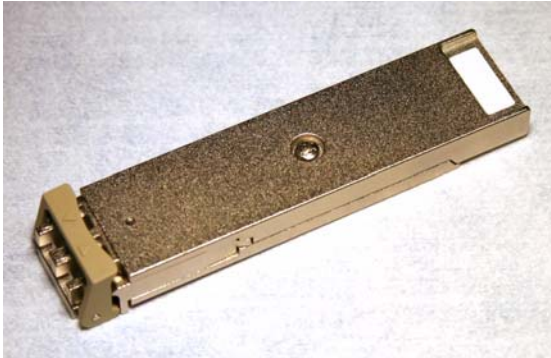


Sun RoHS Compliant 10 Gb/s 850nm XFP Optical Transceiver



Sun Microsystem's MSA compliant 10 Gb/s 850nm XFP optical transceiver is a cost-effective, high-reliability optoelectronic (O/E) device that transmits and receives standard compliant high-speed serial 10 Gb/s optical and electrical signals. The Sun X5558A XFP optical transceiver provides a single product solution for the IEEE 802.3ae 10GBASE-SR, 10GBASE-SW, and 10GFC optical interconnects that are used in Telecommunication, Data Communication, and Storage Area Network applications. The lead free and RoHS Compliant optical transceiver features a 850nm Vertical Cavity Surface Emitting Laser (VCSEL) and a PIN photodiode. The XFI electrical interface uses 10 Gb/s differential data channels for communications to the module as specified in the 10 Gigabit Small Form Factor Pluggable (XFP) Multi-Source Agreement (MSA). The transceiver's MSA compliant "hot-z-pluggable" mechanical design provides the system designer a small footprint 10 Gb/s solution and enables high density front-panel designs with up to 16 10G ports per line card. The Sun X5558A is a 10 Gb/s 850nm optical transceiver targeted at short reach applications. Link lengths greater than 300m can be achieved on 2000MHz*km multimode fiber.

Key Benefits

- Compliant with XFP MSA INF8077i Rev. 4.5
- Lead free and RoHS compliant
- Low power consumption (< 2.0 W max)
- 0°C to 70°C case temperature operating range
- 9.95 Gb/s to 10.75 Gb/s serial optical and electrical interface
- Durable plastic bail delatch mechanism
- LC receptacle optical connector
- Bit error rate < 1×10^{-12}
- Excellent EMI performance
- High reliability
- Requires only 3.3 V and 1.8 V power supplies

Applications

- 10 Gigabit Ethernet (LAN PHY) IEEE 802.3ae 10GBASE-SR and 10GBASE-SW
- 10G Fibre Channel optical interconnects
- Cross-connect switches
- Router interconnect
- MAN aggregation links
- Computer cluster cross-connect
- Custom high-speed data communication links

Highlights

- ◆ **Lead free and RoHS Compliant**
- ◆ **Compliant to Ethernet and Fiber Channel 10 Gb/s Specifications.** Simplifies supply chain.
- ◆ **Hot pluggable** enables real-time in-field system upgrades
- ◆ **System monitoring and component mapping** via I²C management interface
- ◆ **Design based on high volume optoelectronics packaging**
- ◆ **Proven supply chain and reliable long-term supply** based on reliable VCSELs and PIN diodes
- ◆ **Greater than 300 meter reach** over enhanced multimode fiber

Section 1 Functional description

The Sun X5558A RoHS compliant 850nm VCSEL-based 10 Gb/s XFP optical transceiver is a full duplex serial electric, serial optical device with both transmit and receive functions contained in a single module. It is designed to be compliant with IEEE 802.3ae 10GBASE-SR, 10GBASE-SW, and 10G Fibre Channel specifications. The transceiver is also fully compliant with the 10 Gigabit Small Form Factor Pluggable (XFP) Multi-Source Agreement (MSA) INF8077i Rev. 4.5. This device is the ideal solution for high density, cost effective 10 Gb/s 850 nm interconnects over multimode fiber (MMF). A block diagram of the Sun X5558A XFP optical transceiver is shown below.

