratio | BER | | | $10^{-12}$ | | 2 |

Notes:
1. 1/10 Gigabit Ethernet and 1/2/4/8/10G Fibre Channel compatible.
2. Tested with a PRBS $2^{31}$-1 test pattern.

## III. Connectivity Diagnostics® Features

The FCCx410QD3Cxx Quadwire® are equipped with Finisar's Connectivity Diagnostics®, a technology solution enabling real-time performance monitoring and troubleshooting. The following two features are implemented by default:

LynkFind™
By manually pushing in the pull tab, both near- and far-end pull tabs will rapidly blink. To reset the pull tab light off, simply push in the pull tab again on either end of the AOC.

LynkGuardian™
If a digital diagnostic monitor (DDM) triggers an alarm or warning event, or upon a transmitter fault or a receiver loss of signal, the pull tabs of both ends will light up as follows: the near end (where the alarm originates) pull tab will blink slowly, while the far end pull tab will glow solid. Both pull tab lights will alternate blinking and solid in case DDM events occur on both AOCs ends.

## IV. Absolute Maximum Ratings

| Parameter | Symbol | Min | Typ | Max | Unit | Ref. |
|---|---|---|---|---|---|---|
| Maximum Supply Voltage | Vcc1, VccTx, VccRx | -0.5 | | 3.6 | V | |
| Storage Temperature | $T_S$ | -40 | | 85 | °C | 1 |
| Case Operating Temperature | $T_{OP}$ | 0 | | 70 | °C | |
| Relative Humidity | RH | 0 | | 85 | % | 2 |

Notes:
1. Assumes no mechanical load force on the unit. Ensuring no mechanical load force requires a cable bend radius of >105 mm within 100 mm of either cable end module and >60 mm on the rest of the cable.
2. Non-condensing.

## V. Electrical Characteristics ($T_{OP}$ = 0 to 70°C, $V_{CC}$ = 3.3 ± 5% Volts)

| Parameter | Symbol | Min | Typ | Max | Unit | Ref. |
|---|---|---|---|---|---|---|
| Supply Voltage | Vcc1, VccTx, VccRx | 3.15 | | 3.45 | V | |
| Supply Current | Icc | | | 350 | mA | |
| **Link Turn-On Time** | | | | | | |
| Transmit Turn-On Time | | | | 2000 | ms | 1 |
| **Transmitter (per Lane)** | | | | | | |
| Differential data input swing | Vin,pp | 180 | | 1200 | mVpp | 2 |
| Differential input threshold | | | 50 | | mV | |
| | | | | | | |
| **Receiver (per Lane)** | | | | | | |
| Differential data output swing | Vout,pp | 0 | | 800 | mVpp | 3,4 |
| Power Supply Ripple Tolerance | PSR | 50 | | | mVpp | |

Notes:
1. From power-on and end of any fault conditions.
2. AC coupled internally. See Figure 2 for input eye mask requirements. Self-biasing 100Ω differential input.
3. AC coupled with 100Ω differential output impedance. See Figure 3 for output eye mask.
4. Settable in 4 discrete steps. See Figure 5 for Vo settings

## VI. High-Speed Electrical Characteristics per Lane

**($T_{OP}$ = 0 to 70°C, $V_{CC}$ = 3.3 ± 5% Volts)**

| Parameter –Inputs | Symbol | Conditions | Min | Typ | Max | Units | Ref. |
|---|---|---|---|---|---|---|---|
| Reference Differential Input Impedance | $Z_d$ | | | 100 | | Ω | |
| Termination Mismatch | $\Delta Z_M$ | | | | 5 | % | 1 |
| Input AC Common Mode Voltage | | | | | 25 | mV (RMS) | |
| Differential Input Return Loss | SDD11 | 0.01-4.1 GHz | | | | dB | 2 |
| | | 4.1 – 11.1 GHz | | | | dB | 3 |
| Differential to Common Mode Loss | SCD11 | 0.01-11.1 GHz | | | -10 | dB | |
| Jitter Tolerance (Total) | TJ | | | | 0.40 | UI | |
| Jitter Tolerance (Deterministic) | DJ | | | | 0.15 | UI | |

Notes:
1. See SFF-8431 Rev 3.2 (SFP+) section D.15 Termination Mismatch for definition & test recommendations
2. Reflection coefficient given by equation SDD11(dB)< -12+2*SQRT(f), with f in GHz. See Figure 4.
3. Reflection coefficient given by equation SDD11(dB)< -6.3+13Log10(f/5.5), with f in GHz. See Figure 4.

