

# MULTI-RATE GIGABIT ETHERNET & FIBRE CHANNEL SFP TRANSCEIVERS WITH DIGITAL DIAGNOSTICS

## TRPEG1-E2 Single Mode

### Product Description

The TRPEG1-E2 SFP series of multi-rate fiber optic transceivers with integrated digital diagnostics monitoring functionality provide a quick and reliable interface for 1000BASE-LX Gigabit Ethernet and 1.062GBd Fibre Channel applications. The transceivers are designed to support data rates ranging from 1.25Gb/s down to 125Mb/s. The diagnostic functions, alarm and warning features as described in the Multi-Source Agreement (MSA) document, SFF-8472 (Rev. 9.4), are provided via an I<sup>2</sup>C serial interface.

Four options are offered with minimum optical link power budgets of 11dB, 18dB, 22dB and 24dB to support 10km to 80km link applications. Option "LX" uses a 1310nm Fabry Perot laser and provides a minimum optical link budget of 11dB, corresponding to a minimum distance of 10km, assuming fiber loss of 0.45dB/km. Option "EX" uses a 1310nm DFB laser and provides a minimum optical link budget of 18dB, corresponding to a minimum distance of 40km, assuming fiber loss of 0.35dB/km. Options "YX" and "ZX" use 1550nm DFB lasers and provide a minimum optical link budgets of 22dB and 24dB respectively, which correspond to minimum distances of 70km and 80km, assuming fiber loss of 0.25dB/km. All modules satisfy Class I Laser Safety requirements in accordance with the U.S. FDA/CDRH and international IEC-60825 standards.

The transceivers connect to standard 20-pad SFP connectors for hot plug capability. This allows the system designer to make configuration changes or maintenance by simply plugging in different types of transceivers without removing the power supply from the host system.

The transceivers have colored bail-type latches, which offer an easy and convenient way to release the modules. The latch is compliant with the SFP MSA.

The transmitter and receiver DATA interfaces are AC-coupled internally. LV-TTL Transmitter Disable control input and Loss of Signal output interfaces are also provided.

The transceivers operate from a single +3.3V power supply over operating case temperature ranges of -5°C to +70°C or -40°C to +85°C. The housing is made of metal for EMI immunity.



### Features

- ☑ Compliant with IEEE 802.3z Gigabit Ethernet 1000BASE-LX PMD Specifications
- ☑ Compliant with SFP MSA
- ☑ Digital Diagnostics through Serial Interface
- ☑ Internal Calibration for Digital Diagnostics
- ☑ Distance Options to Support 10km to 80km
- ☑ Eye Safe (Class I Laser Safety)
- ☑ Duplex LC Optical Interface
- ☑ Loss of Signal Output & TX Disable Input
- ☑ -40°C to +85°C Operating Case Temperature Option
- ☑ Hot-pluggable
- ☑ Single +3.3V Power Supply

### Absolute Maximum Ratings

| Parameter                               |                  | Symbol   | Minimum | Maximum  | Units |
|-----------------------------------------|------------------|----------|---------|----------|-------|
| Storage Temperature                     |                  | $T_{st}$ | - 40    | + 85     | °C    |
| Operating Case Temperature <sup>1</sup> | Commercial Temp. | $T_{op}$ | - 5     | + 70     | °C    |
|                                         | Industrial Temp. |          | - 40    | + 85     |       |
| Supply Voltage                          |                  | $V_{cc}$ | 0       | + 3.47   | V     |
| Input Voltage                           |                  | $V_{in}$ | 0       | $V_{cc}$ | V     |

<sup>1</sup> Measured on top side of SFP module at the front center vent hole of the cage.