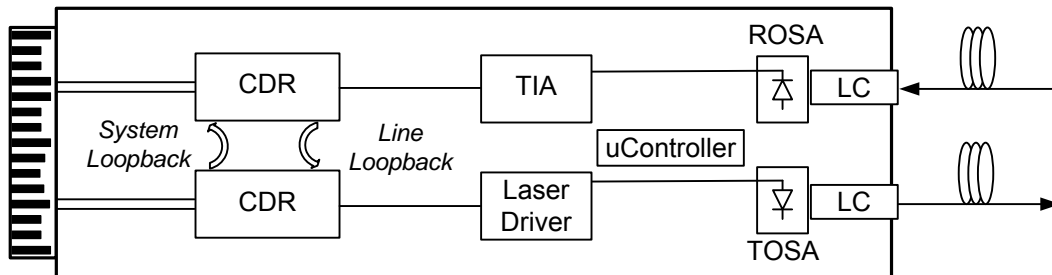


Figure 1 Sun X5558A XFP optical transceiver block diagram

Two loopback modes are available. The loopback modes are controlled through the two-wire serial interface. The loopback modes are useful to facilitate stand-alone testing. In system loopback mode, data recovered from the system side transmit interface is re-directed to the system side receive interface. This facilitates system side test and debug. In network loopback mode, data recovered from the line side receive interface (optics) is looped to the line side transmitter output back to the fiber.

1.1 Transmitter

The transmitter path converts 9.95, 10.3, 10.5 or 10.75 Gb/s NRZ electrical data to a standard compliant optical signal.

The transmitter path accepts a 100 Ω differential 120 mV peak-to-peak to 1000 mV peak-to-peak 10 Gb/s CML electrical signal on TD- and TD+ pins. The differential signals pass through a signal conditioner with equalization that compensates for losses and deterministic jitter present on the input data stream. A reference clock input (RefCLK+, RefCLK-) is used by the internal PLL to determine line rate and signal lock condition. The Tx clock circuit provides a lock alarm output, failure to lock results in Mod_NR asserted. The output of the Tx signal conditioner is input to the laser driver circuit that drives a directly modulated 850 nm VCSEL. The optical signal is engineered to meet the IEEE 802.3ae 10GBASE-SR, 10GBASE-SW, and 10GFC specifications. Closed-loop control of the transmitted laser power over temperature and voltage variations is provided. An LC connectorized receptacle provides the mechanical interface to the multimode fibre plant.

1.2 Receiver

The receiver converts incoming DC balanced serial 9.95, 10.3, 10.5 or 10.75 Gb/s NRZ optical data into serial XFI electrical data. An LC connectorized receptacle provides the mechanical interface to the multimode fiber plant. A high speed PIN photodiode converts the optical signal into a current which is converted to a voltage in a high-gain transimpedance amplifier. The amplified signal is passed to a signal conditioning IC that provides clock and data recovery. Loss of signal, and signal lock detection is included in the receive circuitry that is reflected in the Mod_NR status pin. The



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recovered data is output on the RD+ and RD- pins as a 100 Ω 250 mV peak-to-peak CML signal. The output signal meets the XFP MSA requirements.

1.3 Low Speed Signaling

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

SCL/SDA: 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 SCL (clock), SDA (data), and all low speed outputs.

Mod_NR: Output pin. When asserted high indicates that the module has detected a condition that renders Tx and or Rx data invalid.

Mod_DeSel: Input pin. When held low by the host the module responds to 2-wire serial communication commands. When high the module does not respond to or acknowledge any 2-wire interface communication from the host.

Interrupt: Output pin. When low indicates possible module operational fault or a status critical to the host system.

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

Mod_ABS: Output pin. Asserted high when the XFP module is absent and is pulled low when the XFP module is inserted.

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

P_Down/RST: Multifunction input pin. The module can be powered down or reset by pulling the low-speed P-Down pin high. In power down mode no data is transmitted on the optical Tx or the electrical Rx path. The reset pulse is generated on the falling edge of the P-Down signal. Following reset, the internal PLL's must reacquire lock and will temporarily indicate a Mod_NR failure until the PLL's reacquire lock.