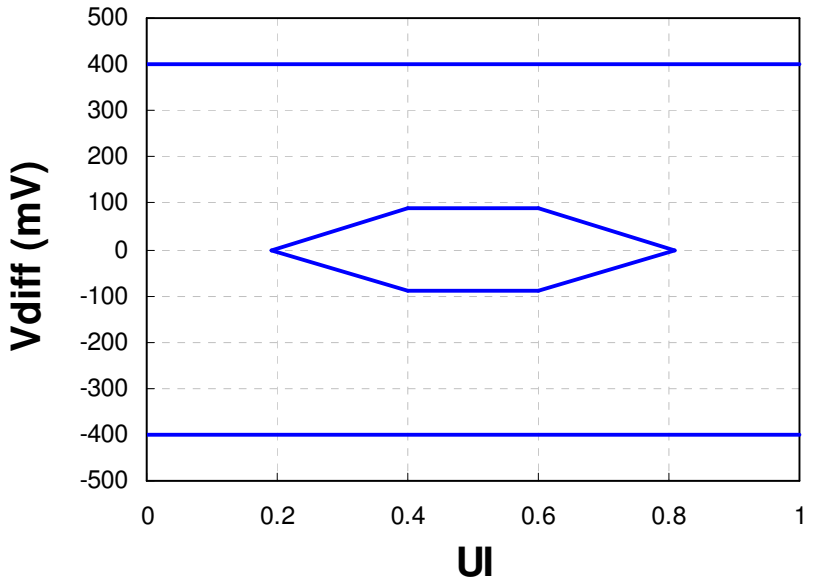



**Figure 2 – Transmitter Input Differential Signal Mask**

| Parameter –Outputs | Symbol | Conditions | Min | Typ | Max | Units | Ref. |
|---|---|---|---|---|---|---|---|
| Reference Differential Output Impedance | $Z_d$ | | | 100 | | Ω | |
| Termination Mismatch | $\Delta Z_M$ | | | | 5 | % | |
| Output AC Common Mode Voltage | | | | | 15 | $mV_{RMS}$ | |
| Output Rise and Fall time (20% to 80%) | $t_{RH}$, $t_{FH}$ | | 24 | | | ps | |
| Differential Output Return Loss | SDD22 | 0.01-4.1 GHz | | | | dB | 1 |
| | | 4.1 – 11.1 GHz | | | | dB | 2 |
| Common Mode Output Return Loss | SCC22 | 0.01-2.5 GHz | | | | dB | 3 |
| | | 2.5-11.1 GHz | | | -3 | dB | |

Notes:
1. Reflection coefficient given by equation SDD22(dB)< -12+2*SQRT(f), with f in GHz. See Figure 4.
2. Reflection coefficient given by equation SDD22(dB)< -6.3+13Log10(f/5.5), with f in GHz. See Figure 4.
3. Reflection coefficient given by equation SCC22(dB)< -7+1.6*f, with f in GHz.

| Receiver Output Jitter Specification | Symbol | Min | Typ | Max | Units | Ref. |
|---|---|---|---|---|---|---|
| Deterministic Jitter | $DJ_{OUT}$ | | | 0.38 | UI | 1 |
| Total Jitter | $TJ_{OUT}$ | | | 0.64 | UI | 1 |

Notes:
1. When transmitter input jitter specs are met.

| Other Informational Specifications (not tested) | Symbol | Min | Typ | Max | Units | Ref. |
|---|---|---|---|---|---|---|
| Max Bit Rate NRZ | B | | | 10.5 | Gb/s | |
| Low Frequency 3dB Cutoff | $f_c$ | 175 | | | kHz | |
| Ch / Ch crosstalk | | | | -26 | dB | |
| Output Pre-emphasis settings (user selectable) | PE | | 0 | | mV | |
| | | | 125 | | mV | |
| | | | 175 | | mV | |
| | | | 325 | | mV | |
| Pre-Emphasis pulse width | | 60 | | 90 | ps | |
| Channel-to-channel skew | | | | 24 | ns | 1 |
| Latency | | 400 | 495 | 600 | ns | 1 |
| Digital clock to data delay | | | | 25 | ns | |
| Digital output rise/fall times | | | | 5 | ns | |
| Digital input / output Cap | | | | 1 | pF | |
| Digital input logic High | | 2 | | | V | |
| Digital input logic Low | | | | 1 | V | |
| ESD Signal pads | | | | 500 | V | 2 |
| ESD (other pads) | | | | 2 | kV | 2 |

Notes:
1. For worst-case 100m length.
2. Human Body Model (HBM)

