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		AUTHORIZED BY J. Blank	DATE 27 Apr. 2011
CLASSIFICATION UNRESTRICTED			

Product Specification

10 GBd SFP+ 1310 nm LRM Linear Transceiver

TRX10GDL0610C3



Product Features:

- Hot pluggable SFP+ optical transceiver
- Programmable input equalizer
- Data rate transparent from 9.95 to 11.3 Gbps
- Low power consumption, 0.75 W typ.
- Excellent EMI performance
- Transmission distance up to 220 m MMF
- 0 °C to +70 °C case operating temperature
- 1310 nm DFB laser
- Duplex LC connector
- Laser Class 1
- RoHS 6/6 compliant

Applications:

- 10G Ethernet 10GBASE-LRM

FCI's SFP+ optical transceiver TRX10GDL0610C3 is a module for transmission over legacy multimode fibers. It complies with the SFP+ MSA specifications (SFF-8431 and SFF-8432) and with 10GBASE-LRM per IEEE 802.3. It is RoHS 6/6 compliant per Directive 2002/95/EC and laser class 1 safety compliant per IEC/CDRH. The sub-Watt power consumption and the excellent EMI performance allow system design with high port density. An adjustable input equalizer allows to overcome host board high frequency signal loss and to optimize module performance in interaction with a host board transmit equalizer.

Supported Standards

Application	Standard	Data Rate
10G Ethernet	IEEE 802.3 10GBASE-LRM	10.3125 Gbps


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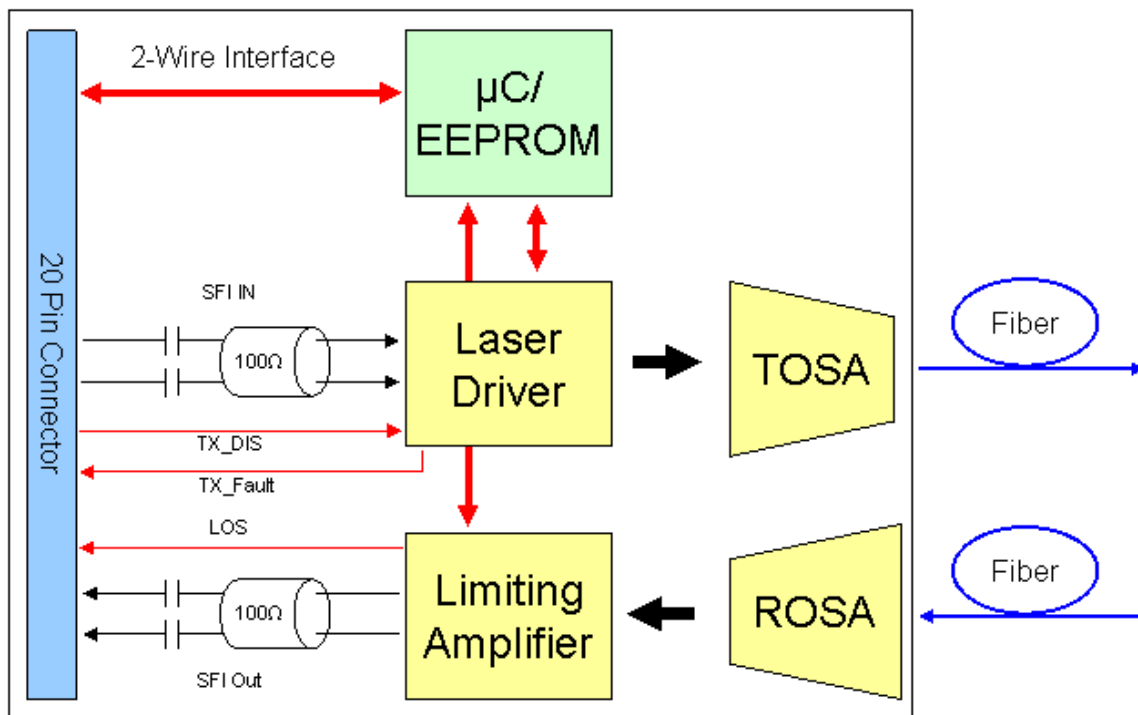
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Functional Description

The transmit path is based on an AC coupled 100 ohm differentially terminated driver coupled to a 1310 nm DFB laser. Laser output may be disabled by pulling the transmitter disable (TX_DIS) line high which is its default state when leaving the input floating due to an internal pull-up resistor. A fault condition is raised upon detection of an abnormal laser state.