Power supply filtering is recommended for the PLRXXL-SC-S43-S1 module. To limit wide band noise power, the host system and module shall each meet a maximum of 2% 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 3% peak-to-peak noise when measured with a filter from 1 MHz – 10 MHz.

Section 2 Pin function definitions

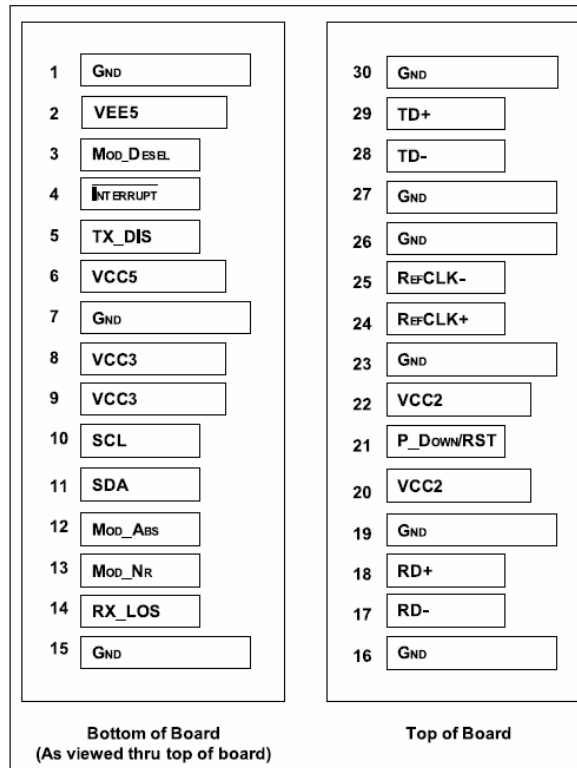


Figure 2 Sun X5558A XFP optical transceiver electrical pin out

Table 1 Sun X5558A XFP optical transceiver pin out descriptions

Pin no.	Type	Name	Description
1		GND ¹	Module Ground
2		VEE5	Not Used; may be left unconnected (Optional -5.2V Power Supply)
3	LVTTTL-I	Mod_Desel	Module De-select; When held low allows the module to respond to 2-wire serial interface commands ¹
4	LVTTTL-O	Interrupt ²	Interrupt; Indicates presence of an important condition which can be read over the serial 2-wire interface
5	LVTTTL-I	TX_DIS	Transmitter Disable; Transmitter Laser Source Turned Off
6		VCC5	+5V Power Supply (not used)
7		GND ¹	Module Ground
8		VCC3	+3.3V Power Supply
9		VCC3	+3.3V Power Supply
10	LVTTTL-I	SCL ²	Two Wire Interface Clock
11	LVTTTL-I/O	SDA ²	Two Wire Interface Data Line
12	LVTTTL-O	Mod_Abs ²	Indicates Module is not present. Grounded in the Module
13	LVTTTL-O	Mod_NR ²	Module Not Ready; Indicating Module Operational Fault



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14	LVTTTL-O	RX_LOS ²	Receiver Loss Of Signal Indicator
15		GND ¹	Module Ground
16		GND ¹	Module Ground
17	CML-O	RD-	Receiver Inverted Data Output
18	CML-O	RD+	Receiver Non-Inverted Data Output
19		GND ¹	Module Ground
20		VCC2	+1.8V Power Supply.
21	LVTTTL-I	P_Down/RST	Power down; When high, the module limits power consumption to 1.5W or below. Serial interface is functional in the low power mode. Reset; The falling edge initiates a complete reset of the module including the serial interface, equivalent to a power cycle.
22		VCC2	+1.8V Power Supply
23		GND ¹	Module Ground
24	PECL-I	RefCLK+	Reference Clock Non-Inverted Input, AC coupled on the host board
25	PECL-I	RefCLK-	Reference Clock Inverted Input, AC coupled on the host board
26		GND ¹	Module Ground
27		GND ¹	Module Ground
28	CML-I	TD-	Transmitter Inverted Data Input
29	CML-I	TD+	Transmitter Non-Inverted Data Input
30		GND ¹	Module Ground
<p>1. Module ground pins (GND) are isolated from the module case and chassis ground within the module 2. Shall be pulled up with 4.7K-10Kohms to a voltage between 3.15V and 3.45V on the host board</p>			

Section 3 Electrical and optical characteristics

3.1 Absolute maximum ratings

Absolute maximum ratings represent the damage threshold of the device. Damage may occur if the device is operated above the limits stated here except for brief excursions. Performance is not guaranteed and reliability is not implied for operation at any condition outside the recommended operating limits.