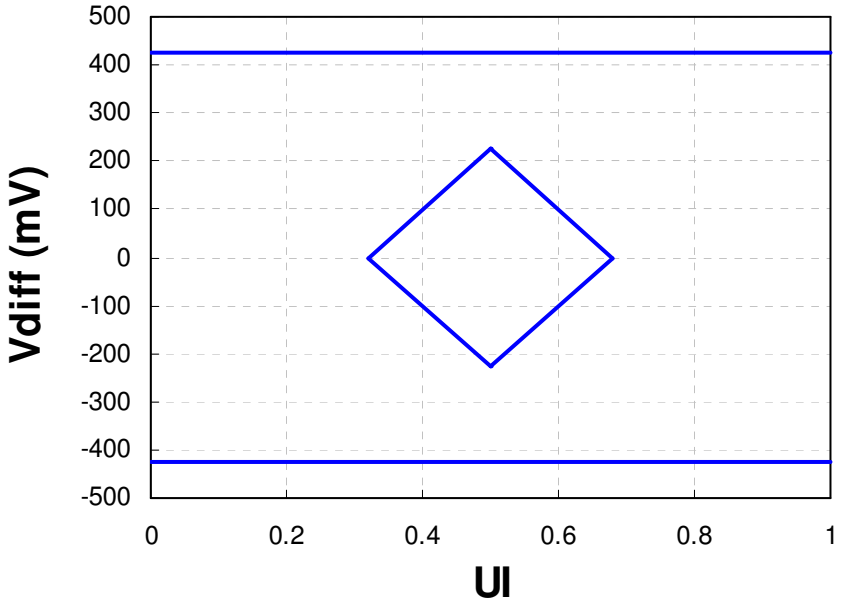



**Figure 3 – Receiver Output Differential Signal Mask**

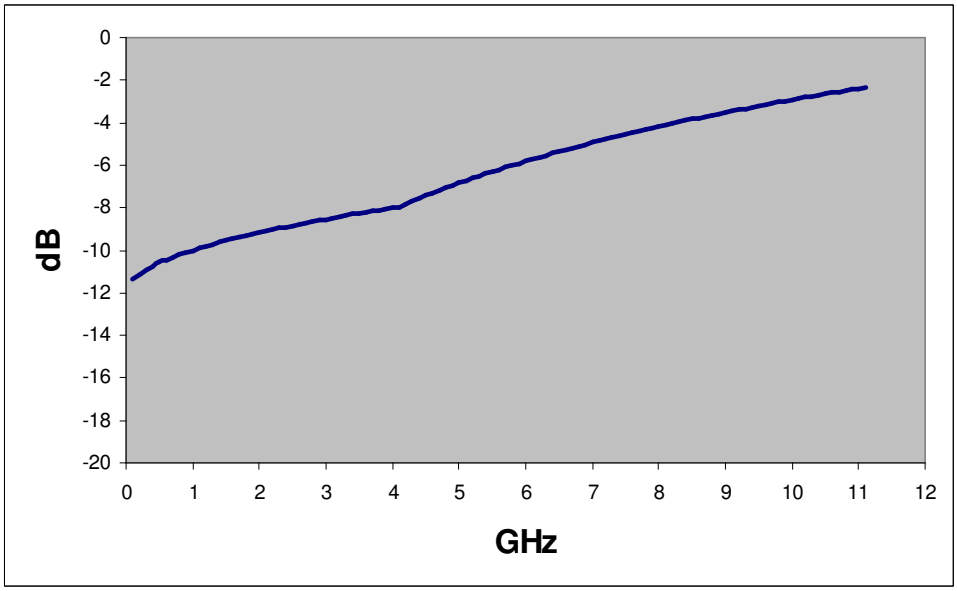



**Figure 4 – Maximum Transmitter Input and Receiver Output Differential Return Loss**

| Power (mW) | | Pre-Emphasis into 100ohms (mV) | | | |
|---|---|---|---|---|---|
| | | 0 | 125 | 175 | 325 |
| Vo (mV) | 0 | 599 | | | |
| | 317 | 751 | 935 | 971 | 1075 |
| | 422 | 787 | 971 | 1007 | 1111 |
| | 739 | 883 | 1055 | 1103 | 1190 |

**Figure 5 – Power Dissipation (mW, maximum) vs. Rx Output Conditions**

## VII. Memory Map and Control Registers

Compatible with SFF-8436.[2] Please see Finisar Application Note AN-2075: Quadwire® EEPROM Mapping[3] for details.

## VIII. Environmental Specifications

Finisar Quadwire® active optical cables have an operating temperature range from 0°C to +70°C case temperature.

| Environmental Specifications | Symbol | Min | Typ | Max | Units | Ref. |
|---|---|---|---|---|---|---|
| Case Operating Temperature | $T_{op}$ | 0 | | 70 | °C | |
| Storage Temperature | $T_{sto}$ | -40 | | 85 | °C | 1 |

1. Assumes no mechanical load force on the unit. Ensuring no mechanical load force requires a cable bend radius of >105 mm within 100 mm of either cable end module and >60 mm on the rest of the cable.