The receive path consists of a receiver optical sub-assembly (ROSA) for optical to electrical conversion, followed by a linear amplifier to boost the electrical signal. A loss of signal (LOS) status line provides information to facilitate easy link detection.

Complete digital optical monitoring is implemented in compliance to SFF-8472 and made accessible via the 2-wire interface providing real time information about all important module parameters and status information.



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Electrical Characteristics

Absolute Maximum Ratings

Rating	Conditions	Symbol	Min	Max	Units
Storage Ambient Temperature		ϑ_{stg}	-40	+85	°C
Powered Case Temperature		ϑ_c	0	+75	°C
Operating Relative Humidity	Non condensing	RH	0	95	%
Supply Voltage Range		$V_{CCT/R}$	-0.5	4.0	V


Any stress beyond the maximum ratings may result in permanent damage to the device. Specifications are guaranteed only under recommended operating conditions.

Recommended Operating Conditions

Parameter	Conditions	Symbol	Min	Typ	Max	Units
Operating Case Temperature		ϑ_{Case}	0		+70	°C
Power Supply Voltage		$V_{CCT/R}$	3.135	3.30	3.465	V
DC Common Mode Voltage	SFI Signals	V_{CM}	-0.5		4.0	V

Low Speed Characteristics

Parameter	Conditions	Symbol	Min	Typ	Max	Units
Supply Current Transmitter	@ V_{CCT}	$I_{V_{CCTX}}$		150		mA
Supply Current Receiver	@ V_{CCR}	$I_{V_{CCRx}}$		70		mA
Total Supply Current	@ $V_{CCT/R}$	$I_{V_{CC}}$			280	mA
Power Consumption				0.75	1.0	W
TX_Fault, RX_LOS	Host Vcc Range 2 V – 3.47 V, $I_{OL_max} = 4$ mA	V_{OL}	0		0.4	V
		V_{OH}	Host_Vcc – 0.5		Host_Vcc + 0.3	
TX_Dis, RS0, RS1	Low Voltage TTL	V_{IL}	-0.3		0.8	
		V_{IH}	2.0		$V_{CCT} + 0.5$	
SCL, SDA	Host Vcc Range 3.13 V – 3.47 V, $I_{OL_max} = 4$ mA	V_{IL}	-0.3		$V_{CCT} * 0.3$	
		V_{IH}	$V_{CCT} * 0.7$		$V_{CCT} + 0.5$	
		V_{OL}	0.0		0.4	
		V_{OH}	Host_Vcc – 0.5		Host_Vcc + 0.3	

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SFI Module Transmitter Input Characteristics


Parameter	Conditions	Symbol	Min	Typ	Max	Units
Nominal Data Rate				10.3125		Gbd
Reference Differential Input Impedance		Z_d		100		Ω
Input AC Common Mode Input Voltage			0		25	mV (RMS)
Differential Input Voltage Swing	$2 \times V(TD+) - V(TD-) $	V_{ID}	150		900	mV
Differential Input S-parameter	0.01 – 4.1 GHz	SDD11			¹⁾	dB
	4.1 – 11.1 GHz				²⁾	dB
Differential to Common Mode Conversion ³⁾	0.01 – 11.1 GHz	SCD11			-10	dB
Total Jitter		TJ			0.28	UI(p-p)
Data Dependent Jitter		DDJ			0.1	UI(p-p)
Uncorrelated Jitter		UJ			0.023	RMS

- 1) Reflection coefficient given by equation $SDD11(dB) < -12 + 2 \times \text{SQRT}(f)$, with f in GHz.
- 2) Reflection coefficient given by equation $SDD11(dB) < -6.3 + 13 \times \text{Log}10(f/5.5)$, with f in GHz.
- 3) Common mode reference impedance is 25 Ω .