**Transmitter Performance Characteristics** (Over Operating Case Temperature,  $V_{CC} = 3.13$  to  $3.47V$ )

All parameters guaranteed only at typical data rate

| Parameter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                 | Symbol                | Minimum                                                 | Typical | Maximum | Units |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------------|---------------------------------------------------------|---------|---------|-------|
| Operating Data Rate                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 | $B$                   | 125                                                     | -       | 1250    | Mb/s  |
| Optical Output Power <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | LX <sup>2</sup> | $P_o$                 | - 9.0                                                   | -       | - 3.0   | dBm   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | EX              |                       | - 4.5                                                   | -       | 0       |       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | YX              |                       | - 2.0                                                   | -       | + 3.0   |       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | ZX              |                       | 0                                                       | -       | + 5.0   |       |
| Center Wavelength                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | LX              | $\lambda_c$           | 1275                                                    | 1310    | 1357    | nm    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | EX              |                       | 1280                                                    | 1310    | 1335    |       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | YX, ZX          |                       | 1500                                                    | 1550    | 1580    |       |
| Spectral Width (RMS)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | LX              | $\Delta\lambda_{RMS}$ | -                                                       | -       | 2.5     | nm    |
| Spectral Width (-20dB)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | EX, YX, ZX      | $\Delta\lambda_{20}$  | -                                                       | -       | 1.0     | nm    |
| Side Mode Suppression Ratio                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | EX, YX, ZX      | $SMSR$                | 30                                                      | -       | -       | dB    |
| Extinction Ratio                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                 | $P_{hi}/P_{lo}$       | 9                                                       | -       | -       | dB    |
| Deterministic Jitter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                 | $DJ$                  | -                                                       | -       | 80      | ps    |
| Total Jitter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                 | $TJ$                  | -                                                       | -       | 227     | ps    |
| Optical Rise/Fall Time (20% to 80%)                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                 | $t_r, t_f$            | -                                                       | -       | 0.32    | ns    |
| Relative Intensity Noise                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                 | $RIN$                 | -                                                       | -       | -120    | dB/Hz |
| Dispersion Penalty <sup>3</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | YX              | -                     | -                                                       | -       | 1.2     | dB    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | ZX              |                       |                                                         |         | 1.5     |       |
| Optical Output Eye                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                 |                       | Compliant with Eye Mask Defined in IEEE 802.3z standard |         |         |       |
| <sup>1</sup> Measured average power coupled into single mode fiber (SMF).<br><sup>2</sup> For 50mm or 62.5mm multimode fiber (MMF) operation, the output power is 0.5dB less and is measured after a SMF offset-launch mode-conditioning patch cord as specified in IEEE 802.3z.<br><sup>3</sup> Specified at 1440ps/nm (YX) and 1600ps/nm (ZX) dispersion, which corresponds to the approximate worst-case dispersion for 70km and 80km G.652/G.654 fiber over the wavelength range of 1500 to 1580nm. |                 |                       |                                                         |         |         |       |

