# Multirate FP SFP Optical Transceiver —1310 nm for up to 2 km Reach

## SFP Series

**Key Features**

- Support line rate from 100 Mbps to 3.1 Gbps
- SFP MSA INF-8074i Revision 1.0 compliant
- Operating case temperature of -40 to 85°C
- Maximum power dissipation of 1.0 W
- Single 3.3 V power supply
- RoHS 6/6 compliant
- Enhanced digital diagnostic monitoring (DDM) support
- Internal AC-coupled electrical interface

### Applications

- SONET OC-48 applications
- SDH STM-16 applications

### Compliance

- SFF 8074i and 8472 MSA
- ITU-T G.957
- Telcordia GR-253-CORE
- Class 1 Laser Safety
- Compliance with Telcordia GR-468

### Compatibility

- OC3 SR/ STM I-1
- OC12 SR/ STM I-4

The JDSU RoHS-compliant small form factor pluggable (SFP) optical transceiver is an integrated fiber optic transceiver that provides a high-speed serial link at signaling rates from 100 Mbps to 3.1 Gbps. The module complies with the SFP multisource agreement (MSA).

The 1310 nm SFP optical transceiver complies with Telcordia GR-253-CORE OC-48 SR-1 (SONET) and ITU-T G.957 STM I-16 (SDH) standards. The JDSU 1310 nm FP SFP optical transceiver is compatible to SONET OC-3 and OC-12, and SDH STM-1 and STM-4 standards.

The SFP optical transceiver integrates the receive and transmit path on one module. In the transmit side, the serial data stream is passed to a laser driver. The laser drivers biases and modulates a 1310 nm FP laser, enabling data transmission over single-mode fiber through an industry-standard LC connector. In the receive side, the optical data stream is recovered from a PIN photodetector transimpedance amplifier, and passed to a post amplifier. This module features a hot-pluggable SFI-compliant electrical interface.

# Section 1 Functional Description

The JDSU RoHS-compliant SFP optical transceiver is a fully duplexed serial electric, serial optical device with both transmit and receive functions contained in a single module that provides a high-speed serial link at signaling rates from 100 Mbps to 3.1 Gbps. It is designed to be compliant with Telcordia GR-253-CORE and ITU-T G.957 for 2 km reach (SONET OC-48 SR-1 / SDH STM I-16) applications. The SFP optical transceiver is compatible to SONET OC-3 and OC-12, and SDH STM-1 and STM-4 applications. The transceiver is also fully compliant with the SFP module MSA INF8074i Rev. 1.0. A block diagram of the 1310 nm FP SFP optical transceiver is shown in Figure 1 on page 3.

The JDSU 1310 nm FP SFP optical transceiver does not need rate select to operate at the designated line rate. It has several low-speed interface connections, including a two-wire serial interface. These connections also include transceiver presence (Mod_Def(0)), transmitter fault (TX_FAULT), transmitter disable (TX_DIS), and receive loss (RX_LOS).

## Transmitter

The transmitter path converts serial NRZ electrical data from line rate of 100 Mbps to 3.1 Gbps to a standard compliant optical signal. The transmitter accepts a 100 Ω differential 300 mV peak-to-peak to 1400 mV peak-to-peak CML electrical signal on TD- and TD+ pins.

Inside the module, the differential signals pass through a laser driver, which transforms the small swing digital voltage to an output modulation that drives a FP laser. The optical signal is engineered to meet the SONET/SDH specifications. Closed-loop control of the transmitted laser power and modulation swing over temperature and voltage variations is provided. The laser is coupled to single-mode optical fiber through an industry-standard LC optical connector.

## Receiver

The receiver converts incoming DC balanced serial NRZ optical data from line rate of 100 Mbps to 3.1 Gbps into serial electrical data. Light is coupled to a PIN photodetector from single-mode optical fiber through an industry-standard LC optical connector. The electrical current from the PIN photodetector is converted to a voltage in a high-gain transimpedance amplifier.

The amplified signal is passed to a post amplifier. Loss of signal, and signal lock detection is included in the receive circuitry that is reflected in the RX_LOS status pin. The recovered data is output on the RD+ and RD- pins as a 100 Ω differential 300 mV to 800 mV peak-to-peak CML signal. The output signal meets the SFP MSA requirements.

