*Accelar*™

# 1 Gbps SFP Shortwave Transceiver

## PL-XPL-00-S13


The 1G Small Form Factor Pluggable (SFP) transceiver provides superior performance in Fibre Channel short reach Gigabit Ethernet applications. It is a star performer in Picolight's family of *Accelar* products customized for high speed, short reach LAN, SAN and intra-POP applications. The 1G SFP features Picolight's highly reliable 850 nm oxide vertical-cavity surface-emitting laser (VCSEL) coupled to a LC optical connector. Its small size allows for high-density board designs that, in turn, enable greater total aggregate bandwidth. The pluggability of the module design further allows manufacturers to populate the optical ports later in the build cycle, providing a just-in-time inventory and cost control. The 1G SFP complies with Fibre Channel 100-M5/M6-SN-1 and 802.3z 1000BASE-SX standards.

**Key benefits**

- Compliant with industry-wide physical and optical specifications
- Superior EMI performance
- Enables higher port densities
- Proven high reliability
- In-house precision alignment

**Applications**

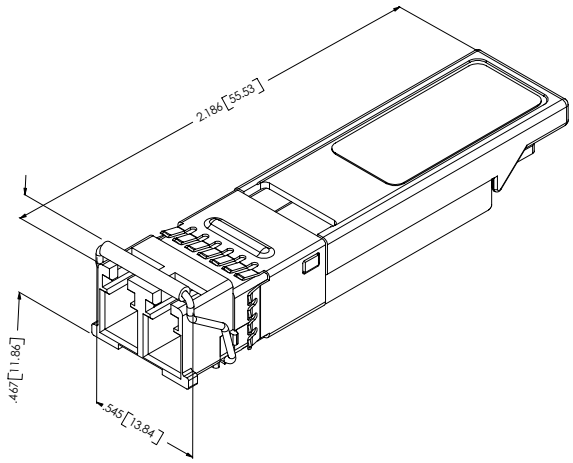
- High-speed storage area networks
  - Switch and hub interconnect
  - Mass storage systems interconnect
  - Host adapter interconnect
- Computer cluster cross-connect
- Enterprise switch interconnects
- Custom high-speed data pipes

## Highlights

- ***Pluggability enables just-in-time (JIT) inventory control of populated cards*** *by allowing separate control of cards and transceivers*
- ***MSA-compliant small form factor footprint*** *is half the size of current implementations, doubling port density and reducing overall system cost*
- ***Host card manufacturing process simplified*** *by moving optical transceiver placement to end of manufacturing line or even to deployment phase*
- ***Enhanced management feature set*** *allows further monitoring of transceiver performance and system stability*
- ***Signal detect and transmitter fault functions*** *enable system status indicators and debugging through system management*
- ***Serial ID*** *allows customer and vendor system specific information to be placed in transceiver*
- ***Full die cast metal housing*** *provides superior EMI performance*

**PL-XPL-00-S13 features**

- Utilizes a Picolight high reliability, high speed, 850 nm, oxide VCSEL
- Hot pluggable
- SFP MSA compliant
- Compliant with Fibre Channel 100-M5/M6-SN-I
- 802.3z 1000BASE-SX compliant
- Low power consumption (< 700 mW)
- High quality LC optical connector
- $0^{o}$C to $70^{o}$C operating range
- Single +3.3 V power supply
- Bit error rate < $1x10^{-12}$
- Up to 860 m on enhanced bandwidth 50/125 μm multimode fiber @ 1.062 & 1.25 Gbps
- Up to 300 m on enhanced bandwidth 62.5/125 μm multimode fiber @ 1.0625 Gbps
- OC transmit disable, signal detect and transmitter fault functions
- CDRH and IEC 60825-1 Class 1 laser eye safe
- FCC Class B compliant
- ESD Class 2 per MIL-STD 883 Method 3015
- UL-94 V-0 certified
- Internal AC Coupling on Both Transmit and Receive Data Signals
- Supplied with Dust Cover




*The PL-XPL-00-S13 transceiver is a cost effective, gigabit serial optical transceiver that is compliant with the Fibre Channel, 100-M5/M6-SN-I and Gigabit Ethernet 1000BASE-SX standards. This transceiver features a Picolight, high reliability, 850 nm, High Speed, Oxide VCSEL Laser coupled to a LC optical connector. This transceiver meets Class 1 laser eye safety requirements. The PL-XPL-00-S13 has GBIC functionality in 1/2 the width. The transceiver complies with the new Small Form Factor Pluggable Multisource Agreement (SFP-MSA).*

## Ordering information

| Part Number: | Description: | Contact Information: |
|---|---|---|
| PL-XPL-00-S13-05 | 1 Gbps, No Rate-Select, 850 nm, Transceiver | Picolight Incorporated<br>4665 Nautilus Court South<br>Boulder, CO 80301<br><br>Tel: 303.530.3189<br>E-mail: sales@picolight.com<br>Web site: www.picolight.com |

# Section 1 Functional description

The PL-XPL-00-S13 850 nm VCSEL Gigabit Transceiver is designed to transmit and receive 8B/10B encoded serial optical data over 50/125 μm or 62.5/125 μm optical fiber.

## Transmitter

The transmitter converts 8B/10B encoded serial PECL electrical data into serial optical data meeting the requirements of Fibre Channel 100-M5/M6-SN-I and IEEE 802.3z 1000 Base-5x specifications. Transmit data lines (TD+ & TD-) are internally AC coupled with 100 Ω differential termination.

An open collector compatible Transmit Disable ($TD_{is}$) is provided. This pin is internally terminated with a 10 kΩ resistor to $Vcc_t$. A logic “1,” or no connection on this pin will disable the laser from transmitting. A logic “0” on this pin provides normal operation.