SFI Module Receiver Output Characteristics

Parameter	Conditions	Symbol	Min	Typ	Max	Units
Nominal Data Rate				10.3125		Gbd
Reference Differential Output Impedance		Z_d		100		Ω
Termination Mismatch		ΔZ_d			5	%
Output AC Common Mode Voltage					7.5	mV (RMS)
Differential Output Amplitude	$R_{Load} = 100 \text{ ohm},$ $P_{IN_OMA} \geq -8 \text{ dBm},$ $2 \times V(RD+) - V(RD-) $	V_{OSPP}	180	250	400	mV
Differential Output S-parameter	0.01 – 4.1 GHz	SDD22			¹⁾	dB
	4.1 – 11.1 GHz				²⁾	dB
Common Mode Output Return Loss ⁴⁾	0.01 – 2.5 GHz	SCC22			³⁾	dB
	2.5 – 11.1 GHz				-3	dB
Receiver Waveform Distortion Penalty		dWDP			1.5	dB

- 1) Reflection coefficient given by equation $SDD22(dB) < -12 + 2 \times \text{SQRT}(f)$, with f in GHz.
- 2) Reflection coefficient given by equation $SDD22(dB) < -6.3 + 13 \times \text{Log}10(f/5.5)$, with f in GHz.
- 3) Reflection coefficient given by equation $SCC22(dB) = -7 + 1.6 \times f$, with f in GHz
- 4) Common mode reference impedance is 25 Ω .

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Optical Characteristics

General Parameters

Parameter	Conditions	Min Modal Bandwidth (MHz*km)	Symbol	Min	Typical 10GBd	Units
Operating Range	62.5 μ m FDDI MMF 62.5 μ m OM1 MMF 50 μ m OM2 MMF 50 μ m OM3 MMF		I_{OP}	0.5	220	m


Optical Transmitter

Parameter	Conditions	Symbol	Min	Typ	Max	Units
Center Wavelength		λ_{TRP}	1290	1310	1330	nm
RMS Spectral Width		$\Delta\lambda$			3.6	nm
Average Launch Power		P_{avg}	-6.5		0.5	dBm
Optical Modulation Amplitude		P_{OMA}	-4.5		1.5	dBm
Extinction Ratio		ER	3.5			dB
Relative Intensity Noise		RIN			-128	dB/Hz

Optical Receiver

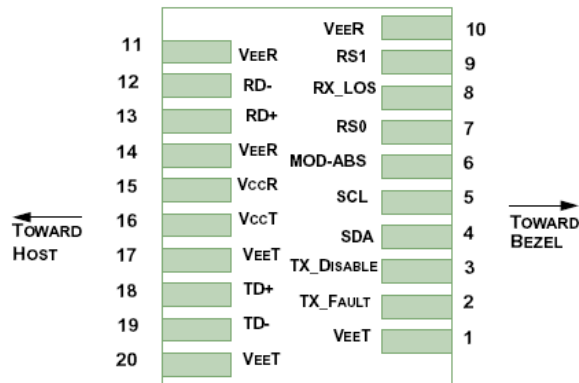
Parameter	Conditions	Symbol	Min	Typ	Max	Units
Center Wavelength		λ_C	1260	1310	1355	nm
Average Input Power		P_{avg}			0.5	dBm
Overload Power in OMA		P_{MAX_OMA}			1.5	dBm
Receiver Sensitivity	PRBS $2^{31}-1$, BER < $1 \cdot 10^{-12}$ @ 10.3125GBd	$P_{IN(OMA)}$		-16	-13	dBm
Stressed Receiver Sensitivity	PRBS $2^{31}-1$, BER < $1 \cdot 10^{-12}$ @ 10.3125GBd	$P_{IN(OMA)}$		-11.5	-8.5	dBm
Stressed Receiver Sensitivity Symmetrical Test	PRBS $2^{31}-1$, BER < $1 \cdot 10^{-12}$ @ 10.3125GBd	$P_{IN(OMA)}$		-11	-8	dBm
Loss of Signal	Assert	P_{avg_as}	-25	-13		dBm
	De-Assert	P_{OMA_deas}		-11	-8	
Loss of Signal Hysteresis		Hyst	0.5			dB