## Low-speed Signaling

Low-speed signaling is based on low voltage TTL (LVTTL) operating at a nominal voltage of 3.3 V.

MOD_DEF(1) / MOD_DEF(2): Two-wire serial interface clock and data line. Hosts should use a pull-up resistor connected to Vcc 3.3 V on the two-wire interface MOD_DEF(1) (clock), MOD_DEF(2) (data), and all low-speed outputs.

TX_FAULT: Output pin. When high, indicates possible transmitter operational fault or a status critical to the host system.

TX_DIS: Input pin. When asserted high, the transmitter output is turned off.

Mod_DEF(0): Output pin. Pulled to ground by the module to indicate that the module is present.

RX_LOS: Output pin. Asserted high when insufficient optical power for reliable signal reception is received.

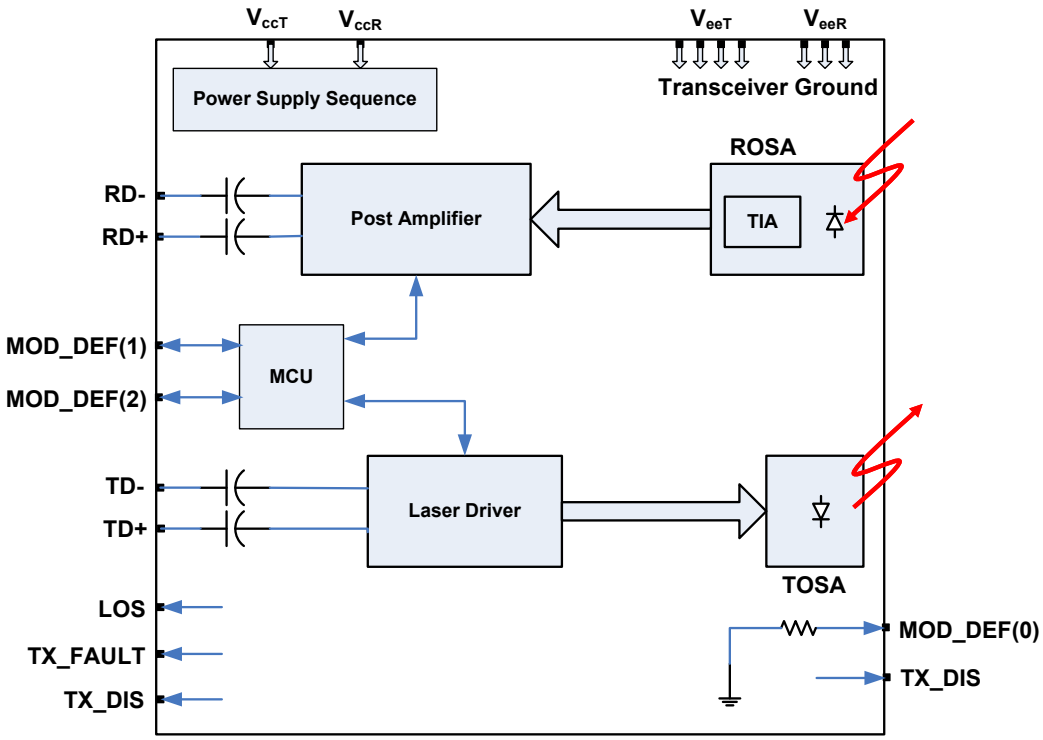
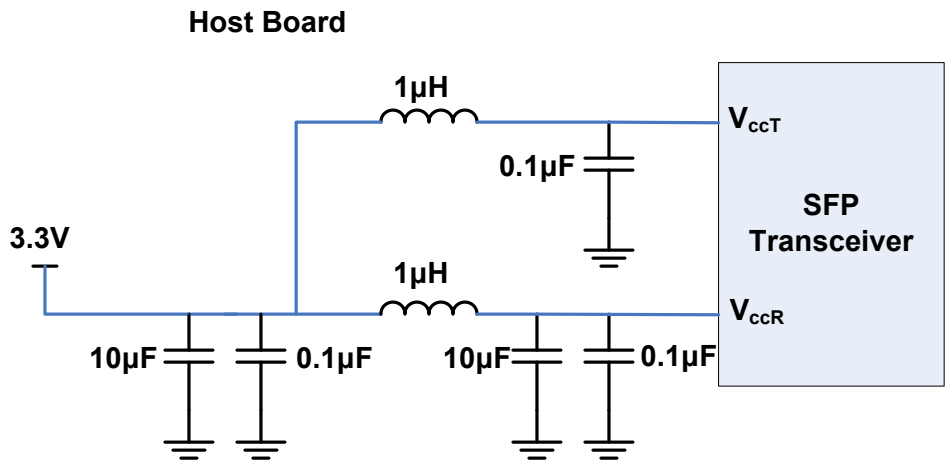