Parameter	Symbol	Ratings	Unit
Storage Temperature	T _{st}	-40 to +100	°C
Operating Case Temperature	T _{op}	-40 to 80 (temporary excursions)	°C
Relative Humidity	RH	5 to 95 (non-condensing)	%
Power Supply Voltages	V _{CC2,max}	-0.5 to 2.3	V
	V _{CC3,max}	-0.5 to 3.8	V

3.2 Electrical characteristics

(T_{op} = 0°C - 70°C case temperature, unless otherwise stated)

Parameter	Symbol	Min	Typ.	Max	Unit	Notes
Supply currents and voltages						
Voltage ₃	V _{CC3}	3.13	3.3	3.47	V	With Respect to GND
Voltage ₅	V _{CC5}		5.0		V	Not used, no internal connection
Voltage ₂	V _{CC2}	1.71	1.8	1.89		VPS
Supply Current ₃	I _{CC3}		450	500	mA	
Supply Current ₅	I _{CC5}		0		mA	
Supply Current ₂	I _{CC2}		10	15	mA	VPS
Low speed control and sense signals (detailed specification in XFP MSA INF8077i Rev. 4.5)						
Outputs (Interrupt, Mod_NR, RX_LOS)	V _{OL}	0.0		0.4	V	Rpullup pulled to host _Vcc, measured at host side of connector. IOL(max)=3mA
	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, P_Down/RST, M_DSEL)	V _{IL}	-0.3		0.8	V	Pulled up in module to Vcc3
	V _{IH}	2.0		V _{CC3} + 0.3	V	Pulled up in module to Vcc3
SCL and SDA Inputs	V _{IL}	-0.3		V _{CC3} *0.3		Rpullup pulled to host _Vcc, measured at XFP side of connector.
	V _{IH}	V _{CC3} *0.7		V _{CC3} +0.5		Rpullup pulled to host _Vcc, measured at XFP side of connector.
Transmitter Input (detailed specification in XFP MSA INF8077i Rev. 4.5)						
Data Input Baud Rate Nominal		9.95	10.3125	10.75	GBd	
Data Input Bit Rate Tolerance				+/-100	ppm	
Data Input Differential Impedance	R _I	80	100	120	Ω	



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Receiver Output (detailed specification in XFP MSA INF8077i Rev. 4.5)						
Data Output Baud Rate Nominal		9.95	10.3125	10.75	GBd	
Data Output Bit Rate Stability				+/-100	ppm	

3.3 Input reference clock specifications

Parameter	Symbol	Min	Typ.	Max	Unit	Notes
Clock Differential Input Impedance	Zd	80	100	120	Ω	
Differential Input Clock Amplitude		640		1600	mV	AC coupled PECL
Reference Clock Duty Cycle		40		60	%	
Reference Clock Rise/Fall time	Tr/Tf	200		1250	ps	20%-80%
Reference Clock Frequency	f ₀		Baud/64		MHz	
RMS Random Jitter	σ			10	ps	up to 100 MHz
Reference Clock Frequency Tolerance	Δf	-100		+100	ppm	