The transmitter has an internal PIN monitor diode that is used to ensure constant optical power output across supply voltage and temperature variations.

An open collector compatible Transmit Fault (TFault) is provided. The Transmit Fault signal must be pulled high on the host board for proper operation. A logic “1” output from this pin indicates that a transmitter fault has occurred, or the transceiver is not fully seated and the transmitter is not functioning. A logic “0” on this pin indicates normal operation.

## Receiver

The receiver converts 8B/10B encoded serial optical data into serial PECL electrical data. Receive data lines (RD+ & RD-) are internally AC coupled with 100 Ω differential source impedance, and must be terminated with a 100 Ω differential load.

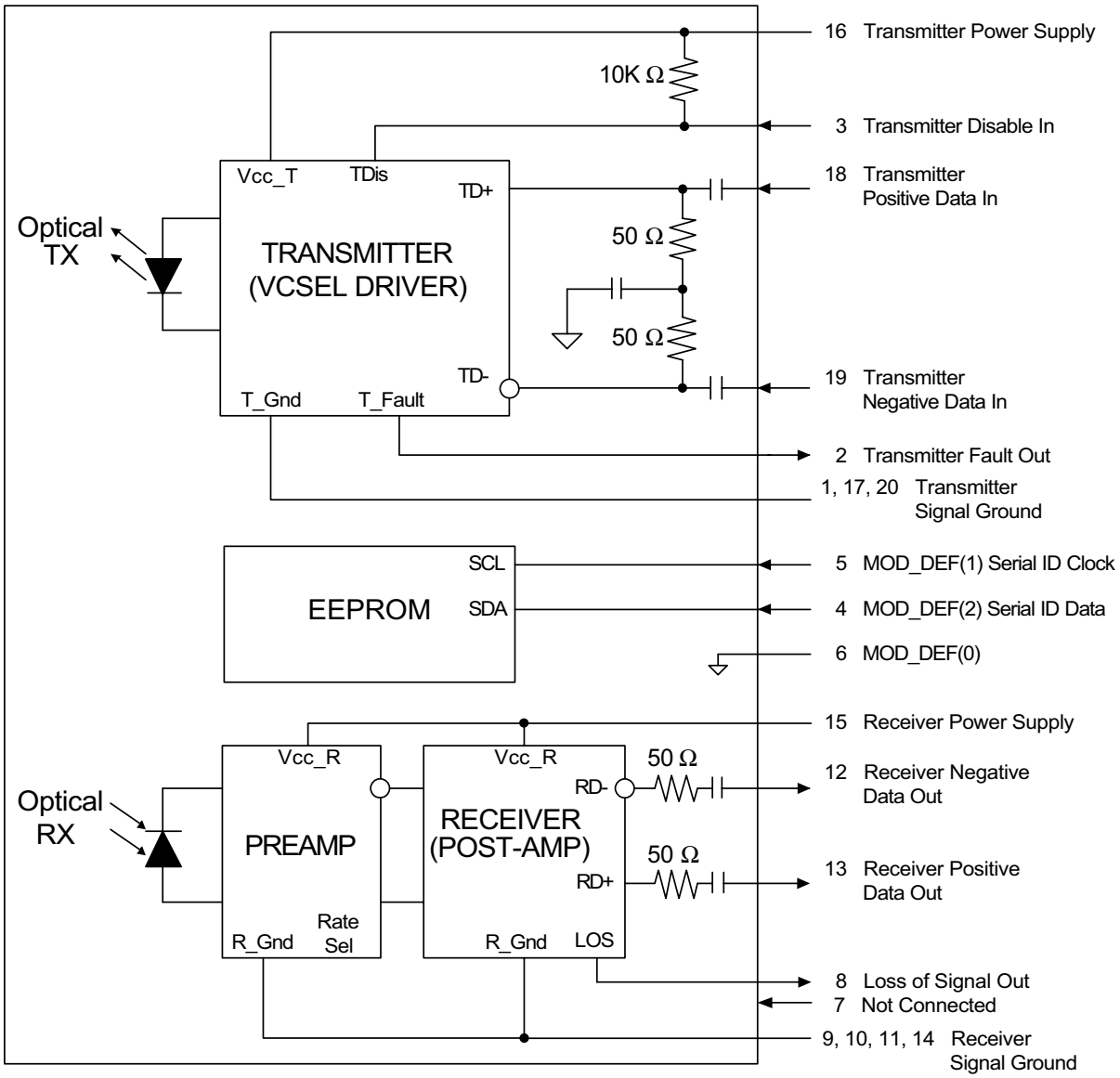
An open collector compatible Loss of Signal is provided. The LOS must be pulled high on the host board for proper operation. A logic “0” indicates that light has been detected at the input to the receiver (see Section 3.4 Optical characteristic, Loss of Signal Assert/Deassert Time on page 8). A logic “1” output indicates that insufficient light has been detected for proper operation.

Power supply filtering is recommended for both the transmitter and receiver. Filtering should be placed on the host assembly as close to the Vcc pins as possible for optimal performance.

Recommended “Application Schematics” are shown in Figure 2 on page 5.

See also Picolight Optical Transceiver User Guide. Document number 16000041, Application Notes on Grounding, Shielding and Filtering.