**Figure 1 SFP optical transceiver functional block diagram**

# Section 2 Application Schematics

Power supply filtering is recommended for the 1310 nm FP SFP optical transceiver. To limit wide band noise power, the host system and module shall each meet a maximum of two percent peak-to-peak noise when measured with a 1 MHz low pass filter. In addition, the host system and the module shall each meet a maximum of three percent peak-to-peak noise when measured with a filter from 1 –10 MHz. Recommended power supply network connections to the 1310 nm FP SFP optical transceiver are shown in Figure 2 below.




Notes:
1. Power supply filtering components should be placed as close to the Vcc pins of the host connector as possible for optimal performance.
2. ESR of inductor should be less than 0.5 Ω to ensure proper power supply levels.

**Figure 2 Recommended power supply filter network**

# Section 3 Specifications

Technical specifications related to the 1310 nm FP SFP optical transceiver include:

- Section 3.1 Pin Function Definitions
- Section 3.2 Absolute Maximum Ratings
- Section 3.3 Electrical Characteristics
- Section 3.4 Jitter Specifications
- Section 3.5 Timing Requirement of Control and Status I/O
- Section 3.6 SFP Two-wire Interface Protocol and Management Interface
- Section 3.7 Optical Transmitter Characteristics
- Section 3.8 Optical Receiver Characteristics
- Section 3.9 Regulatory Compliance
- Section 3.10 Module Outline
- Section 3.11 Connectors