3.4 Timing requirements for control and status I/O

Parameter	Symbol	Min	Max	Unit	Notes
TX_DIS assert time	t _{off}		10	μ sec	Rising edge of TX_DIS to fall of output signal below 10% of nominal
TX_DIS negate time	t _{on}		2	msec	Falling edge of TX_DIS to rise of output signal above 90% of nominal
Time to initialize	t _{init}		300	msec	From power on or from falling edge of P_Down/RST
Interrupt Assert Delay	Interrupt_on		200	msec	From occurrence of the condition triggering Interrupt.
Interrupt Negate Delay	Interrupt_off		500	μ sec	From clear on read Interrupt flags
P_Down/RST Assert Delay	P_Down/RST_on		100	μ sec	From power down initiation
Mod_NR Assert Delay	Mod_NR_on		1	msec	From occurrence of fault to assertion of Mod_NR
Mod_NR Negate Delay	Mod_NR_off		1	msec	From clearance of signal to negation of Mod_NR
P-Down Reset Time		10		μ sec	Min. length of P-Down assert to initiate reset
RX_LOS Assert Delay	t _{loss_on}		100	μ sec	From Occurrence of loss of signal to assertion of RX_LOS
RX_LOS Negate Delay	t _{loss_off}		100	μ sec	From Occurrence of return of signal to negation of RX_LOS

2-wire serial bus timing is described in Chapter 4 of XFP MSA INF8077i Rev. 4.5

3.5 XFP 2-wire interface protocol and Management Interface

The Sun X5558A XFP optical transceiver incorporates a XFP compliant 2-wire management interface which is used for serial ID, digital diagnostics, and certain control functions. It is modeled on the SFF-8472 Rev 9.3 specification modified to accommodate a single 2-wire interface address. In addition to the basic I²C read/write functionality the modules support packet error checking that, when enabled, allows the host system to confirm the validity of any read data. Details of the protocol and interface are explicitly described in the MSA. Please refer to the MSA for design reference.

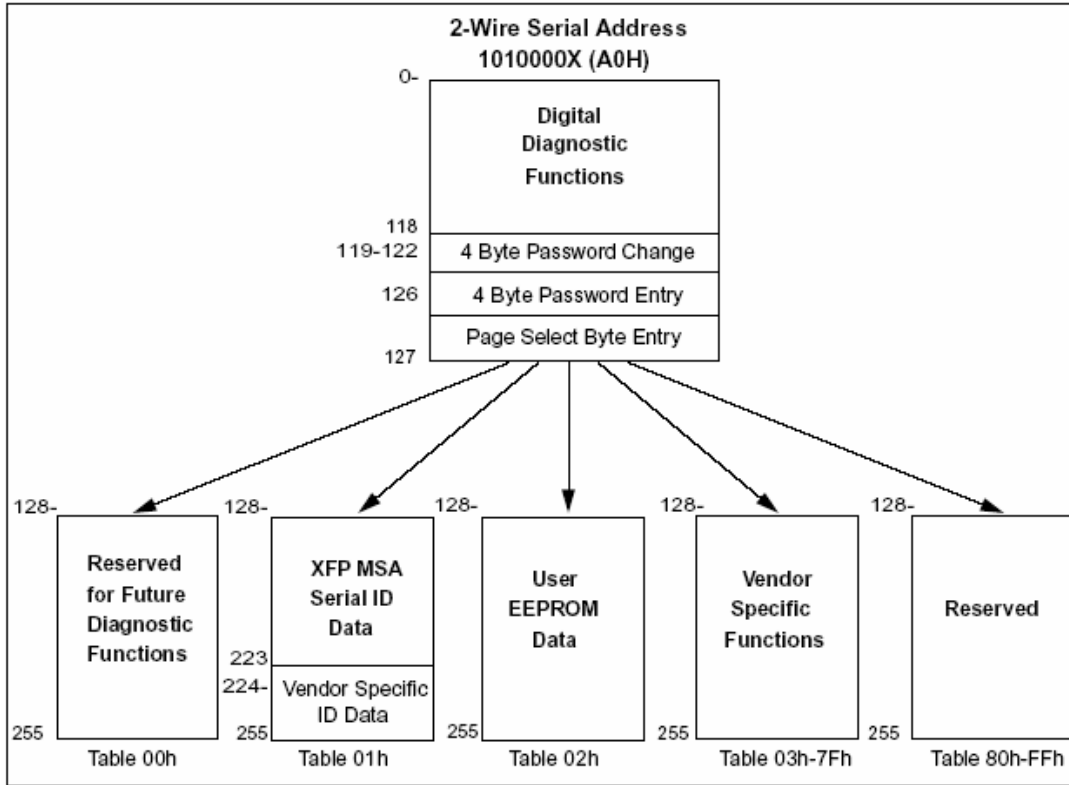


Figure 3 Sun X5558A optical transceiver 2-wire serial digital diagnostic memory map