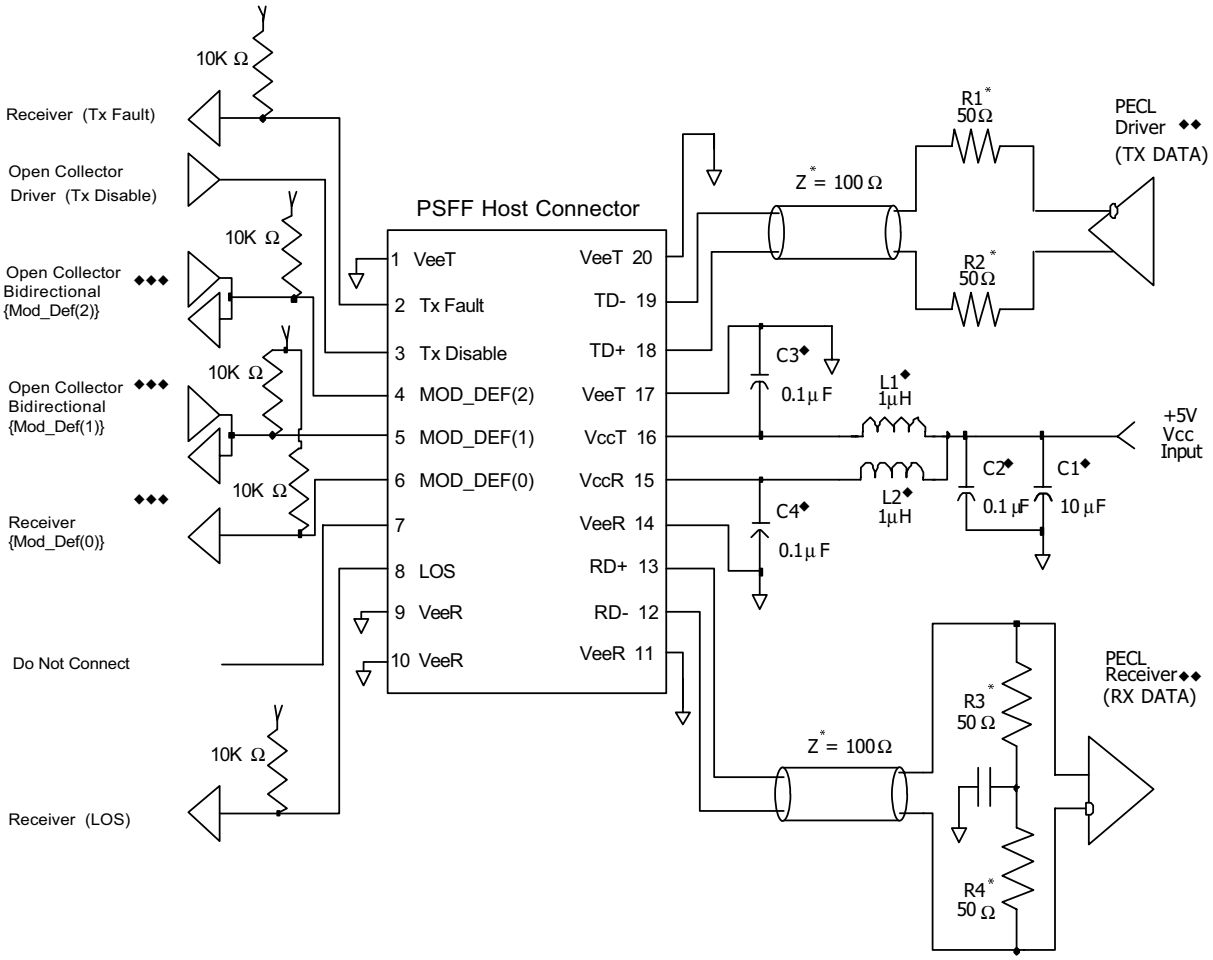
**Figure 1 Block diagram**



# Section 2 Application schematics

Recommended connections to the PL-XPL-00-S13 transceiver are shown in Figure 2 below.

**Figure 2 Recommended application schematic for the PL-XPL-00-S13 transceiver**




## Notes

◆ Power supply filtering components should be placed as close to the $V_{cc}$ pins of the host connector as possible for optimal performance.

◆◆ PECL driver and receiver will require biasing networks. Please consult application notes from suppliers of these components.

◆◆◆ MOD_DEF(2) and MOD_DEF(1) should be bi-directional open collector connections in order to implement serial ID (MOD_DEF[0,1,1]) PL-XPL-00-S13 transceiver.

* Transmission lines should be 100 Ω differential traces. It is recommended that the termination resistor for the PECL Receiver (R3 + R4) be placed beyond the input pins of the PECL Receiver. Series Source Termination Resistors on the PECL Driver (R1+R2) should be placed as close to the driver output pins as possible.

# Section 3 Technical data

Technical data related to the 1 Gbps SFP Shortwave Transceiver includes:



## 3.1 Pin function definitions

**Figure 3 Transceiver pin descriptions**

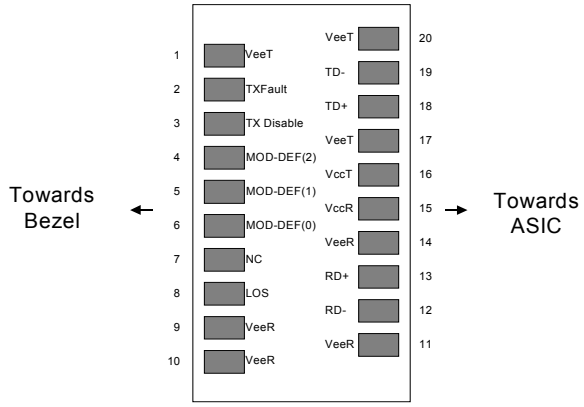



**Table 1 Transceiver pin descriptions**

| Pin Number | Symbol | Name | Description |
|---|---|---|---|
| **Receiver** | | | |
| 8 | LOS | Loss of Signal Out (OC) | Sufficient optical signal for potential BER < $1x10^{-12}$ = Logic “0”<br>Insufficient optical signal for potential BER < $1x10^{-12}$ = Logic “1”<br>This pin is open collector compatible, and should be pulled up to Host Vcc with a 10 kΩ resistor. |
| 9, 10, 11, 14 | VeeR | Receiver Signal Ground | These pins should be connected to signal ground on the host board. |
| 12 | RD- | Receiver Negative DATA Out (PECL) | Light on = Logic “0” Output<br>Receiver DATA output is internally AC coupled and series terminated with a 50 Ω resistor. |

