

## Product Specification

### Quadwire® FDR Parallel Active Optical Cable

#### FCBx414QD3Cyy

#### PRODUCT FEATURES

- Four-channel full-duplex active optical cable
- Multirate capability: 1.06Gb/s to 14.025Gb/s per channel
- Complies with QSFP MSA high-density form factor
- Reliable VCSEL array technology using multimode fiber
- Round, plenum-rated (OFNP) and riser-rated (OFNR), low smoke zero halogen (LSZH) cables
- Hot Pluggable
- Built-in digital diagnostic functions
- Low power dissipation: <1.3W per cable end
- Commercial operating case temperature range: 0°C to 70°C
- RoHS-6 Compliant (lead-free)



#### APPLICATIONS

- Infiniband 4xFDR, 4xQDR
- 40G Ethernet
- 4G/8G/10G/14G Fibre Channel
- HPC Interconnections
- SATA/SA

#### PRODUCT SELECTION (Standard Lengths\*)

| <b>FCBx414QD3Cyy</b>                                                  |                                                                                                                                                     |
|-----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| 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

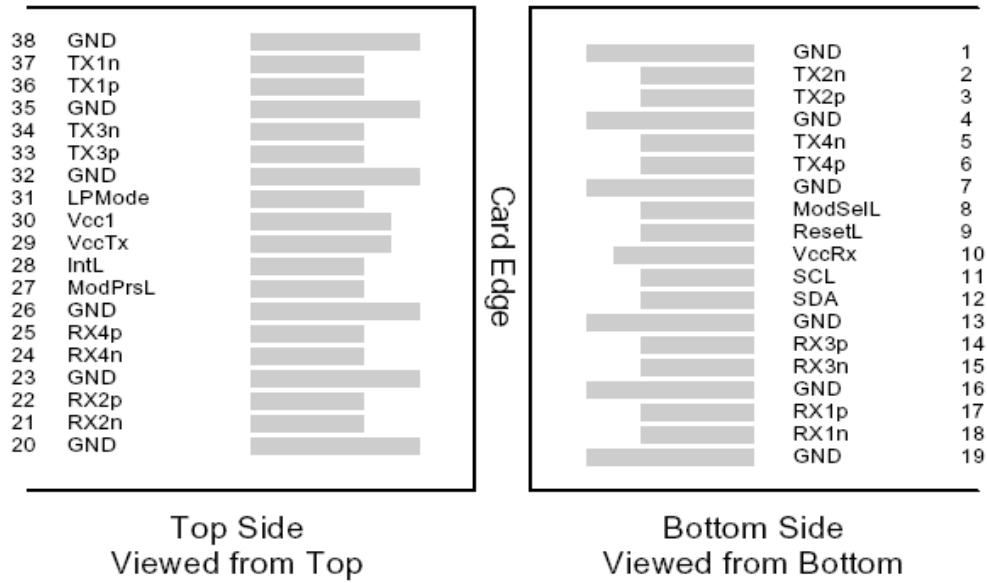


Figure 1 – QSFP MSA-compliant 38-pin connector

| 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       | 56.25                                                                           | Gb/s   |                                                                           |
| Maximum Data Rate per Lane        | 14.0625                                                                         | Gb/s   |                                                                           |
| Standard Cable Lengths            | 3, 5, 10, 15, 20, 30, 50, 100                                                   | meters | Other lengths may be available upon request (< 300m)                      |
| 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 ribbon fiber cable assembly, riser-rated                              |        |                                                                           |
| Maximum Power Consumption per End | 1.3                                                                             | Watts  | Varies with output voltage swing and pre-emphasis settings (see Figure 2) |
| 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 |     | 14062.5           | Mb/sec | 1    |
| Bit Error Ratio          | BER    |      |     | 10 <sup>-12</sup> |        | 2    |

**Notes:**

1. 1/10 Gigabit Ethernet and 1/2/4/8/10/16G Fibre Channel compatible.
2. Tested with a PRBS 2<sup>31</sup>-1 test pattern.

### III. Absolute Maximum Ratings

| Parameter                  | Symbol                                                         | Min  | Typ | Max | Unit | Ref. |
|----------------------------|----------------------------------------------------------------|------|-----|-----|------|------|
| Maximum Supply Voltage     | V <sub>cc1</sub> ,<br>V <sub>ccTx</sub> ,<br>V <sub>ccRx</sub> | -0.5 |     | 3.6 | V    |      |
| Storage Temperature        | T <sub>s</sub>                                                 | -40  |     | 85  | °C   | 1    |
| Case Operating Temperature | T <sub>OP</sub>                                                | 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.