Note: The specified characteristics are met within the recommended range of operating. Unless otherwise noted, typical data are quoted at nominal voltages and +25°C ambient temperature.

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Application Information


Connector Pinout



Electrical Pin Definition

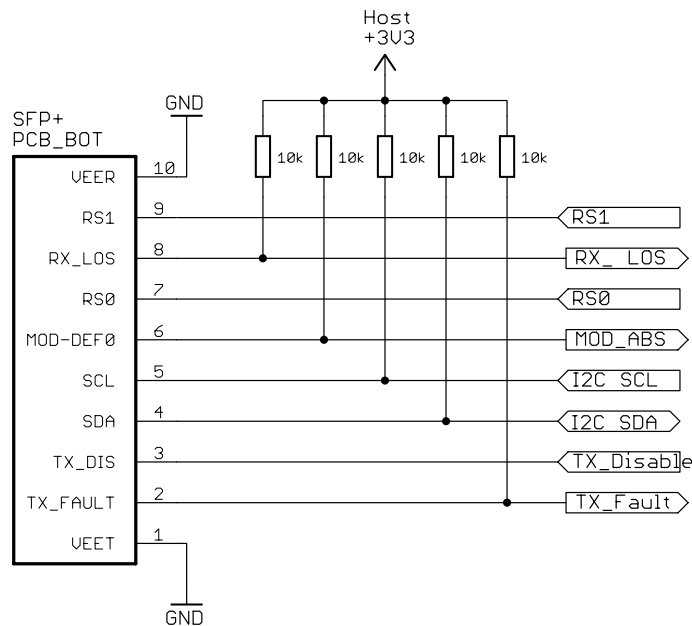
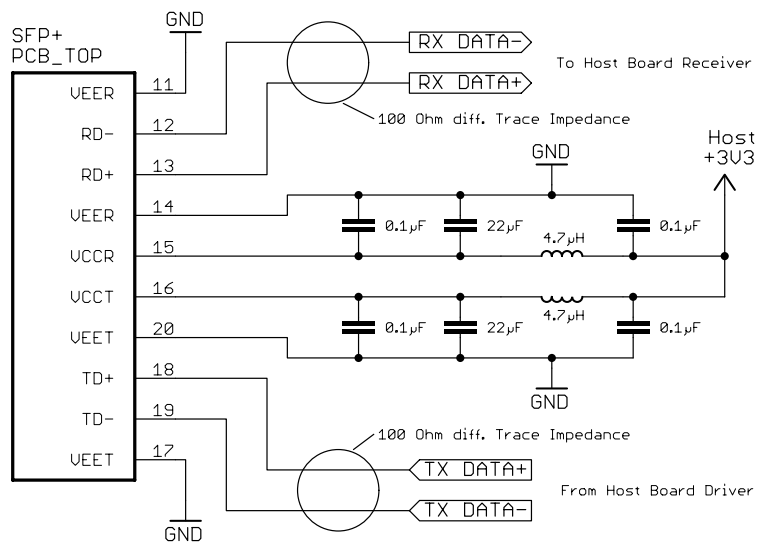
PIN	Logic	Symbol	Name / Description	Note
1		VeeT	Module Transmitter Ground	1
2	LVTTL-O	TX_Fault	Module Transmitter Fault	
3	LVTTL-I	TX_Dis	Transmitter Disable; Turns off transmitter laser output	
4	LVTTL-I/O	SDA	2-Wire Serial Interface Data Line	2
5	LVTTL-I	SCL	2-Wire Serial Interface Clock	2
6		MOD_ABS	(=MOD_DEF0) Module Absent, shorted to module ground	
7	LVTTL-I	RS0	Receiver Rate Select	
8	LVTTL-O	RX_LOS	Receiver Loss of Signal Indication Active LOW	
9	LVTTL-I	RS1	Transmitter Rate Select	
10		VeeR	Module Receiver Ground	1
11		VeeR	Module Receiver Ground	1
12	CML-O	RD-	Receiver Inverted Data Output	
13	CML-O	RD+	Receiver Data Output	
14		VeeR	Module Receiver Ground	1
15		VccR	Module Receiver 3.3 V Supply	
16		VccT	Module Transmitter 3.3 V Supply	
17		VeeT	Module Transmitter Ground	1
18	CML-I	TD+	Transmitter Non-Inverted Data Input	
19	CML-I	TD-	Transmitter Inverted Data Input	
20		VeeT	Module Transmitter Ground	1