**Table 1 Transceiver pin descriptions** (continued)

| Pin Number | Symbol | Name | Description |
|---|---|---|---|
| 13 | RD+ | Receiver Positive DATA Out (PECL) | Light on = Logic “1” Output<br>Receiver DATA output is internally AC coupled and series terminated with a 50 Ω resistor. |
| 15 | VccR | Receiver Power Supply | This pin should be connected to a filtered +3.3V power supply on the host board. See Specification notes on page 10 for filtering suggestions. |
| 7 | NC | NC | No connection inside the module. |
| **Transmitter** | | | |
| 3 | TX Disable | Transmitter Disable In (LVTTL) | Logic “1” Input (or no connection) = Laser off<br>Logic “0” Input = Laser on<br>This pin is internally pulled up to $Vcc_T$ with a 10 kΩ resistor. |
| 1, 17, 20 | VeeT | Transmitter Signal Ground | These pins should be connected to signal ground on the host board. |
| 2 | TX Fault | Transmitter Fault Out (OC) | Logic “1” Output = Laser Fault (Laser off before t_fault)<br>Logic “0” Output = Normal Operation<br>This pin is open collector compatible, and should be pulled up to Host Vcc with a 10 kΩ resistor. |
| 16 | VccT | Transmitter Power Supply | This pin should be connected to a filtered +3.3V power supply on the host board. See Application schematics on page 5 for filtering suggestions. |
| 18 | TD+ | Transmitter Positive DATA In (PECL) | Logic “1” Input = Light on<br>Transmitter DATA inputs are internally AC coupled and terminated with a differential 100 Ω resistor. |
| 19 | TD- | Transmitter Negative DATA In (PECL) | Logic “0” Input = Light on<br>Transmitter DATA inputs are internally AC coupled and terminated with a differential 100 Ω resistor. |
| **Module Definition** | | | |
| 6, 5, 4 | MOD_DEF (0:2) | Module Definition Identifiers | Serial ID implemented (See Annex A)<br>Module Definition pins should be pulled up to Host Vcc with 10 kΩ resistors. |

## 3.2 Absolute maximum ratings

| Parameter | Symbol | Ratings | Unit |
|---|---|---|---|
| Storage Temperature | $T_{st}$ | -40 to +100 | °C |
| Operating Case Temperature | $T_c$ | 0 to +70 | °C |
| Power Supply Voltage | $V_{cc}$ | 0 to +3.6 | V |
| Transmitter Differential Input Voltage | $V_D$ | 2.0 | V |
| Relative Humidity | RH | 5 to 95 | % |

## 3.3 Electrical characteristics

(TC = 0°C to 70°C, Vcc = 3.15V to 3.45V unless specified otherwise)

| Parameter | Symbol | Min | Typical | Max | Unit | Notes[1] |
|---|---|---|---|---|---|---|
| Supply Voltage | Vcc | 3.15 | 3.3 | 3.45 | V | |
| Data Rate | | 1.0 | 1.25 | 1.30 | Gbps | BER < $1x10^{-12}$ |
| **Transmitter** | | | | | | |
| Supply Current | $I_{CCT}$ | | 45 | 70 | mA | |
| Data Input Voltage Swing | $V_{TDp-p}$ | 600 | 800 | 2000 | $mV_{p-p}$ | Differential, peak to peak, [3] |
| Data Input Rise/Fall Time | | 60 | | 300 | ps | 20% - 80%, Differential, [4] |
| Data Input Skew | | | | 30 | ps | |
| Data Input Deterministic Jitter | DJ | | | 0.10 | UI | ±K28.5 pattern, [1] |
| Data Input Total Jitter | TJ | | | 0.24 | UI | $2^7$-1 pattern, BER < $1x10^{-12}$, [1] |
| Transmit Disable Voltage Level | $V_{IH}$ | Vcc -1.0 | | Vcc | V | Laser output disabled after $T_{TD}$ if input level is $V_{IH}$; Laser output enabled after $T_{TEN}$ if input level is $V_{IL}$ |
| | $V_{IL}$ | 0 | | 0.8 | V | |
| Transmit Disable/Enable Assert Time | $T_{TD}$ | | | 10 | µs | |
| | $T_{TEN}$ | | | 1 | ms | |
| Transmit Fault Output Voltage Level | $V_{OH}$ | Vcc -1.0 | | Vcc | V | Transmit fault level is $V_{OH}$ and Laser output disabled $T_{Fault}$ after laser fault. |
| | $V_{OL}$ | 0 | | 0.5 | V | |
| Transmit Fault Assert and Reset Times | $T_{Fault}$ | | | 100 | µs | Transmitter fault is $V_{OL}$ and Laser output restored $T_{INI}$ after transmitter disable is asserted for $T_{Reset}$, then disabled. |
| | $T_{Reset}$ | 10 | | | µs | |
| Initialization Time | $T_{INI}$ | | | 300 | ms | After Hot Plug or Vcc ≥ 3.15V |
| **Receiver** | | | | | | |
| Supply Current | $I_{CCR}$ | | 80 | 125 | mA | |
| Data Output Voltage Swing | | 600 | | 900 | $mV_{p-p}$ | $R_{LOAD}$ = 100 Ω, Differential |
| Data Output Rise/Fall Time | | | | 300 | ps | 20% - 80%, Differential |
| Data Output Skew | | | | 100 | ps | $R_{LOAD}$ = 100 Ω, Differential |
| Data Output Deterministic Jitter Added | DJ | | | 0.38 | UI | ±K28.5 pattern, [1] |
| Data Output Total Jitter | TJ | | | 0.65 | UI | $2^7$-1 pattern, BER < $1x10^{-12}$, [1] |
| Loss of Signal Voltage Level | $V_{OH}$ | Vcc -1.0 | | Vcc | V | LOS output level $V_{OL}$ $T_{LOSD}$ after light input > LOSD, [2] LOS output level $V_{OH}$ $T_{LOSA}$ after light input < LOSA, [2] |
| | $V_{OL}$ | 0 | | 0.5 | V | |
| Loss of Signal Assert/Deassert Time | $T_{LOSA}$ | | | 100 | µs | |
| | $T_{LOSD}$ | | | 100 | µs | |

