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

## 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

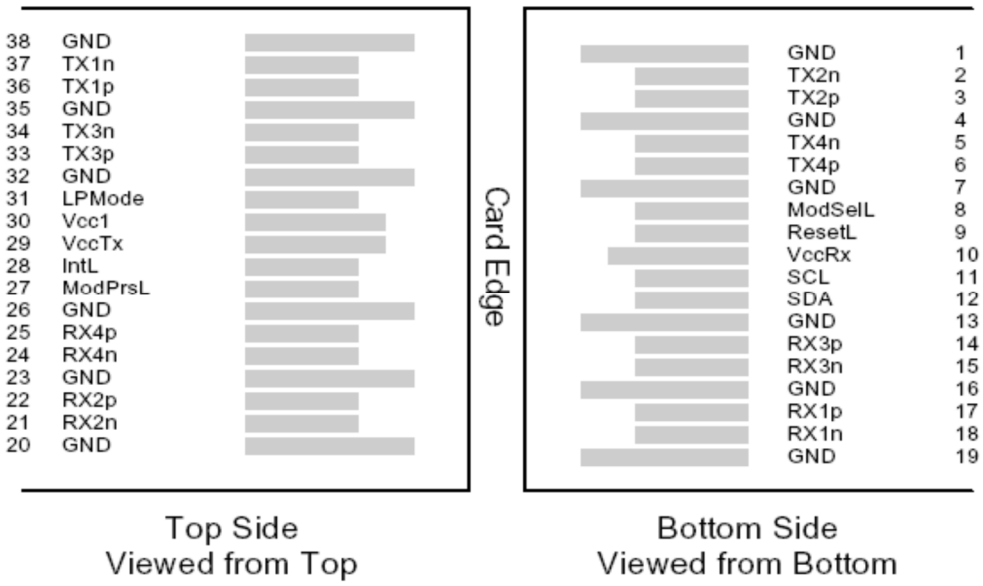



**Figure 1 – QSFP MSA-compliant 38-pin connector**

| 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 | |
| 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 data pattern for bit rate above 2.5Gb/s, PRBS $2^{23}$-1 for bit rate 2.5Gb/s, and PRBS $2^{7}$-1 for bit rate 1.25Gb/s.

## III. Connectivity Diagnostics® Technology

Finisar's FCCx410QD3Cxx Quadwire® AOCs are equipped with Connectivity Diagnostics®, which combines out-of-band signaling between the transceivers at the two ends of the AOC, and LED lights embedded in their pull tabs.

The Quadwire® implements two Connectivity Diagonostics® features:

LynkFind™ — Helps locate the other end of the AOC. Manually pushing-in either pull tab will light up their LED lights on both ends.

LynkGuardian™ — Reports the health status of the AOC. Any Digital Diagnostic Monitoring warning/alarm events, transmitter fault or receiver loss of signal will light up the pull-tab LED lights on both ends.

A detailed description of Connectivity Diagnostics® is provided in Finisar's Application Note AN-2158 [4].

## 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 | 100 | | 1200 | 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 SFF-8636 [2] Table 6-33 for the output differential amplitude control.