## 3.1 Pin Function Definitions

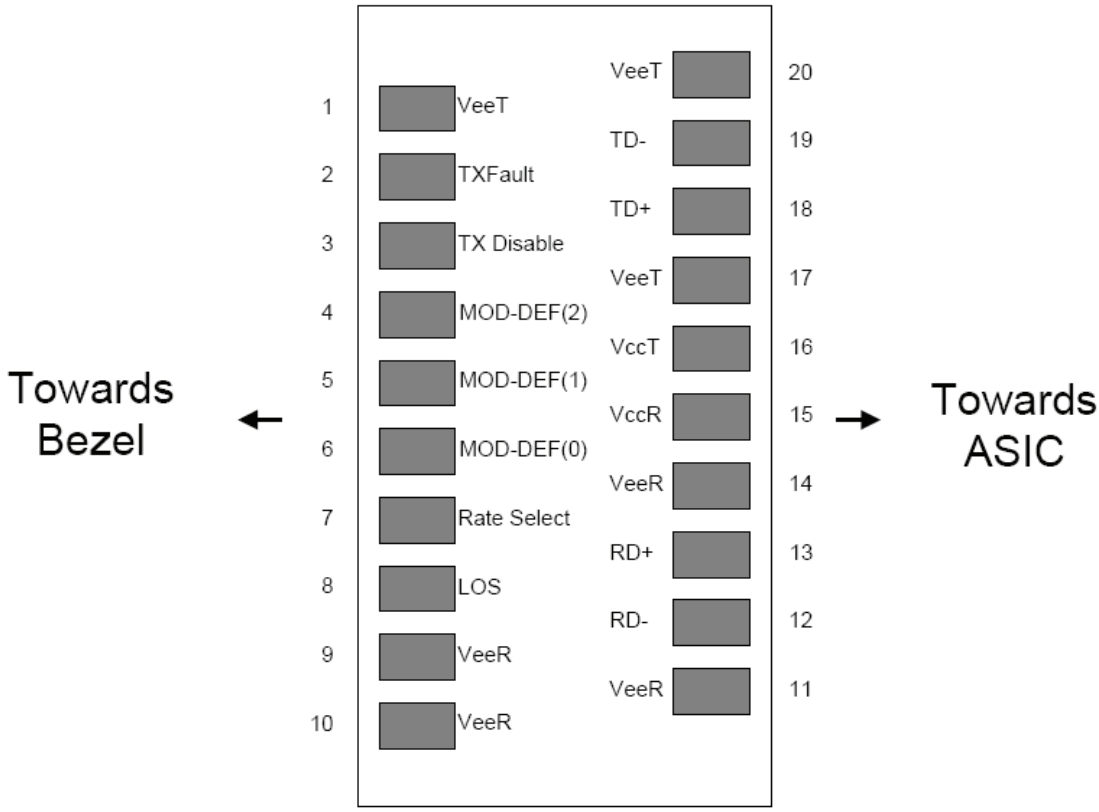



**Figure 3 SFP optical transceiver pin-out on host board**

**Table 1 SFP Optical Transceiver Pin Descriptions**

| Pin Number | Type | Name | Description |
|---|---|---|---|
| 1 | VeeT | GND[1] | Transmit ground |
| 2 | TX_FAULT[2] | LVTTL-O | Transmitter fault indicator |
| 3 | TX_DIS | LVTTL-I | Transmitter disable; Transmitter laser source turned off |
| 4 | MOD_DEF(2) | LVTTL-I | Two-wire serial interface data |
| 5 | MOD_DEF(1) | LVTTL-I | Two-wire serial interface clock |
| 6 | MOD_DEF(0) | | Transceiver presence, pull down to GND via a 499 Ω resistor. |
| 7 | Rate_select | CMOS | No connect |
| 8 | Rx_LOS | LVTTL-O | Receive loss of signal |
| 9 | VeeT | GND[1] | Transmit ground |
| 10 | VeeR | GND[1] | Receive ground |
| 11 | VeeR | GND[1] | Receive ground |
| 12 | RD- | CML | Receiver inverted data output |
| 13 | RD+ | CML | Receiver noninverted data output |
| 14 | VeeR | GND[1] | Receive ground |
| 15 | VccR | | Receive power; 3.3 V |
| 16 | VccT | | Transmit power; 3.3 V |
| 17 | VeeT | GND[1] | Transmit ground |
| 18 | TD+ | CML | Transmitter noninverted data input |
| 19 | TD- | CML | Transmitter inverted data input |
| 20 | VeeT | GND[1] | Transmit ground |

1. Module ground pins (GND) are isolated from the module case and chassis ground within the module
2. Shall be pulled up with 4.7 – 10 kΩ to a voltage between 3.15 and 3.45 V on the host board

## 3.2 Absolute Maximum Ratings

| Parameter | Symbol | Ratings | Unit |
|---|---|---|---|
| Storage temperature | $T_{ST}$ | -40 to +85 | °C |
| Case temperature | $T_C$ | -40 to +85 | °C |
| Relative humidity | RH | 5 to 95 (noncondensing) | % |
| Static electrical discharge (Human Body Model) | ESD | 500 | V |
| Power supply voltage | $V_{CC}$ | -0.3 to +4.0 | V |

Note:
Absolute maximum ratings represent the damage threshold of the device.
Damage may occur if the device is subjected to conditions beyond the limits stated here.

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## 3.3 Electrical Characteristics

| Parameter | Symbol | Minimum | Typical | Maximum | Unit | Notes |
|---|---|---|---|---|---|---|
| **Supply currents and voltages** | | | | | | |
| Supply voltage | $V_{CC}$ | 3.13 | 3.3 | 3.47 | V | All electrical and optical specifications apply over the supply voltage range |
| Supply current | $I_{CC}$ | | | 300 | mA | |
| Data rate | | 100 | | 3125 | Mbps | |
| Electrical input voltage swing | $V_{TDp-p}$ | 300 | | 1400 | mV | Differential, peak to peak. |
| Electrical output rise / fall time | tr/tf | | | 175 | ps | 20 – 80%, differential |
| Electrical output swing | | 300 | | 800 | mV | Differential, peak to peak |
| **Low speed control and sense signals (detailed specification in SFP MSA INF8074i Rev. 1.0)** | | | | | | |
| Outputs (TX_FAULT, LOS) | $V_{OL}$ | 0 | | 0.4 | V | Rpullup pulled to host _Vcc, measured at host side of connector. $I_{OL}$(max)=3 mA |
| | $V_{OH}$ | host_Vcc-0.5 | | host_Vcc+0.3 | V | Rpullup pulled to host _Vcc, measured at host side of connector |
| Inputs (TX_DIS) | $V_{IL}$ | -0.3 | | 0.8 | V | Pulled up in module to Vcc |
| | $V_{IH}$ | 2 | | Vcc3+0.3 | V | Pulled up in module to Vcc |
| MOD_DEF(1) / MOD_DEF(2) | $V_{IL}$ | -0.3 | | Vcc3*0.3 | V | Rpullup pulled to host _Vcc, measured at SFP side of connector |
| | $V_{IH}$ | Vcc3*0.7 | | Vcc3+0.5 | V | Rpullup pulled to host _Vcc, measured at SFP side of connector |