1. See Specification notes on page 10 for referenced notes.

## 3.4 Optical characteristic

(TC = 0°C to 70°C, Vcc = 3.15V to 3.45V unless specified otherwise)

| Parameter | Symbol | Min. | Typical | Max | Unit | Notes[1] |
|---|---|---|---|---|---|---|
| **Transmitter** | | | | | | |
| Wavelength | $\lambda_p$ | 830 | 850 | 860 | nm | |
| RMS Spectral Width | $\Delta\lambda$ | | 0.5 | 0.85 | nm | |
| Average Optical Power | $P_{AVG}$ | -9.5 | -6.0 | -1.8 | dBm | |
| Optical Output Rise/Fall Time | $t_{rise/fall}$ | | | 200 | ps | 20% - 80% |
| Deterministic Jitter Added | DJ | | | 0.20 | UI | ±K28.5 pattern,[1] |
| Total Jitter Added | TJ | | | 0.43 | UI | $2^7$-1 pattern, BER<1x10$^{-12}$, [1] |
| Relative Intensity Noise | RIN | | -125 | -118 | dB/Hz | 1GHz, 12 dB reflection |
| **Receiver** | | | | | | |
| Wavelength | $\lambda$ | 830 | 850 | 860 | nm | |
| Maximum Input Power | Pm | 0 | | | dBm | |
| Sensitivity (OMA) | S | 31 | 18 | | $\mu W_{p-p}$ | Equivalent to -17dBm @ 9dB ER |
| Stressed Sensitivity (OMA) | $S_S$ | 67 | 49 | | $\mu W_{p-p}$ | Equivalent to -13.65dBm @ 9dB ER |
| Loss of Signal Assert/Deassert Level | LOSD | -27 | -21 | -17 | dBm | Chatter Free Operation |
| | LOSA | -29 | -23 | -18 | dBm | |
| LOS Hysteresis | LOSD-LOSA | 0.5 | | 6 | dB optical | Chatter Free Operation |
| Low Frequency Cutoff | $F_C$ | | 0.3 | 1.0 | MHz | -3 dB, P<-16 dBm |
| Optical Modulation Bandwidth | $BW_1$ | 700 | | 1400 | MHz | -3 dB, P<-16 dBm |
| Optical Return Loss | | 12 | | | dB | |

1. See Specification notes on page 10 for referenced notes.

## 3.5 Link length

(TC = 0°C to 70°C, Vcc = 3.15V to 3.45V unless specified otherwise)

| Data Rate / Standard | Fiber Type | Modal Bandwidth @ 850 nm (MHz*km) | Distance Range (m) | Notes[1] |
|---|---|---|---|---|
| 1.0625 GBd Fibre Channel 100-M5-SN-I 100-M6-SN-I | 62.5/125 μm MMF | 200 | 2 to 300 | 6 |
| | 50/125 μm MMF | 500 | 2 to 500 | 6 |
| | 50/125 μm MMF | 2200 | 2 to 860 | 6,7 |
| 1.25 GBd IEEE 802.3z 1000BASE-SX | 62.5/125 μm MMF | 200 | 2 to 275 | 6 |
| | 50/125 μm MMF | 500 | 2 to 550 | 6 |
| | 50/125 μm MMF | 2000 | 2 to 860 | 6,7 |

1. See Specification notes on page 10 for referenced notes.

### Specification notes

1. UI (Unit Interval): one UI is equal to one bit time. For example, 1.125 Gbits/s corresponds to a UI of 880ps.
2. For LOSA and LOSD definitions see Loss of Signal Assert/Deassert Level in Section 3.4 Optical characteristic on page 9.
3. SERDES typically supply 1600 $mV_{p-p}$ (differential). Therefore, attenuation of the transmitted signal may be necessary to meet the maximum data input voltage swing specification. It is recommended that series 50 Ω source terminating resistors be placed as close to the SERDES output as possible to attenuate the signal, improve EMI, and improve signal integrity.
4. Measured with stressed eye pattern as per FC-PI (Fibre Channel) using the worst case specifications.
5. For optical modulation bandwidth, sensitivity, and stressed sensitivity specifications, see Section 3.4 Optical characteristic on page 9.
6. Distances, shown in the “Link Length” table, are the distances specified in Fibre Channel and IEEE 802.3z standards. “Link Length” distances are calculated for worst case fiber and transceiver characteristics based on the optical and electrical specifications shown in this document using techniques utilized in IEEE 802.3z (Gigabit Ethernet). In the nominal case, longer distances are achievable.
7. New Bandwidth Enhanced MMF.

## 3.6 Regulatory compliance

The PL-XPL-00-S13 complies with common ESD, EMI, Immunity, and Component recognition requirements and specification (see details in Table 2 on page 10).