### IV. Electrical Characteristics (T<sub>OP</sub> = 0 to 70°C, V<sub>CC</sub> = 3.3 ± 5% Volts)

| Parameter                      | Symbol                                                         | Min  | Typ | Max  | Unit             | Ref. |
|--------------------------------|----------------------------------------------------------------|------|-----|------|------------------|------|
| Supply Voltage                 | V <sub>cc1</sub> ,<br>V <sub>ccTx</sub> ,<br>V <sub>ccRx</sub> | 3.15 |     | 3.45 | V                |      |
| Supply Current                 | I <sub>cc</sub>                                                |      |     | 350  | mA               |      |
| <b>Link Turn-On Time</b>       |                                                                |      |     |      |                  |      |
| Transmit Turn-On Time          |                                                                |      |     | 2000 | ms               | 1    |
| <b>Transmitter (per Lane)</b>  |                                                                |      |     |      |                  |      |
| Differential data input swing  | V <sub>in,pp</sub>                                             | 180  |     | 1200 | mV <sub>pp</sub> | 2    |
| Differential input threshold   |                                                                |      | 50  |      | mV               |      |
| <b>Receiver (per Lane)</b>     |                                                                |      |     |      |                  |      |
| Differential data output swing | V <sub>out,pp</sub>                                            | 0    |     | 800  | mV <sub>pp</sub> | 3,4  |
| Power Supply Ripple Tolerance  | PSR                                                            | 50   |     |      | mV <sub>pp</sub> |      |

**Notes:**

1. From power-on and end of any fault conditions.
2. AC coupled internally. 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 2 for V<sub>o</sub> settings

## V. High-Speed Electrical Characteristics per Lane

( $T_{OP} = 0$  to  $70^{\circ}C$ ,  $V_{CC} = 3.3 \pm 5\%$  Volts)

| Parameter –Inputs                      | Symbol       | Conditions     | Min | Typ | Max  | Units    | Ref. |
|----------------------------------------|--------------|----------------|-----|-----|------|----------|------|
| Reference Differential Input Impedance | $Z_d$        |                |     | 100 |      | $\Omega$ |      |
| 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.
3. Reflection coefficient given by equation  $SDD11(dB) < -6.3 + 13 \log_{10}(f/5.5)$ , with f in GHz.

| Parameter –Outputs                      | Symbol           | Conditions     | Min | Typ | Max | Units             | Ref. |
|-----------------------------------------|------------------|----------------|-----|-----|-----|-------------------|------|
| Reference Differential Output Impedance | $Z_d$            |                |     | 100 |     | $\Omega$          |      |
| Termination Mismatch                    | $\Delta Z_M$     |                |     |     | 5   | %                 |      |
| Output AC Common Mode Voltage           |                  |                |     |     | 15  | mV <sub>RMS</sub> |      |
| Output Rise and Fall time (20% to 80%)  | $t_{RH}, t_{FH}$ | 14 Gbps        | 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.
2. Reflection coefficient given by equation  $SDD22(dB) < -6.3 + 13 \log_{10}(f/5.5)$ , with f in GHz.
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      |     |     | 14.0625     | 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    |      |
| 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     | HBM  |
| ESD (other pads)                                |        |     |     | 2           | kV    | HBM  |
| Channel-to-channel skew                         |        |     |     | 913         | ps    | 1    |
| Latency                                         |        |     |     | 1086+4990/m | ps    |      |

Notes:

1. For cable lengths  $\leq 7m$ . For longer cable lengths, the maximum channel-to-channel skew = 1204ps + (cable length – 8m) \* 992ps.

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

Figure 2 – Power Dissipation (mW, maximum) vs. Rx Output Conditions

## VI. Memory Map and Control Registers

Compatible with SFF-8436.<sup>2</sup> Please see Finisar Application Note AN-2075: Quadwire<sup>®</sup> EEPROM Mapping<sup>3</sup> for details.

## VII. Environmental Specifications

Finisar Quadwire<sup>®</sup> 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.

**VIII. Regulatory Compliance**

Finisar FDR Quadwire<sup>®</sup> active optical cables are RoHS-6 Compliant. Copies of certificates to be available at Finisar Corporation upon request.

Quadwire<sup>®</sup> 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).

**IX. Mechanical Specifications**

Finisar FDR Quadwire<sup>®</sup> mechanical specifications are based on QSFP transceiver module specifications, substituting the MPO connectors with a cable connecting both ends.



**Figure 3 – Quadwire<sup>®</sup> mechanical drawing**

| Cable Mechanical Specifications                                           | Min | Typical | Max | Units |
|---------------------------------------------------------------------------|-----|---------|-----|-------|
| Minimum bend radius                                                       | 60  |         |     | mm    |
| Minimum bend radius within 100 mm of the Quadwire <sup>®</sup> 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 4 – Quadwire<sup>®</sup> production-level product label

**X. 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<sup>®</sup> EEPROM Mapping, Rev E

**XI. For More Information**

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