## IX. Regulatory Compliance

Finisar Quadwire® active optical cables are RoHS-6 Compliant. Copies of certificates are available at Finisar Corporation upon request.

Quadwire® active optical cables are Class 1 laser eye safety compliant per IEC 60825-1.

The round cable jacket is available in both plenum-rated (OFNP) and riser-rated (OFNR) low smoke zero-halogen (LSZH).

## X. Mechanical Specifications

The Quadwire® mechanical specifications are based on QSFP transceiver module specifications, substituting the MPO connectors with a cable connecting both ends. Rigid pull-tab is opaque in non-illuminated mode and amber in illuminated mode.

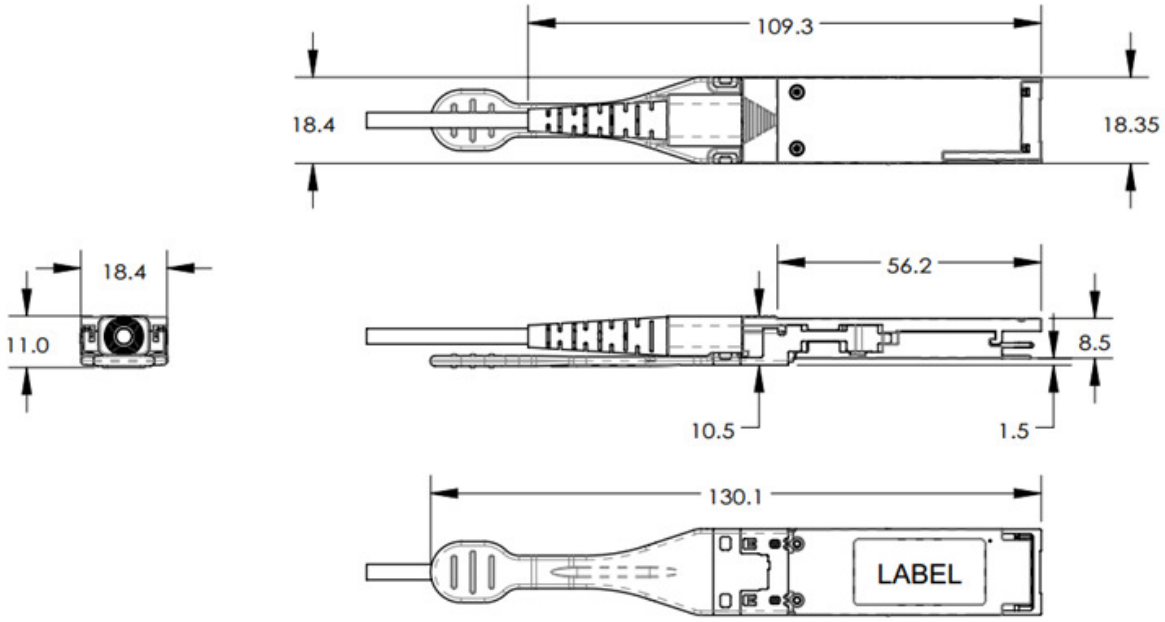



**Figure 5 – Quadwire® with Connectivity Diagnostics® mechanical drawing**

| Cable Mechanical Specifications | Min | Typical | Max | Units |
|---|---|---|---|---|
| Minimum bend radius | 60 | | | mm |
| Minimum bend radius within 100 mm of the Quadwire® module end | 105 | | | mm |
| Diameter | 3.0 | 3.3 | 3.6 | mm |

| Insertion, Extraction and Retention Forces | Min | Max | Units | Notes |
|---|---|---|---|---|
| Cable Proof (Tensile) Test (0°) | | 44.0 | Newtons | |
| Cable Proof (Tensile) Test (90°) | | 33.0 | Newtons | |
| Impact Test | | 8 | Cycles | 1.5m drop |
| Flex Test | | 8.9 | Newtons | |
| Twist Test | | 13.0 | Newtons | |
| Module retention | 90 | N/A | Newtons | No damage below 90N |
| Host Connector Retention | 180 | N/A | Newtons | No damage below 180N |




**Figure 6 – Quadwire® production-level product label**

## XI. References

1. INF-8438i – Specification for QSFP (Quad Small Formfactor Pluggable) Transceiver, Rev 1.0, November 2006

2. SFF-8636 – Specification for QSFP+ Copper and Optical Transceiver, Rev 2.7, January 2016

3. Application Note AN-2075: Quadwire® EEPROM Mapping, Rev E

4. Application Note AN-2158: Finisar's Connectivity Diagnostics™ for Active Optical Cables

## XII. For More Information

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