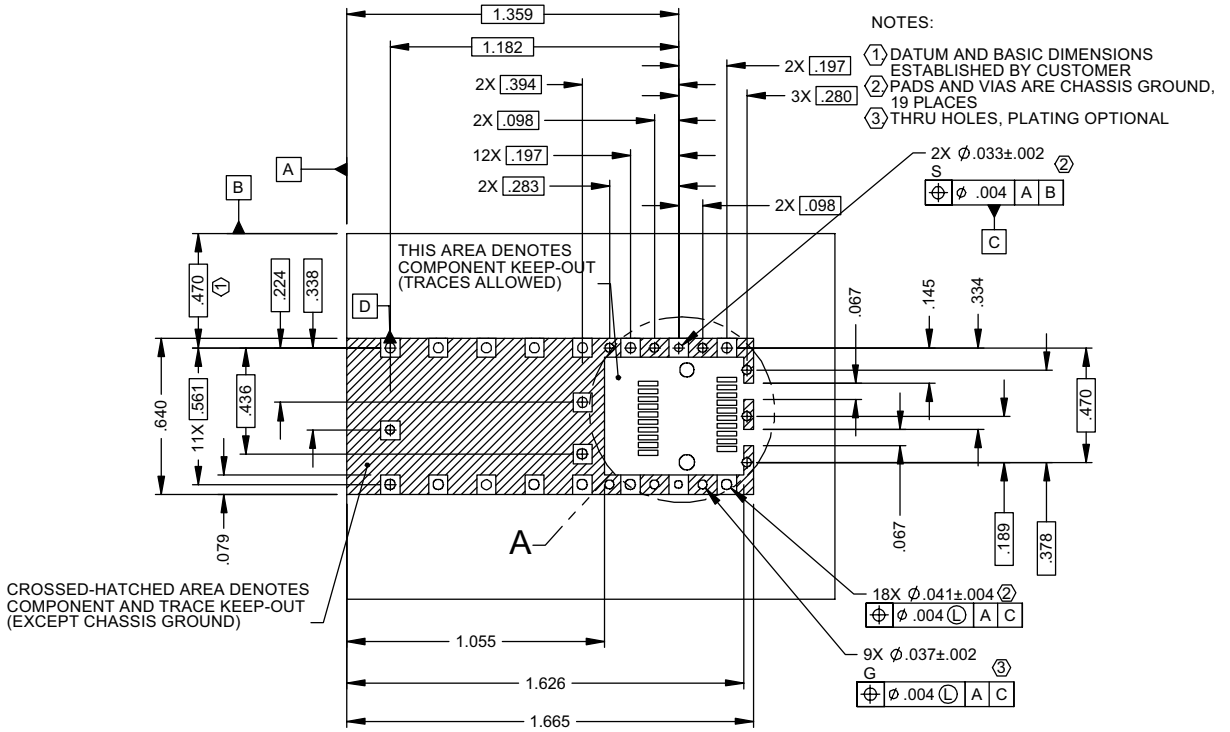
ESD, EMI, and Immunity are dependent on the overall system design. Information included herein is intended as a figure of merit for designers to use as a basis for design decisions.

**Table 2 Regulatory compliance**

| Feature | Test Method | Performance |
|---|---|---|
| Laser Eye Safety | U.S. 21CFR (J) 1040.10 & 1040.11<br>IEC 60825-1 1988<br>IEC 60825-2 1997 | CDRH compliant and Class 1 laser safe.<br>Accession #9922782<br>TUV Certificate # |
| Electrostatic Discharge (ESD) to electrical pins | MIL-STD 883C; Method 3015.4 | Class 1 (> 1 kV) |
| Electrostatic Discharge (ESD) to optical connector | IEC 61000-4-2: 1999 | Withstand discharges of 15 kV using a “Human Body Model” probe |
| Electromagnetic Interference (EMI) | FCC Part 15 Subpart J Class B<br>CISPR 22: 1997<br>EN 55022: 1998 Class B<br>VCCI Class I | Noise frequency range: 30 MHz to 10 GHz. Good system EMI design practice required to achieve Class B margins. |
| Immunity | IEC 61000-4-3: 1998 | Field strength of 3 V/m RMS, from 10 MHz to 1 GHz. No effect on transceiver performance is detectable between these limits. |
| Component | UL 1950<br>CSA C22.2 #950<br>IEC 60950: 1999 | UL File #<br>CSA File #<br>TUV Certificate # |