1. Module ground pins Vee are isolated from the module case.
2. Shall be pulled up with 1k-10k ohms to a voltage between 3.13 V and 3.47 V on the host board.

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Application Schematics

Recommended electrical connections to transceiver are shown below. Pull-ups: 1k – 10k ohms.



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Interfacing the Transceiver

Communication is done by a serial 2-wire interface compatible to the I2C bus protocol. Refer to SFF-8472 for a more detailed explanation of the registers:

Base Address A0h	
Register	Content
0 - 95	Serial Transceiver ID as defined in SFP MSA
96 - 127	FCI Specific
128 - 255	Reserved

Base Address A2h	
Register	Content
0 - 55	Alarm & Warnings Thresholds & Limits
56 - 95	External calibration constants (not used)
96 - 119	Values from real time diagnostic monitoring
120(LSB) - 123(MSB)	Passcode change field
124(LSB) - 127(MSB)	Passcode entry field
128 - 247	Customer specific, writable area
248	Input equalizer setting
249 - 253	Reserved
254	Feature code
255	Reserved

Digital Optical Monitoring

The transceiver offers the ability to monitor important module parameter during operation. All five parameters listed below are continuously monitored for getting information about the current module status. All data is calibrated internally; there is no need for external post processing.

Temperature

Internally measured temperature data is represented as two's complement of a signed 16-bit value in increments of 1/256 °C over a range of -40 to +100 °C. Accuracy is better than +/-3 °C.

Supply Voltage (VCC)


Internally measured supply voltage. Represented as a 16-bit unsigned integer with the voltage defined as the full 16 bit value (0 – 65535) with LSB equal to 100 µVolt, which yields to a total range of 0 to +6.55 Volts. Accuracy is better than +/-3 %.

Laser Bias Current

The DFB laser bias current is represented as a 16 bit unsigned integer with the current defined as the full 16-bit value (0 – 65535) with LSB equal to 2 µA. Accuracy is better than +/-10 %.

Optical Transmitter Power

TX output power measurement is based on internal monitor diode feedback. Represented as a 16-bit unsigned integer with the power defined as the full 16 bit value (0 – 65535) with LSB equal to 0.1 µW. Accuracy is better than +/-3 dB over a range of $P_{avg_{min}}$ to $P_{avg_{max}}$.

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Receiver Optical Power

RX input power measurement is based on photodiode average current. Represented as a 16-bit unsigned integer with the power defined as the full 16 bit value (0 – 65535) with LSB equal to 0.1 μ W. Accuracy is better than +/-3 dB over a range of -13 dBm to 0.5 dBm.

Note: The specified characteristics are met within the recommended range of operating conditions regarding temperature and voltage.

