Gigabit Ethernet/Fibre Channel Small Form Factor Transceiver with Signal Detect

Features

- International Class 1 laser safety certified
- 1063Mb/s to 1250Mb/s data rates
- (ANSI) Fibre Channel compliant [1]
- (IEEE 802.3) Gigabit Ethernet compliant [2]
- Short wavelength (SW) (distance ≤ 550m)
- Gigabit electrical serial interface
- Serial electrical ⇔ light conversion
- UL & CSA approved
- LVTTL Signal-Detect Output
- Single +3.3V Power Supply
- Low bit error rate (< 10^{-12})
- High reliability: AFR < 0.01%/khr @50° C

Applications

- Gigabit Fibre Channel
- Gigabit Ethernet
- Client/Server environments
- Distributed multi-processing
- Fault tolerant applications
- Visualization, real-time video, collaboration
- Channel extenders, data storage, archiving
- Data acquisition

Description

The 1063/1250 Mb/s Small Form Factor PTH Transceiver (SFF-1063/1250N-SW) is an integrated fiber optic transceiver that provides a high-speed serial link at a signaling rate of 1062.5 to 1250 Mb/s. The SFF-1063/1250N-SW conforms to the American National Standards Institute's (ANSI) Fibre Channel, FC-0 specification for short wavelength operation (100-M5-SN-I and 100-M6-SN-I). It also conforms to draft 2 of the IEEE 802.3z, 1000Base-SX standard [2].

The SFF-1063/1250N-SW is ideally suited for Fibre Channel Arbitrated Loop (FC-AL) and Gigabit Ethernet applications, but can be used for other serial applications where high data rates are required. This specification applies to a pin through hole (PTH) module which has a 2 by 5 electrical connector pin configuration.

The SFF-1063/1250N-SW uses a short wavelength (850nm) VCSEL (Vertical Cavity Surface Emitter Laser) source. This enables low cost data transmission over optical fibers at distances up to 550m. A 50/125µm multimode optical fiber, terminated with an industry standard LC connector, is the preferred medium. (A 62.5/125µm multimode fiber can be substituted with shorter maximum link distances.)

Encoded (8B/10B) [3], [4], gigabit/sec, serial, differential, PECL signals traverse a connector interfacing the SFF-1063/1250N-SW to the host card. The serial data modulates the laser and is sent out over the outgoing fiber of a duplex cable.

Incoming, modulated light is detected by a photoreceiver mounted in the LC receptacle. The optical signal is converted to an electrical one, amplified and delivered to the host card. This module is designed to work with industry standard "10b" Serializer/Deserializer modules.

The SFF-1063/1250N-SW is a Class 1 laser safe product. The optical power levels, under normal operation, are at eye safe levels. Optical fiber cables can be connected and disconnected without shutting off the laser transmitter.

Package Outline

Pin Assignments

Pin Name	Type	Pin #
Rx Ground	Ground	1
Rx Power	Power	2
Rx_SD	Status Out	3
Rx_DAT -	Signal Out	4
Rx_DAT +	Signal Out	5
Tx Power	Power	6
Tx Ground	Ground	7
Tx_Disable	Control In	8
Tx_DAT +	Signal In	9
Tx_DAT -	Signal In	10

Ordering Information

Product Descriptor	Part Number	Signaling Rate	Wavelength
SFF-1063/1250N-SW	IBM42F10SNNAA20	1062.5Mb/s	850nm
	IBM42F12SNNAA20	1250Mb/s	