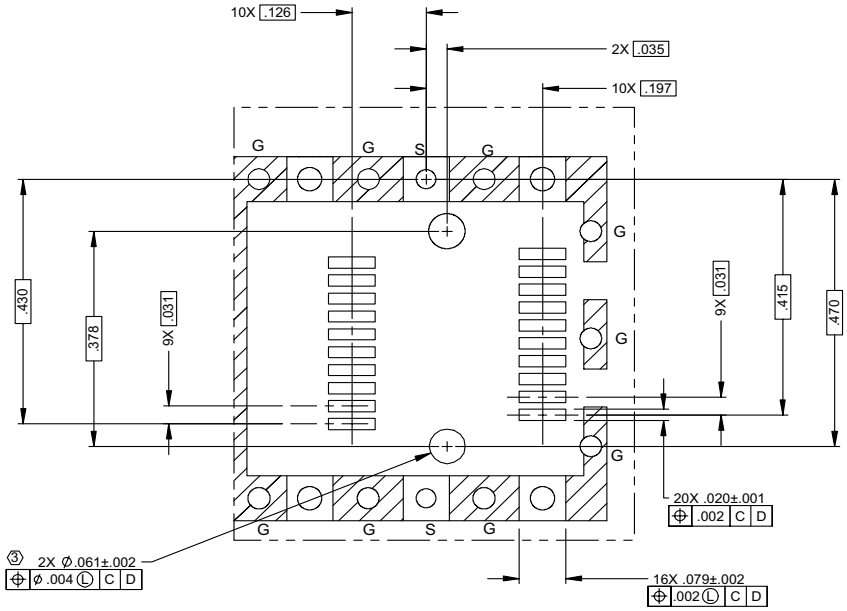
## 3.7 PCB layout

**Figure 4 Board layout**




NOTE: UNLESS SPECIFIED, TOLERANCES ARE ±.005

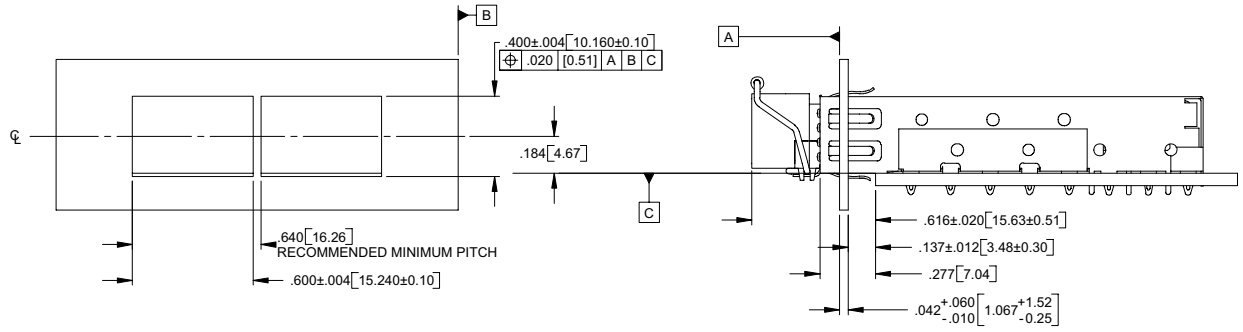
**Figure 5 Detail layout**




NOTE: UNLESS SPECIFIED, TOLERANCES ARE ±.005
DETAIL A
SCALE 7 : 1

## 3.8 Front panel opening

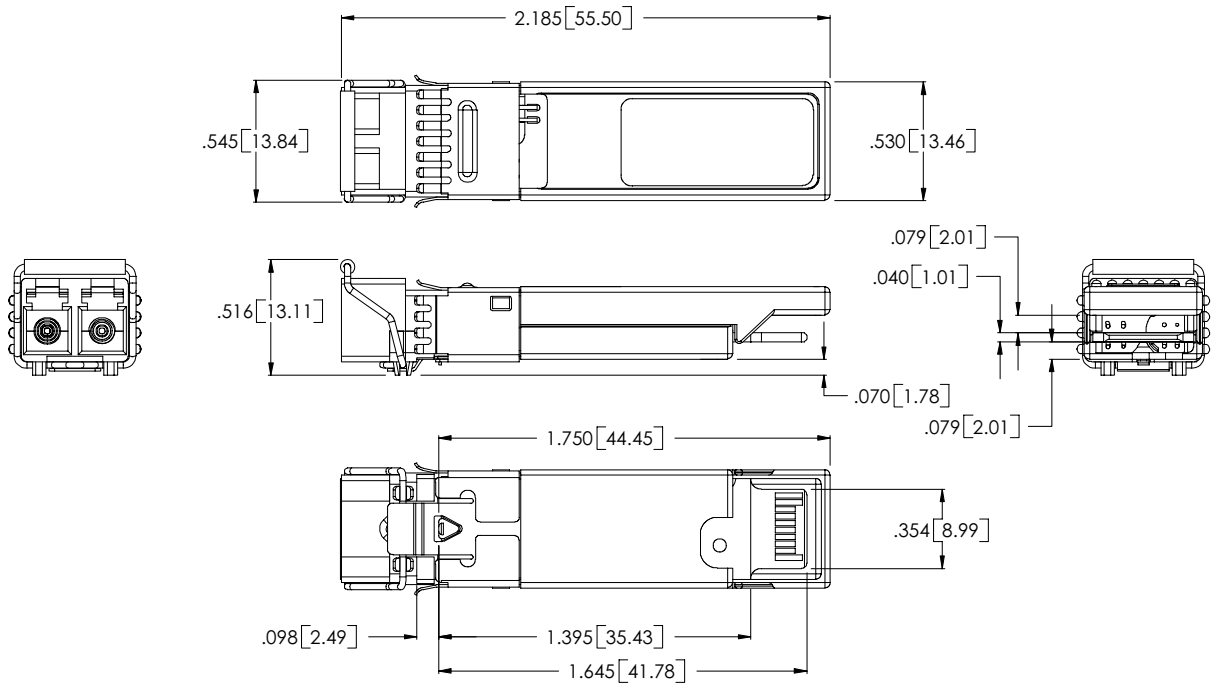
**Figure 6**




NOTE: UNLESS SPECIDIED, TOLERANCES ARE ±.005 [±0.13]