3.6 Optical characteristics

(T _{op} = 0°C - 70°C case temperature, unless otherwise stated)						
Parameter*	Symbol	Min	Typ.	Max	Unit	Notes
Transmitter						
Signal Speed		9.95	10.3125	10.75	Gb/s	
Signal Tolerance				+/-100	ppm	
Average Optical Power	P _{Avg}	-6.5	-2.8	-1.5	dBm	
Extinction Ratio	Er	3	6		dB	
IEEE 802.3ae-2005 Triple trade off curve compliance						Triple trade off curves define OMA, Spectral Width and Center Wavelength (any two parameters fix the third)
OMA (Optical modulation amplitude)	OMA	380	600	1200	uW	
RMS Spectral Width	Δλ		0.25	0.45	nm	



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Center Wavelength	λ_p	840	850	860	nm	
Relative Intensity Noise	RIN ₁₂ OMA			-128	dB/Hz	
Transmitter and Dispersion Penalty	TDP			3.9	dB	
Return Loss Tolerance				12	dB	
Receiver						
Signal Speed		9.95	10.3125	10.75	GBd	
Wavelength	λ_p	840		860	nm	
Return Reflectance				-12	dB	
Average Receive Power				-1.0	dBm	
Stressed Rx Sensitivity OMA	S _s			-7.5	dBm	
Bit Error Ratio	BER			10 ⁻¹²		Without FEC
* See IEEE 802.3 Clause 52 Media Access Control (MAC) Parameters, Physical Layer, and Management Parameters for 10 Gb/s Operation for complete specification						

3.7 Optical link distances

Data Rate	Fiber Type	Modal Bandwidth @ 850nm (MHz-km)	Worst Case Distance Range Specified (m)	Typical Range (m)
9.95-10.3125 Gb/s	62.5/125um MMF	160	2 - 26	
	62.5/125um MMF	200	2 - 33	
	50/125um MMF	400	2 - 66	
	50/125um MMF	500	2 - 82	
	50/125um MMF	2000	2 - 300	>400

3.8 Regulatory compliance

The Sun X5558A XFP optical transceiver is lead-free and RoHS-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 Sun X5558A XFP 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 UL94-V0 EN 60950	UL File E209897 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 U. S. 21CFR 1040.10	TUV Certificate CDRH compliant and Class 1 laser eye safe
Electromagnetic Compatibility		
CE	EU Declaration of Conformity	Compliant with European EMC and Safety Standards
Electromagnetic Emissions	EMC Directive 89/336/EEC FCC CFR47 Part 15 IEC/CISPR 22 AS/NZS CISPR22 EN 55022 ICES-003, Issue 4 VCCI-03	Noise frequency range: 30 MHz to 40 GHz. Good system EMI design practice required to achieve Class B margins.
Electromagnetic Immunity	EMC Directive 89/336/EEC IEC /CISPR/24 EN 55024	
ESD Immunity	EN 61000-4-2	Exceeds Requirements. Withstands discharges of; 15kV contact, 25kV air
Radiated Immunity	EN 61000-4-3	Exceeds Requirements. Field strength of 10V/m RMS, from 10 MHz to 1 GHz. No effect on transmitter/receiver performance is detectable between these limits.