Laser Safety Compliance Requirements

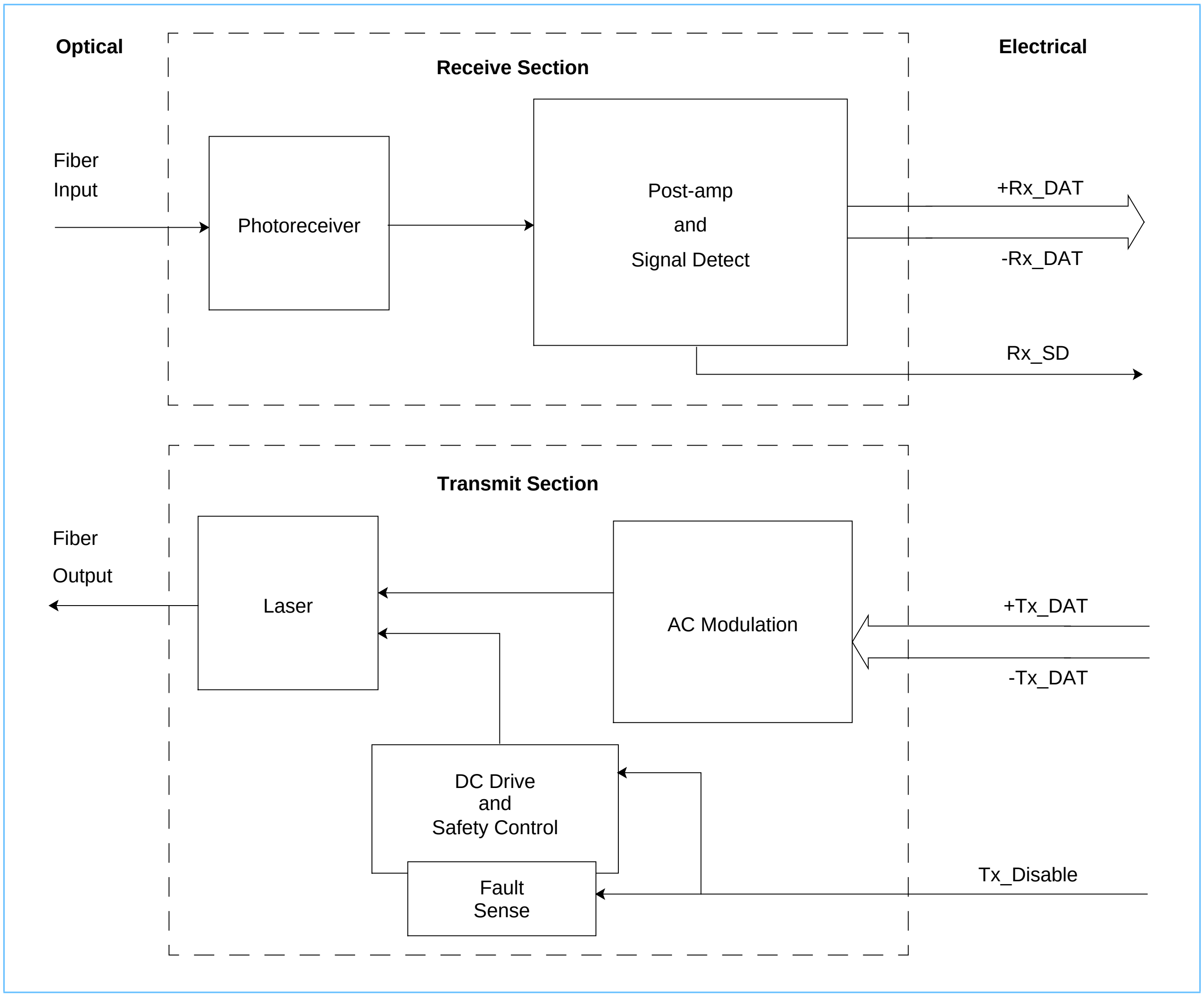
The SFF-1063/1250N-SW is designed and certified as a Class 1 laser product. If the power supply voltage exceeds 4.0 volts, this may no longer remain a Class 1 product. The system using the SFF-1063/1250N-SW must provide power supply over voltage protection that guarantees the supply does not exceed 4.0 volts under all fault conditions.

Caution: Operating the power supply above 4.0V or otherwise operating the SFF-1063/1250N-SW in a manner inconsistent with its design and function may result in hazardous radiation exposure, and may be considered an act of modifying or new manufacturing of a laser product under US regulations contained in 21 CFR(J) or CENELEC regulations contained in EN 60825. The person(s) performing such an act is required by law to recertify and reidentify the product in accordance with the provisions of 21 CFR(J) for distribution within the United States, and in accordance with provisions of CENELEC EN 60825 (or successive regulations) for distribution within the CENELEC countries or countries using the IEC 825 standard.

ESD Handling

Take normal static precautions during handling and assembly of the SFF-1063/1250N-SW to prevent damage and/or degradation that can be induced by electrostatic discharge.