Tx Input Equalizer Adjustment

The transceiver is equipped with an equalizer at the transmitter input (at the electrical module interface) to compensate for high frequency signal loss on the host board printed circuit board (Host-PCB) into which the transceiver is plugged and to allow performance optimization in interaction with an host board equalizers (if there is one).

There are different module equalizer settings available to adjust the strength of the equalization which may be selected according to the line length of Host-PCB signal tracks.


MSB	Content of Register 248 in Table A2h						LSB
reserved	Tx2	Tx1	Tx0	reserved	reserved	reserved	reserved

Register 248 is always readable, but only writable if a valid passcode has been written to registers 124 – 127 of table A2h before (see paragraph Passcode Entry and Modification below). Reserved bits of register 248 should be written to 0. After power up, the module always comes up with its factory programmed default equalizer setting.

Transmitter Input Signal Equalizer Settings:

Tx2	Tx1	Tx0	Description
0	X	X	Input equalizer off
1	0	0	Low equalization
1	0	1	Reserved
1	1	0	Default equalization (factory setting)
1	1	1	Reserved

X: don't care

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Programmability Feature Code


Register 254 of table A2h indicates the programmability features available and an implementation code to distinguish different implementations. This is a read only register.

MSB	Content of Register 254 in Table A2h						LSB
Tx Equal.	reserved	reserved	reserved	reserved	I-Code2	I-Code1	I-Code0

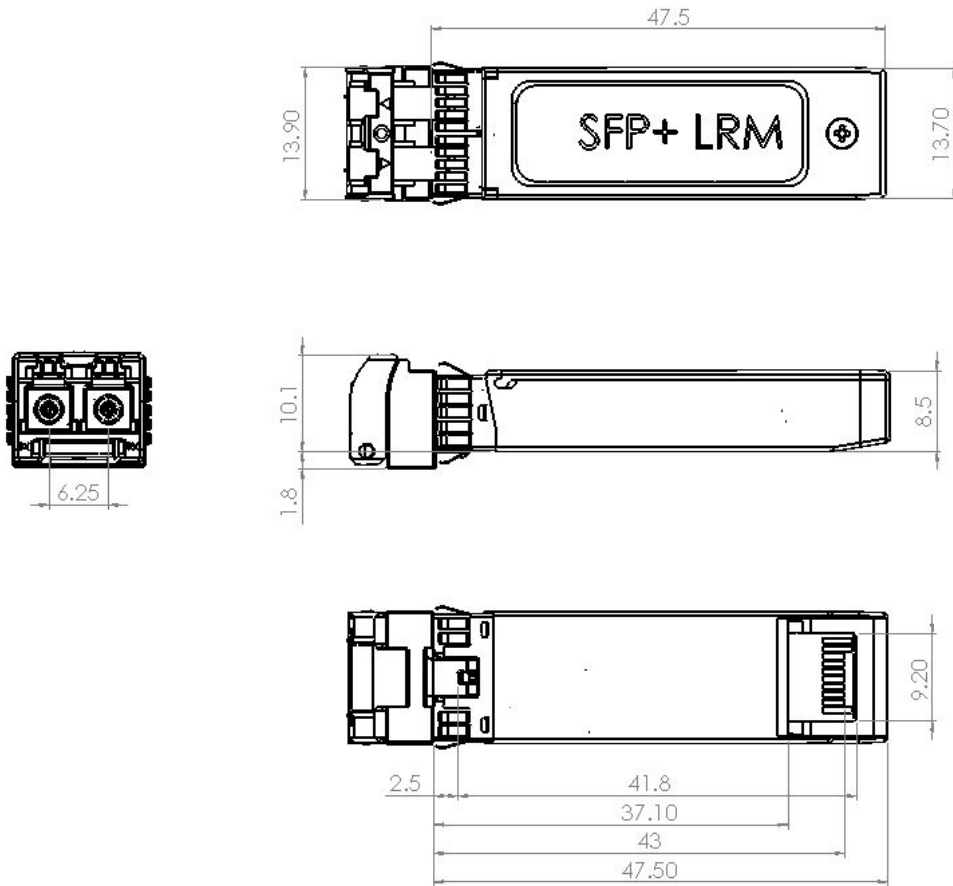
Tx Equal.: is set to 1 if the transceiver supports programming of the Tx equalizer.
I-Code2...0: implementation code. Yields 001b at read out.