## 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.

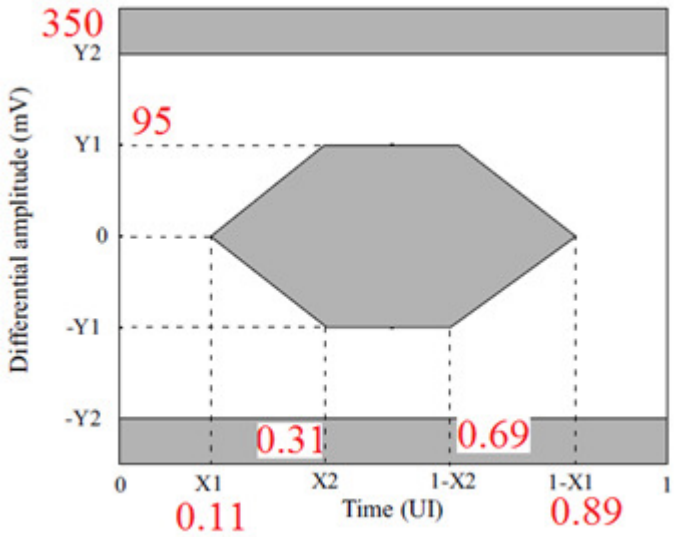



**Figure 2 – Transmitter Input Differential Signal Mask**

| 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 | |

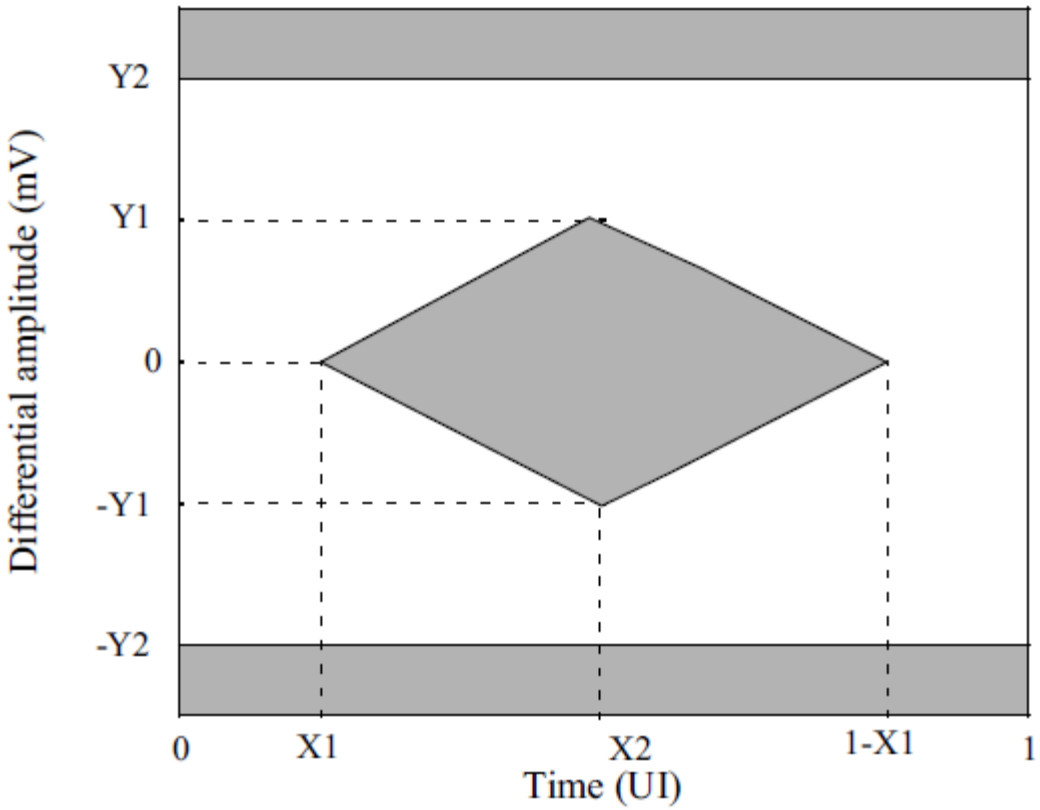
Notes:
1. Reflection coefficient given by equation SDD22(dB)< -12+2*SQRT(f), with f in GHz. See Figure 4.
2. Reflection coefficient given by equation SDD22(dB)< -6.3+13Log10(f/5.5), with f in GHz. See Figure 4.
3. Reflection coefficient given by equation SCC22(dB)< -7+1.6*f, with f in GHz.

| 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 | | | | 5 | dB | 1 |
| Pre-Emphasis pulse width | | 60 | | 90 | ps | |
| Channel-to-channel skew | | | | 24 | ns | 2 |
| Latency | | 400 | 495 | 600 | ns | 2 |
| 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 | 3 |
| ESD (other pads) | | | | 2 | kV | 3 |

Notes:
1. Test data based on fixed amplitude value 0. (If AMP value=0x0f, max value of Pre-E will be smaller)
2. For worst-case 100m length.
3. Human Body Model (HBM)