3.9 Connectors

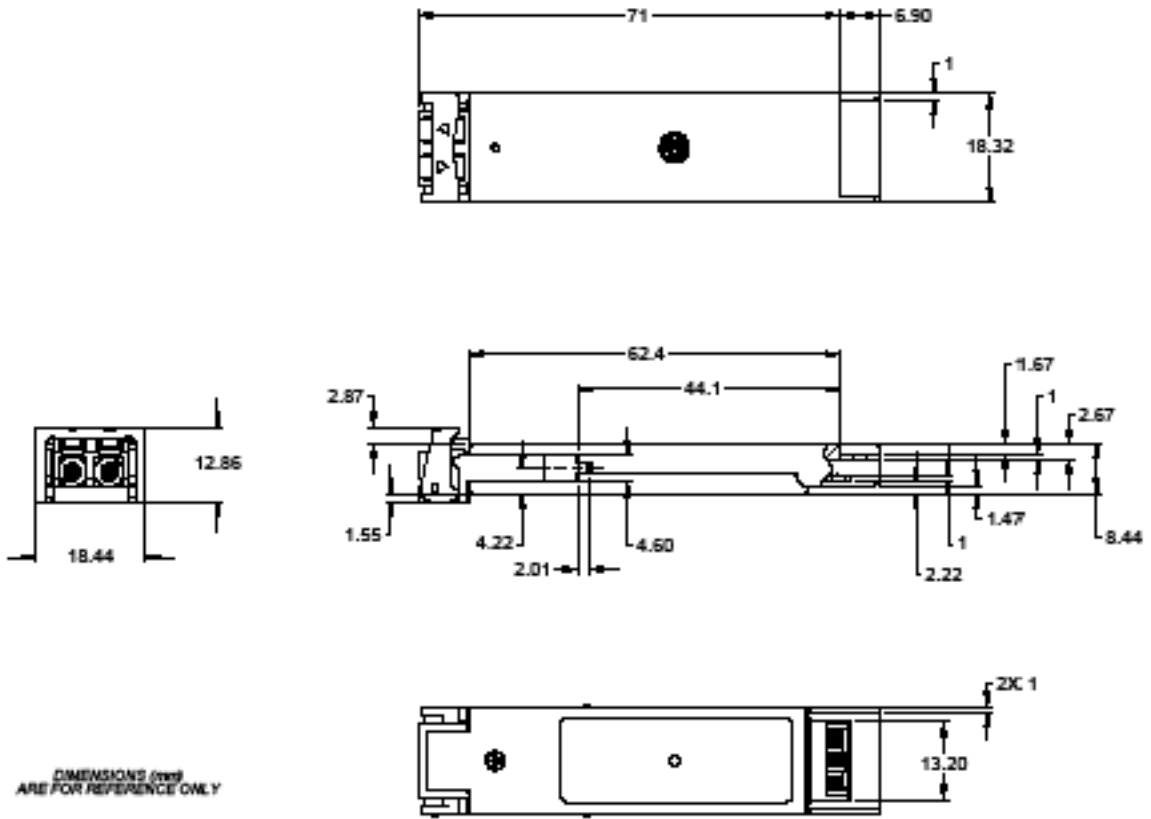
Fiber

The Sun X5558A XFP optical transceiver has a duplex LC receptacled connector.

Electrical

The electrical connector is the 30-way, two row PCB edge connector. Customer connector is Tyco/AMP Part No. 788862C or equivalent.

3.10 XFP optical transceiver outline



Section 4 Related information

4.1 Packaging and handling instructions

Connector covers

The Sun X5558A XFP 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 de-greasing chemicals

It is recommended using 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-methylpyrrolidone).

This product is not designed for aqueous wash.

Housing

The Sun X5558A housing is made from zinc.

4.2 ESD discharge

Handling

Normal ESD precautions are required during the handling of this transceiver. 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 XFP optical transceiver'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).



4.3 Eye safety

The Sun X5558A XFP optical transceiver is an international Class 1 laser product per IEC 60825-1 Amendment 2 (2001) and IEC 60825-2 1997. The Sun X5558A transceiver 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).

Ordering Information

Part Number:	Description:	Contact Information:
Sun X5558A	Lead free and RoHS compliant 850nm XFP duplex LC receptacle 10 Gigabit transceiver module with beige, plastic bail - SUN Microsystems	Web site: www.sun.com Tel: 1-866-596-7234 (US & Canada) Tel: 1-650-960-1300 (International)

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