## 3.9 Module outline

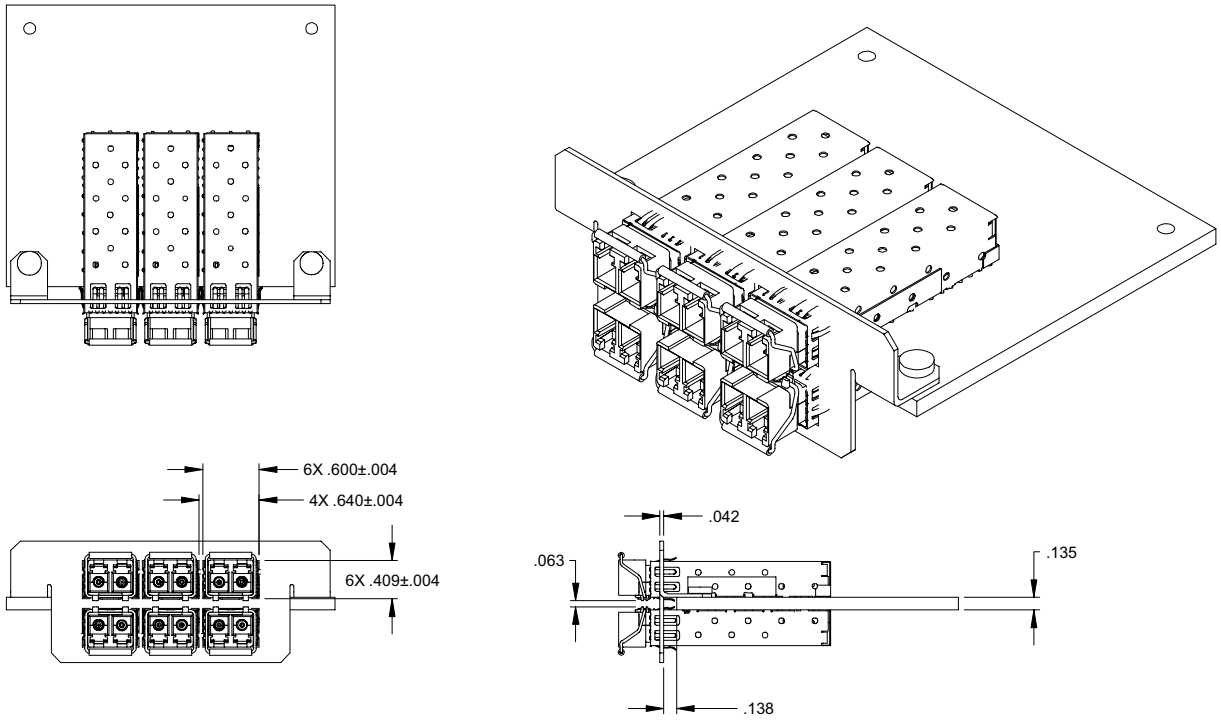
**Figure 7**




NOTE: UNLESS SPECIFIED, TOLERANCES ARE ±.005 (0.127)

## 3.10 Transceiver belly-to-belly mounting

**Figure 8**




# Section 4 Related information

Other information related to the 1 Gbps SFP Shortwave Transceiver includes:

- Section 4.1 Annex A - Serial ID operation below
- Section 4.2 Package and handling instructions on page 14
- Section 4.3 ESD Discharge (ESD) on page 14
- Section 4.4 Eye safety on page 15

## 4.1 Annex A - Serial ID operation

The PL-XPL-00-S13 is equipped with a 2-wire serial EEPROM that is used to store information about the module. See Section IV, “Module Definition Interface and Data Field Description” of the SFP-MSA Pin Definitions and Host Board Layout document. The information is accessed through the MOD_DEF(1), and MOD_DEF(2) connector pins of the module.

### Reading the data

The specification for this EEPROM (ATMEL AT24CO1A Type) contains all the timing and addressing information required for accessing the data.

MOD_DEF(0), pin 6 on the PL-XPL-00-S13 transceiver, is connected to Logic 0 (Ground) on the transceiver.

MOD_DEF(1), pin 5 on the PL-XPL-00-S13 transceiver, is connected to the SCL pin of the EEPROM.

MOD_DEF(2), pin 4 on the PL-XPL-00-S13 module, is connected to the SDA pin of the EEPROM.

The EEPROM WP pin is internally tied to Vcc with no external access, permanently protecting the data stored within. Any write commands will be ignored.

The device address pins, A0, A1, and A2, are connected to the ground, fixing the device address used to read data [10100001], any other device addresses will be ignored.

### Decoding the data

The information stored in the EEPROM including organization is defined in the Small Form-Factor Pluggable Multisource (SFP-MSA) Pin Definitions and Host Board Layout document, dated 3/13/00, Section IV.

## 4.2 Package and handling instructions

### Process plug

The PL-XPL-00-S13 is supplied with a dust cover. This plug protects the transceiver's optics during standard manufacturing processes by preventing contamination from air borne particles.

**Note:** It is recommended that the dust cover remain in the transceiver whenever an optical fiber connector is not inserted.

### Recommended cleaning and de-greasing chemicals

Picolight recommends the use of methyl, isopropyl and isobutyl alcohols for cleaning.

Do not use halogenated hydrocarbons (e.g. trichloroethane, ketones such as acetone, chloroform, ethyl acetate, MEK, methylene chloride, methylene dichloride, phenol, N-methylpyrolldone).

### Flammability

The PL-XPL-00-S13 housing is made of cast zinc.

## 4.3 ESD Discharge (ESD)

### Handling

Normal ESD precautions are 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 utilizing standard grounded benches, floor mats, and wrist straps.

### Test and operation

In most applications, the optical connector will protrude through the system chassis and be subjected to the same ESD environment as the system. Once properly installed in the system, this transceiver should meet and exceed common ESD testing practices and fulfill system ESD requirements.

Typical of optical transceivers, this module's receiver contains a highly sensitive optical detector and amplifier which may become temporarily saturated during an ESD strike. This could result in a short burst of bit errors. Such an event might require that the application re-acquire synchronization at the higher layers (e.g. Serializer/Deserializer chip).

## 4.4 Eye safety

The PL-XPL-00-S13 is an international Class 1 laser product per IEC 825-1: 1993, and per CDRH, 21 CFR 1040 Laser Safety Requirements. The PL-XPL-00-S13 is an eye safe device when operated within the limits of this specification.

Operating this product in a manner inconsistent with intended usage and specification may result in hazardous radiation exposure.

**CAUTION!**

Tampering with this laser based product or operating this product outside the limits of this specification may be considered an act of "manufacturing," and will require, under law, recertification of the modified product with the U.S. Food and Drug Administration (21 CFR 1040).

**CAUTION!**

The use of optical instruments with this product will increase eye hazard. At the normal operating current, optical output power with an unaided eye can be as much as 30 uW at a wavelength of 850 nm. Approximately ten times this power level could be collected with an eye loupe. Under a failure condition, this level could increase by a factor of two.