**Receiver Performance Characteristics** (Over Operating Case Temperature,  $V_{CC} = 3.13$  to  $3.47V$ )

All parameters guaranteed only at typical data rate

| Parameter                                                                                                                                |                        |            | Symbol                              | Minimum | Typical | Maximum | Units |
|------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------------|-------------------------------------|---------|---------|---------|-------|
| Operating Data Rate                                                                                                                      |                        |            | $B$                                 | 125     | -       | 1250    | Mb/s  |
| Minimum Input Optical Power (10 <sup>-12</sup> BER) <sup>1</sup>                                                                         |                        | LX         | $P_{min}$                           | - 20.0  | -       | -       | dBm   |
|                                                                                                                                          |                        | EX         |                                     | - 22.5  | -       | -       |       |
|                                                                                                                                          |                        | YX, ZX     |                                     | - 24.0  | -       | -       |       |
| Maximum Input Optical Power (10 <sup>-12</sup> BER) <sup>1</sup>                                                                         |                        |            | $P_{max}$                           | - 3.0   | -       | -       | dBm   |
| LOS Thresholds                                                                                                                           | Increasing Light Input | LX         | $P_{los+}$                          | -       | -       | - 20.0  | dBm   |
|                                                                                                                                          |                        | EX         |                                     | -       | -       | - 22.5  |       |
|                                                                                                                                          |                        | YX, ZX     |                                     | -       | -       | - 24.0  |       |
|                                                                                                                                          | Decreasing Light Input | LX         | $P_{los-}$                          | - 30.0  | -       | -       |       |
|                                                                                                                                          |                        | EX, YX, ZX |                                     | - 35.0  | -       | -       |       |
| LOS Timing Delay                                                                                                                         | Increasing Light Input |            | $t_{loss\_off}$                     | -       | -       | 100     | μs    |
|                                                                                                                                          | Decreasing Light Input |            | $t_{loss\_on}$                      | -       | -       | 100     |       |
| LOS Hysteresis                                                                                                                           |                        |            | -                                   | 0.5     | -       | -       | dB    |
| Deterministic Jitter                                                                                                                     |                        |            | $DJ$                                | -       | -       | 170     | ps    |
| Total Jitter                                                                                                                             |                        |            | $TJ$                                | -       | -       | 266     | ps    |
| Wavelength of Operation                                                                                                                  |                        |            | $\lambda$                           | 1100    | -       | 1600    | nm    |
| Optical Return Loss                                                                                                                      |                        |            | $ORL$                               | 12      | -       | -       | dB    |
| Electrical 3dB Upper Cutoff Frequency                                                                                                    |                        |            | -                                   | -       | -       | 1500    | MHz   |
| Stressed Receiver Sensitivity                                                                                                            |                        |            | Compliant with IEEE 802.3z standard |         |         |         |       |
| <sup>1</sup> When measured with 2 <sup>7</sup> -1 PRBS at 125Mb/s, 1062.5Mb/s & 1250Mb/s and 1310nm for LX & EX, and 1550nm for YX & ZX. |                        |            |                                     |         |         |         |       |

**Transmitter Electrical Interface** (Over Operating Case Temperature,  $V_{CC} = 3.13$  to  $3.47V$ )

| Parameter                                    | Symbol       | Minimum | Typical | Maximum        | Units |
|----------------------------------------------|--------------|---------|---------|----------------|-------|
| Input Voltage Swing (TD+ & TD-) <sup>1</sup> | $V_{PP-DIF}$ | 0.50    | -       | 2.4            | V     |
| Input HIGH Voltage (TX Disable) <sup>2</sup> | $V_{IH}$     | 2.0     | -       | $V_{CC}$       | V     |
| Input LOW Voltage (TX Disable) <sup>2</sup>  | $V_{IL}$     | 0       | -       | 0.8            | V     |
| Output HIGH Voltage (TX Fault) <sup>3</sup>  | $V_{OH}$     | 2.0     | -       | $V_{CC} + 0.3$ | V     |
| Output LOW Voltage (TX Fault) <sup>3</sup>   | $V_{OL}$     | 0       | -       | 0.8            | V     |

<sup>1</sup>Differential peak-to-peak voltage.<sup>2</sup>There is an internal 4.7 to 10k $\Omega$  pull-up resistor to  $V_{CC}$ .<sup>3</sup>Open collector compatible, 4.7 to 10k $\Omega$  pull-up resistor to  $V_{CC}$  (Host Supply Voltage).**Receiver Electrical Interface** (Over Operating Case Temperature,  $V_{CC} = 3.13$  to  $3.47V$ )

| Parameter                                     | Symbol       | Minimum | Typical | Maximum        | Units |
|-----------------------------------------------|--------------|---------|---------|----------------|-------|
| Output Voltage Swing (RD+ & RD-) <sup>1</sup> | $V_{PP-DIF}$ | 0.6     | -       | 2.0            | V     |
| Output HIGH Voltage (LOS) <sup>2</sup>        | $V_{OH}$     | 2.0     | -       | $V_{CC} + 0.3$ | V     |
| Output LOW Voltage (LOS) <sup>2</sup>         | $V_{OL}$     | 0       | -       | 0.5            | V     |