## 3.4 Jitter Specifications

| Parameter | Max | Unit | Notes |
|---|---|---|---|
| Jitter generation (peak to peak) | 70 | mUI(p-p) | PRBS $2^{23}$-1 data pattern, at OC-48 data rate |
| Jitter generation (rms) | 7 | mUI(rms) | |
| Jitter transfer / Jitter tolerance | Compliant with Telcordia GR-253-CORE when operated with a SONET-compliant CDR | | |

## 3.5 Timing Requirement of Control and Status I/O

| Parameter | Symbol | Min | Max | Unit | Notes |
|---|---|---|---|---|---|
| Initialization time | $t_{INI}$ | | 300 | ms | After hot plug or Vcc ≥2.97 V |
| TX_FAULT assert time | $t_{Fault}$ | | 1 | ms | Time from a fault condition to TX_FAULT assertion |
| TX_DISABLE for reset | $t_{Reset}$ | 10 | | µs | Time TX_DSIABLE must held HIGH to reset TX_FAULT |
| RX_LOS assert time | $t_{LOSA}$ | | 100 | µs | |
| RX_LOS deassert time | $t_{LOSD}$ | | 100 | µs | |
| Two-wire serial clock rate | f_serial_clock | | 100 | kHz | |

## 3.6 SFP Two-wire Interface Protocol and Management Interface

The JDSU 1310 nm FP SFP Optical Transceiver incorporates a SFP compliant two-wire management interface which is used for serial ID, digital diagnostics, and certain control functions. It is modeled on the SFF INT-8472i Rev. 10.3 specification modified to accommodate a single two-wire interface address. Details of the protocol and interface are explicitly described in the MSA. Please refer to the MSA for design reference.

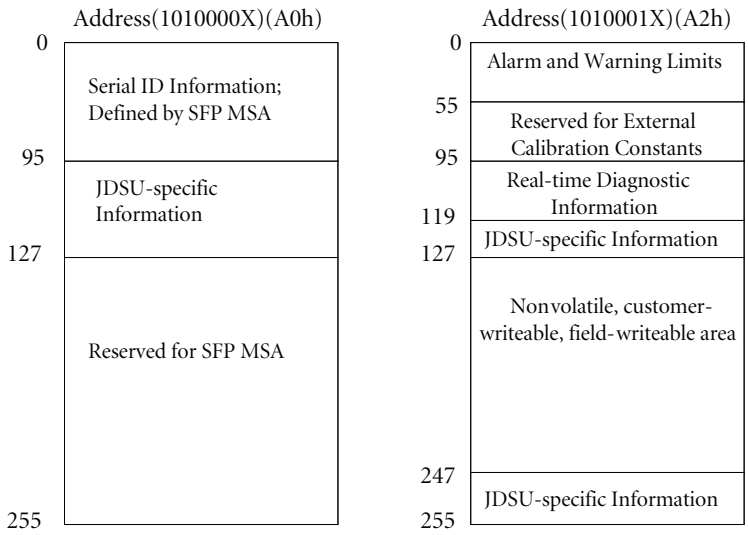


**Figure 4 SFP two-wire serial digital diagnostic memory map**

## 3.7 Optical Transmitter Characteristics

| Parameter | Symbol | Minimum | Typical | Maximum | Unit |
|---|---|---|---|---|---|
| Wavelength | $\lambda_c$ | 1260 | | 1355 | nm |
| Average optical power (EOL) | $P_{AVG}$ | -9.5 | | -2.5 | dBm |
| Extinction ratio | ER | 9 | | | dB |
| Optical rise/fall time | | | | 160 | ps |
| Mask margin | | 10 | | | % |