Block Diagram



Transmit Section

The input, an AC coupled differential data stream from the host, enters the AC Modulation section of the laser driver circuitry where it modulates the output optical intensity of a semiconductor laser. The DC Drive maintains the laser at the correct preset power level. In addition, safety circuits in the DC Drive will shut off the laser if a fault is detected. *The host must provide the AC coupling for the +Tx/-Tx lines.* A 10nF capacitor is recommended.

Receive Section

The incoming modulated optical signal is converted to an electrical signal by the photoreceiver. This electrical signal is then amplified and converted to a differential serial output data stream and delivered to the host. A transition detector detects sufficient AC level of modulated light entering the photoreceiver. This signal is provided to the host as a signal detect status line. *The host must provide the AC coupling for the +Rx/-Rx lines.* A 10 nF capacitor is recommended.

Input Signal Definitions

Levels for the signals described in this section are listed in Transmit Signal Interface on page 7 and Control Electrical Interface on page 8.

Tx_DAT

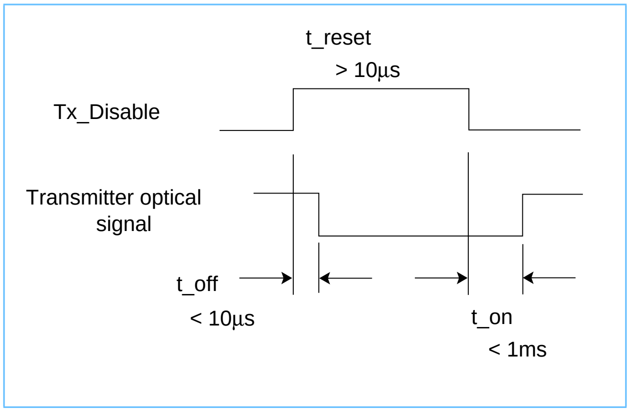
A differential PECL serial data stream is presented to the SFF-1063/1250N-SW for transmission onto an optical fiber by modulating the optical output intensity of a laser.

Tx_Disable

When high (a logical one), the Tx_Disable signal turns off the power to both the AC and DC laser driver circuits. It will also reset a laser fault if one should happen. When low (a logical zero), the laser will be turned on within 1ms if a hard fault is not detected. This signal should be driven with push-pull driver.

Also, this signal has a pull-down resistor on the transceiver so if the host does not drive this signal the laser will default to the on state.

Timing of Tx_Disable Function



Output Signal Definitions

Levels for the signals described in this section are listed in Receive Signal Interface on page 7 and Control Electrical Interface on page 8.

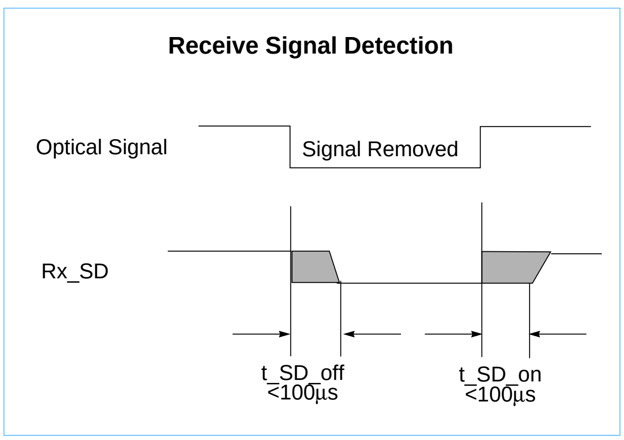
Rx_DAT

The incoming optical signal is converted and repowered as a differential PECL serial data stream. The Receive Signal Interface table on page 7 gives the voltage levels and timing characteristics for the Rx_DAT signals.