X1=0.29, X2=0.5, Y1=150, Y2=425

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

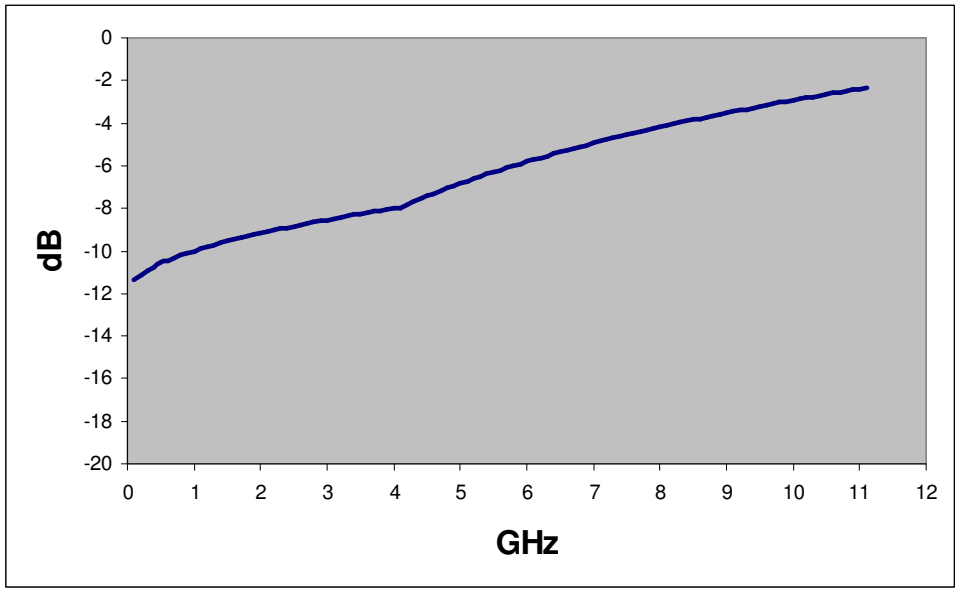



**Figure 4 – Maximum Transmitter Input and Receiver Output Differential Return Loss**

## 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.

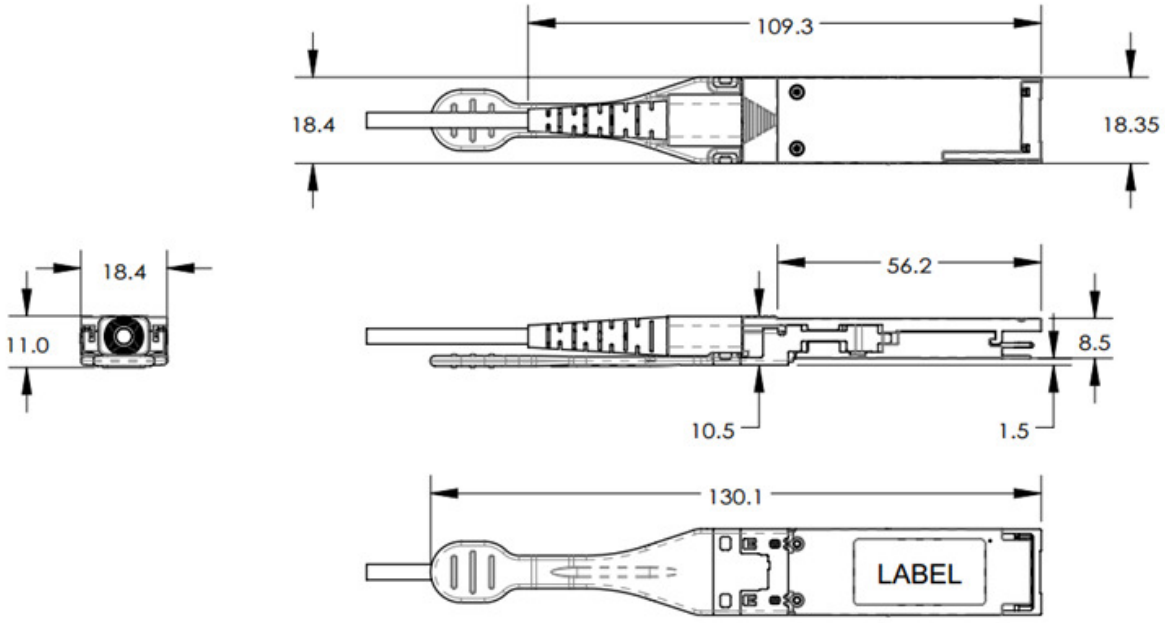



**Figure 5 – Quadwire® with Connectivity Diagnostics® mechanical drawing**

| 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 |

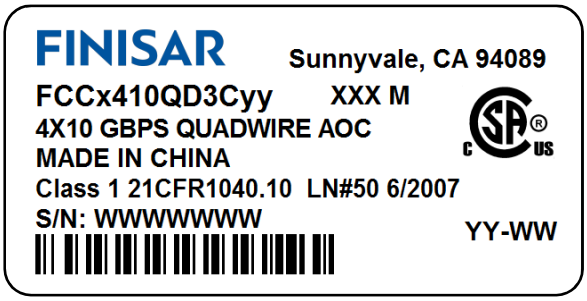



**Figure 6 – Quadwire® production-level product label**

## 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

Finisar Corporation
1389 Moffett Park Drive
Sunnyvale, CA 94089-1133
Tel. 1-408-548-1000
Fax 1-408-541-6138
sales@finisar.com
www.finisar.com