## 3.8 Optical Receiver Characteristics

| Parameter | Symbol | Minimum | Typical | Maximum | Unit |
|---|---|---|---|---|---|
| Wavelength | $\lambda$ | 1260 | | 1355 | nm |
| Receive overload | $P_m$ | | | >1 | dBm |
| Receiver sensitivity with presence of noise[2] | | | | | |
| 2.488 Gbps or above | | | | -18 | dBm |
| 2.125 Gbps or below (include 1.25 Gbps, 622 Mbps, 155 Mbps, 100 Mbps) | | | | -21 | dBm |
| Loss of signal assert/deassert level | LOSD | | | -22 | dBm |
| | LOSA | -33 | | | dBm |

## 3.9 Regulatory Compliance

The 1310 nm FP SFP optical transceiver is lead-free and RoHS 6/6-compliant per Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

The 1310 nm FP SFP optical transceiver complies with international electromagnetic compatibility (EMC) and international safety requirements and standards. EMC performance is 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 |
|---|---|---|
| Component safety | UL 60950<br>UL94-V0<br>EN 60950 | TUV Certificate<br>TUV Certificate<br>TUV Report/Certificate (CB Scheme) |
| RoHS-compliance | Directive 2002/95/EC | Compliant per the Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment |
| Laser eye safety | EN 60825<br>U.S. 21CFR 1040.10 | TUV Certificate<br>CDRH compliant and Class 1 laser eye safe |
| **Electromagnetic Compatibility** | | |
| Electromagnetic emissions | EMC Directive 89/336/EEC<br>FCC CFR47 Part 15<br>IEC/CISPR 22<br>AS/NZS CISPR22<br>EN 55022<br>ICES-003, Issue 4<br>VCCI-03 | Noise frequency range: 30 MHz to 40 GHz.<br>Good system EMI design practice required to achieve Class B margins. |
| Electromagnetic immunity | EMC Directive 89/336/EEC<br>IEC /CISPR/24<br>EN 55024 | |
| ESD immunity | EN 61000-4-2 | Exceeds requirements. Withstands discharges of; 8 kV contact, 15 kV air |
| Radiated immunity | EN 61000-4-3 | Exceeds requirements. Field strength of 10 V/m RMS, from 10 MHz to 1 GHz. No effect on transmitter/receiver performance is detectable between these limits. |