<sup>1</sup>Differential peak-to-peak voltage across external 100 $\Omega$  load.<sup>2</sup>Open collector compatible, 4.7 to 10k $\Omega$  pull-up resistor to  $V_{CC}$  (Host Supply Voltage).**Electrical Power Supply Characteristics** (Over Operating Case Temperature,  $V_{CC} = 3.13$  to  $3.47V$ )

| Parameter      | Symbol     | Minimum | Typical | Maximum | Units |
|----------------|------------|---------|---------|---------|-------|
| Supply Voltage | $V_{CC}$   | 3.13    | 3.3     | 3.47    | V     |
| Supply Current | LX         | -       | 190     | 245     | mA    |
|                | EX, YX, ZX | -       | 200     | 300     |       |

**Module Definition**

| MOD_DEF(0)<br>pin 6 | MOD_DEF(1)<br>pin 5 | MOD_DEF(2)<br>pin 4 | Interpretation by Host            |
|---------------------|---------------------|---------------------|-----------------------------------|
| TTL LOW             | SCL                 | SDA                 | Serial module definition protocol |

**Electrical Pad Layout**

|    |                    |    |               |
|----|--------------------|----|---------------|
| 20 | TX GND             | 1  | TX GND        |
| 19 | TD- (TX DATA IN-)  | 2  | TX Fault      |
| 18 | TD+ (TX DATA IN+)  | 3  | TX Disable    |
| 17 | TX GND             | 4  | MOD_DEF(2)    |
| 16 | VccTX              | 5  | MOD_DEF(1)    |
| 15 | VccRX              | 6  | MOD_DEF(0)    |
| 14 | RX GND             | 7  | NO CONNECTION |
| 13 | RD+ (RX DATA OUT+) | 8  | LOS           |
| 12 | RD- (RX DATA OUT-) | 9  | RX GND        |
| 11 | RX GND             | 10 | RX GND        |

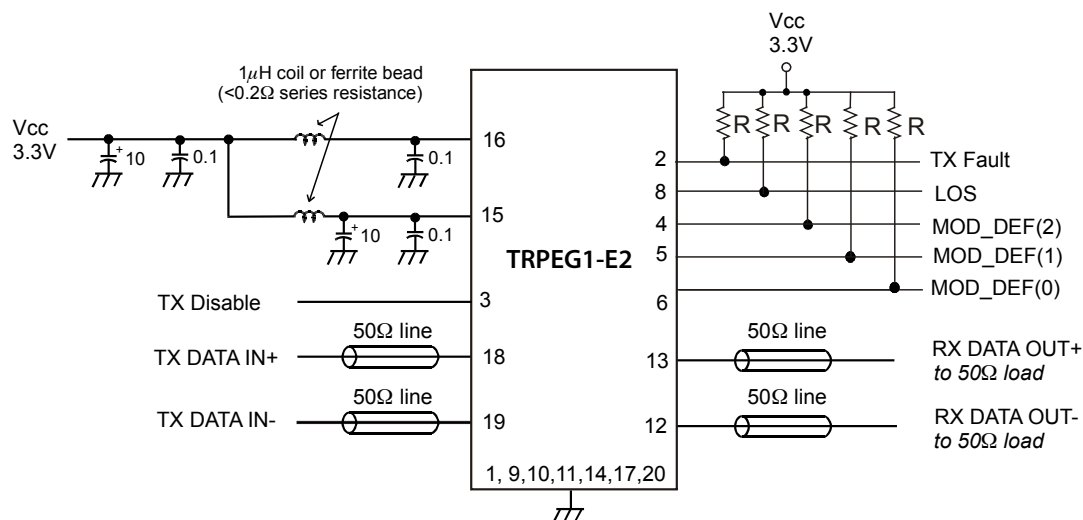
Top of Board

Bottom of Board  
(as viewed thru top of board)**Host Board Connector Pad Layout**

|    |  |    |
|----|--|----|
| 1  |  | 20 |
| 2  |  | 19 |
| 3  |  | 18 |
| 4  |  | 17 |
| 5  |  | 16 |
| 6  |  | 15 |
| 7  |  | 14 |
| 8  |  | 13 |
| 9  |  | 12 |
| 10 |  | 11 |

Toward  
BezelToward  
ASIC

### Example of SFP host board schematic



R: 4.7 to 10k $\Omega$

## Application Notes

**Electrical Interface:** All signal interfaces are compliant with the SFP MSA specification. The high speed DATA interface is differential AC-coupled internally with 0.1μF and can be directly connected to a 3.3V SERDES IC. All low speed control and sense output signals are open collector TTL compatible and should be pulled up with a 4.7 - 10kΩ resistor on the host board.