Passcode Entry and Modification


Write-access to the transceiver programmability features and to the customer specific writable area (128 – 247 of table A2h) is granted via a valid passcode which has to be written to the passcode entry field (registers 124-127 of table A2h). Please contact FCI for the factory preset initial passcode. The passcode may be changed to a proprietary one by entering the new one into the passcode change field (registers 120-123 of table A2h) after a valid passcode has been written to the passcode entry field.

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Module Outline



All dimensions shown are in millimeters.

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Module Safety & Compliance

FCI's SFP+ LRM module is designed to meet international standards and requirements. The module is RoHS compliant according to the European Parliament requirements on the restriction of the use of hazardous substances in electrical and electronic equipment (RoHS). The module optical output power meets Class 1 requirements for laser safety.

Requirements	Standard
Module Safety	IEC 60950-1:2001 EN 60950-1:2001
RoHS Compliance	RoHS 6/6 Directive 2002/95/EC Amendment 4054 (2005/747/EC)
Laser Safety (Class 1)	CDRH 21 CFR 1040.10 and 1040.11 (according FDA) IEC 60825-1 Rev2 2007 (according IEC)

ESD & Electromagnetic Compatibility

Requirements	Standard	Value
EMI (Emission)	FCC Part 15 B EN 55022 Class B CISPR 22 30 MHz ... 40 GHz	At least 6 dB margin to Class B limit
EMI (Immunity)	IEC 61000-4-3, 10 MHz ... 1 GHz	No bit errors at sensitivity limit
ESD (Electrical connector)	EIA/JESD22-A114-B MIL-STD 883C Method 3015.7	≥ 2 kV ≥ 1 kV (SFI signals)
ESD (Module case)	Air Discharge EN61000-4-2, Criterion B	≥ 15 kV
ESD (Module case)	Contact Discharge EN61000-4-2, Criterion B	≥ 8 kV

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Eye Safety

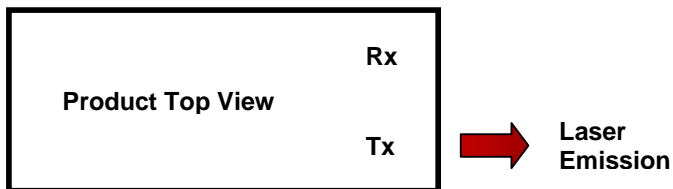
This laser based singlemode transceiver is a Class 1 product. It complies with IEC 60825-1 Edition 2 and FDA performance standards for laser products (21 CFR 1040.10 and 1040.11) except for deviations pursuant to Laser Notice 50, dated July 26, 2001.

CLASS 1 LASER PRODUCT


To meet laser safety requirements the transceiver shall be operated within the Absolute Maximum Ratings.

Note: All adjustments have been made at the factory prior to shipment of the devices. No maintenance or alteration to the device is required. Tampering with or modifying the performance of the device will result in voided product warranty. Failure to adhere to the above restrictions could result in a modification that is considered an act of "manufacturing", and will require, under law, recertification of the modified product with the U.S. Food and Drug Administration (ref. 21 CFR 1040.10 (i)).

LASER EMISSION DATA




Wavelength	1310 nm
Maximum total output power (as defined by IEC: within 7 mm aperture at 70 mm distance)	15.6 mW / 11.9 dBm
Beam divergence (full angle) / NA (half angle)	11° / 0.1 rad

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Ordering Information

Application	Standard	Part Number
10G Ethernet	IEEE 802.3 10GBASE-LRM	TRX10GDL0610C3

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REVISION RECORD

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A		Initial version.		27 Apr. 2011