## 3.10 Module Outline

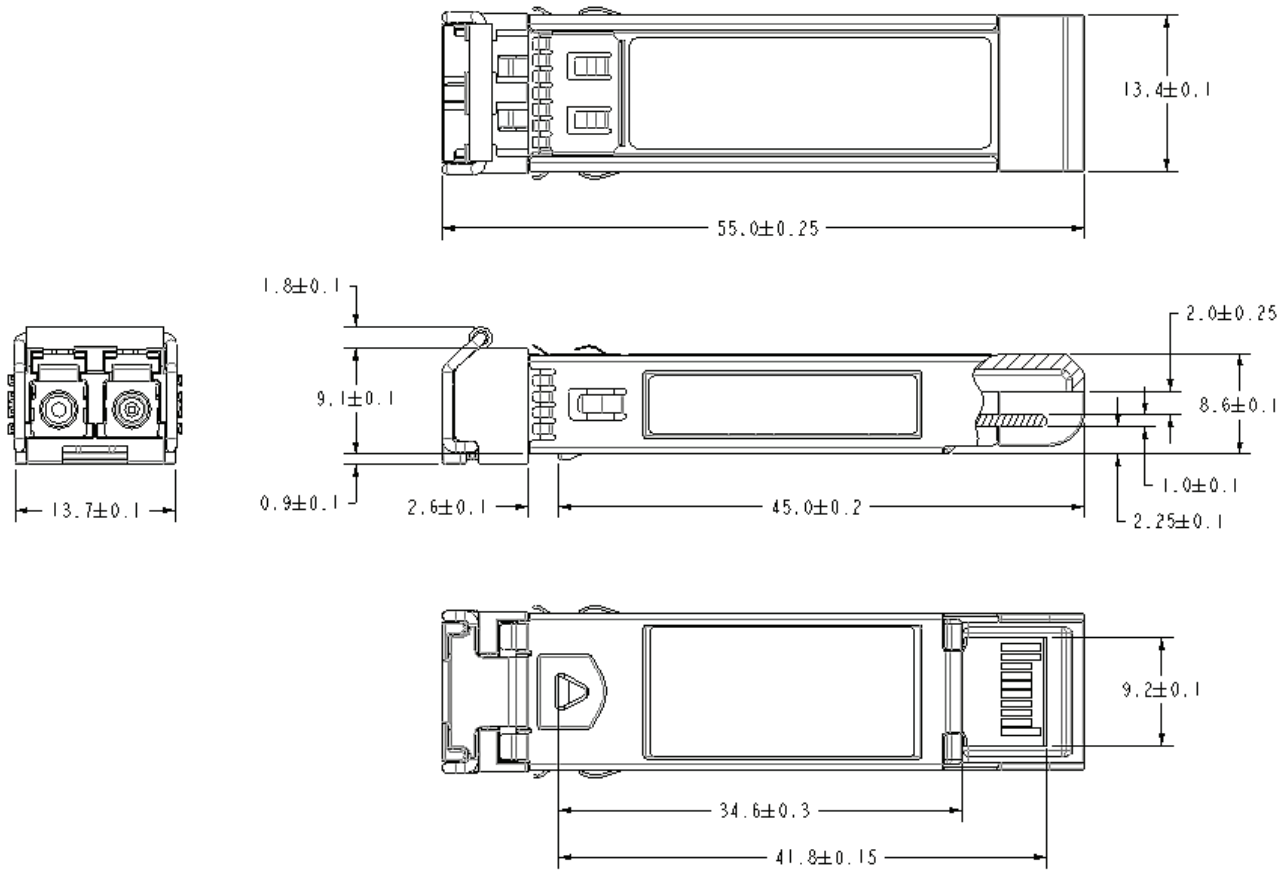


**Figure 5 Module Outline**

## 3.11 Connectors

**Fiber**
The SFP module has a duplex LC receptacle connector.

**Electrical**
The electrical connector is the 20-way, two-row PCB edge connector.

# Section 4 Related Information

Other information related to the JDSU 1310 nm FP SFP optical transceiver includes:
- Section 4.1 Packing and Handling Instructions
- Section 4.2 ESD Discharge (ESD)
- Section 4.3 Eye Safety

## 4.1 Package and Handling Instructions

**Connector covers**
The 1310 nm FP SFP optical transceiver is supplied with an LC duplex receptacle. The connector plug supplied protects the connector during standard manufacturing processes and handling by preventing contamination from dust, aqueous solutions, body oils, or airborne particles.

Note: It is recommended that the connector plug remain on whenever the transceiver optical fiber connector is not inserted.

**Recommended cleaning and degreasing chemicals**
JDSU recommends the use of methyl, isopropyl and isobutyl alcohols for cleaning.

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

This product is not designed for aqueous wash.

**Housing**
The 1310 nm FP SFP optical transceiver housing is made from die-cast zinc and stainless steel sheet metal.

## 4.2 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 otherwise handled 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 (serializer/deserializer chip).

## 4.3 Eye Safety

The 1310 nm FP SFP optical transceiver is an international Class 1 laser product per IEC 60825-1 second edition 2007. The product also complies with U.S.A. regulations for Class 1 products contained in 21 CFR 1040.10 and 1040.11. Laser emissions from Class 1 laser products are not considered hazardous 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).

## Ordering Information

For more information on this or other products and their availability, please contact your local JDSU account manager or JDSU directly at 1-800-498-JDSU (5378) in North America and +800-5378-JDSU worldwide, or via e-mail at customer.service@jdsu.com.

**Sample: SFP-MS1LKTD3DCA**

| Product Code | Description |
|---|---|
| SFP-MS1LKTD3DCA | OC-48 SR-1 Multirate, Industrial Temperature, SFP Transceiver |
| SFP-MS1LKTD3DTA | 3.1G SR-1, Industrial Temperature, SFP Transceiver |