**Loss of Signal (LOS):** The Loss of Signal circuit monitors the level of the incoming optical signal and generates a logic HIGH when an insufficient photocurrent is produced.

**TX Fault:** The output indicates LOW when the transmitter is operating normally, and HIGH with a laser fault including laser end-of-life. TX Fault is an open collector/drain output and should be pulled up with a 4.7 - 10kΩ resistor on the host board. TX Fault is non-latching (automatically deasserts when fault goes away).

**TX Disable:** When the TX Disable pin is at logic HIGH, the transmitter optical output is disabled (less than -45dBm).

**Serial Identification and Monitoring:** The module definition of SFP is indicated by the three module definition pins, MOD\_DEF(0), MOD\_DEF(1) and MOD\_DEF(2). Upon power

## Laser Safety

**Laser Safety:** All transceivers are Class I Laser products per FDA/CDRH and IEC-60825 standards. They must be operated under specified operating conditions.

up, MOD\_DEF(1:2) appear as NC (no connection), and MOD\_DEF(0) is TTL LOW. When the host system detects this condition, it activates the serial protocol (standard two-wire I<sup>2</sup>C serial interface) and generates the serial clock signal (SCL). The positive edge clocks data into the EEPROM segments of the SFP that are not write protected, and the negative edge clocks data from the SFP.

The serial data signal (SDA) is for serial data transfer. The host uses SDA in conjunction with SCL to mark the start and end of serial protocol activation. The supported monitoring functions are temperature, voltage, bias current, transmitter power, average receiver signal, all alarms and warnings, and software monitoring of TX Fault/LOS. The device is internally calibrated.

The data transfer protocol and the details of the mandatory and vendor specific data structures are defined in the SFP MSA, and SFF-8472, Rev. 9.4.

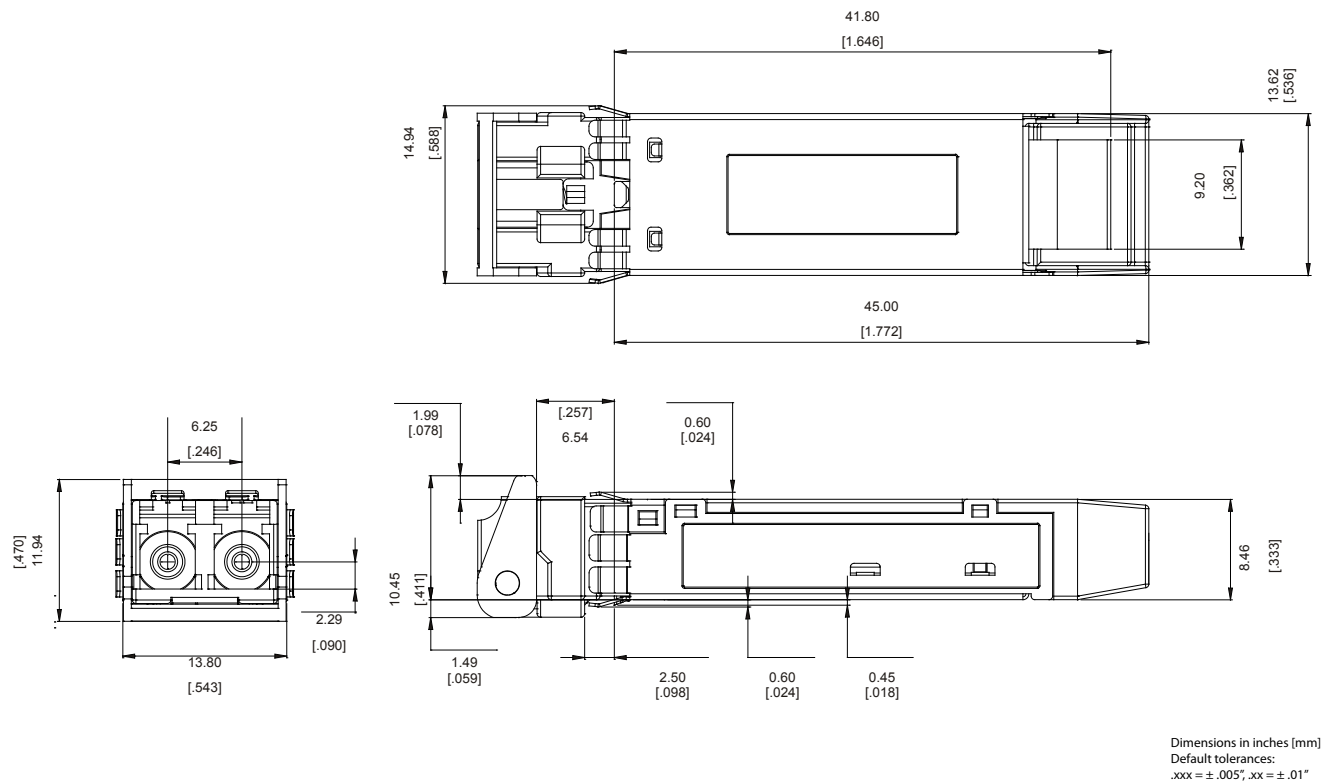
**Power Supply and Grounding:** The power supply line should be well-filtered. All 0.1  $\mu$ F power supply bypass capacitors should be as close to the transceiver module as possible.

**Oplink Communications, Inc.**  
DATE OF MANUFACTURE:

 This product complies with  
21 CFR 1040.10 and 1040.11  
**Meets Class I Laser Safety Requirements**



## Package Outline



## Ordering Information

| Part Number     | Type | Operating Temperature | Latch Color | Nominal Wavelength | Optical Link Power Budget <sup>4</sup> | Distance <sup>1</sup> |
|-----------------|------|-----------------------|-------------|--------------------|----------------------------------------|-----------------------|
| TRPEG1CLXC000E2 | LX   | - 5°C to +70°C        | Blue        | 1310nm             | 11dB                                   | 10km                  |
| TRPEG1EEXC000E2 | EX   | - 5°C to +70°C        | Brown       | 1310nm             | 18dB                                   | 40km <sup>2</sup>     |
| TRPEG1HYXC000E2 | YX   | - 5°C to +70°C        | Orange      | 1550nm             | 22dB                                   | 70km <sup>3</sup>     |
| TRPEG1JZXC000E2 | ZX   | - 5°C to +70°C        | Green       | 1550nm             | 24dB                                   | 80km <sup>3</sup>     |
| TRPEG1CLXI000E2 | LX   | - 40°C to +85°C       | Blue        | 1310nm             | 11dB                                   | 10km                  |
| TRPEG1EEXI000E2 | EX   | - 40°C to +85°C       | Brown       | 1310nm             | 18dB                                   | 40km <sup>2</sup>     |
| TRPEG1HYXI000E2 | YX   | - 40°C to +85°C       | Orange      | 1550nm             | 22dB                                   | 70km <sup>3</sup>     |
| TRPEG1JZXI000E2 | ZX   | - 40°C to +85°C       | Green       | 1550nm             | 24dB                                   | 80km <sup>3</sup>     |

<sup>1</sup>The indicated transmission distance is for guidelines only, not guaranteed. The exact distance is dependent on the fiber loss, connector and splice loss, and allocated system penalty. Longer distances can be supported if the optical link power budget is satisfied.

<sup>2</sup>Assuming a total connector and splice loss of 2dB, total system penalty of 2dB and fiber cable loss of 0.35dB/km.

<sup>3</sup>Assuming a total connector and splice loss of 2dB, total system penalty of 2dB and fiber cable loss of 0.25dB/km.

<sup>4</sup>Minimum Optical Link Power Budget.