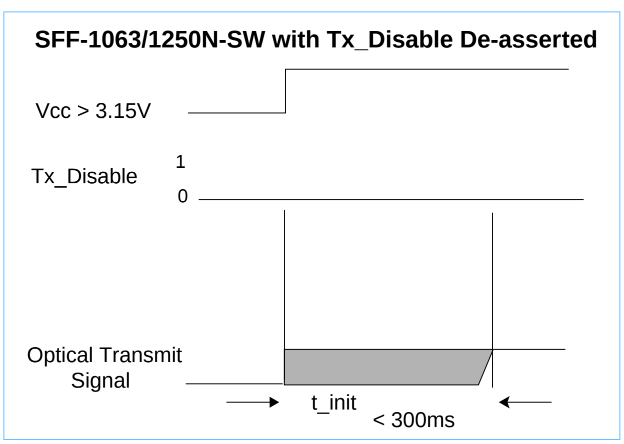
Rx_SD

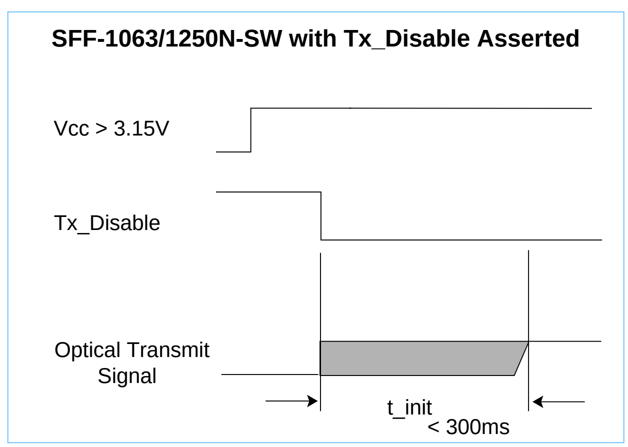
The Receive Signal Detect line is high (a logical one) when the incoming modulated light intensity is sufficient for reliable operation. This is the state for normal operation. The line is low (a logical zero) when incoming modulated light intensity is below that required to guarantee the correct operation of the link. Normally, this only occurs when either the link is unplugged or the companion transceiver is turned off. This signal is normally used by the system for diagnostic purposes. This signal has a push-pull output driver

Timing of Tx_SD Function.



Operation / Initialization Timings





Absolute Maximum Ratings

Symbol	Parameter	Min.	Typical	Max.	Unit	Notes
T_S	Storage Temperature	-40		85	°C	1
RH_S	Relative Humidity–Storage	0		95	%	1, 2
V_{CC}	Supply Voltage	-0.5		4.0	V	1
V_I	TTL DC Input Voltage	0		V_{CC} + 0.7	V	1
T_{SOLD}	Connector Pin Temp during soldering			165/5	°C/s	1,3
T_{SOLD}	Optics Temperature during soldering			100/60	°C/s	4
ESD_{EP}	HBM ESD Rating to Electrical Pins			1500	V	5
ESD_{LC}	HBM ESD Rating to LC Receptacle			12000	V	

1. Stresses listed may be applied one at a time without causing permanent damage. Exposure to these values for extended periods may affect reliability. Specification Compliance is only defined within Specified Operating Conditions.
2. Non-condensing environment.
3. The connector pin temperature can be measured with a thermocouple attached to pin 3 of 2x5 header
4. The optics temperature can be measured with a thermocouple on the device with the cover off.
5. The HBM (human body model) is a 100pF capacitor discharged through a 1.5KΩ resistor into each pin per MIL-STD-883C.

Specified Operating Conditions

Symbol	Parameter	Min.	Typical	Max.	Unit
T_{OP}	Ambient Operating Temperature	0		70	°C
$V_{DD}T$, $V_{DD}R$	Supply Voltage	3.135	3.3	3.465	V
RH_{OP}	Relative Humidity Operating	8		80	%

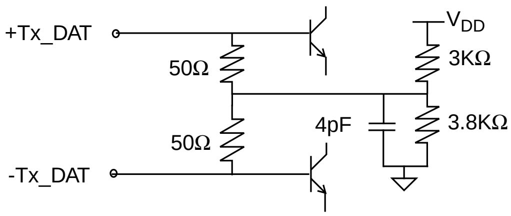
Power Supply Interface

Symbol	Parameter	Min	Typical	Max.	Unit
I_{TX}	Tx Power Current (@ 3.3V)		60		mA
I_{RX}	Rx Power Current (@ 3.3V)		90		mA
I_{TX}	Tx Power Current (@ 3.465V)			85	mA
I_{RX}	Rx Power Current (@ 3.465V)			115	mA
	Ripple & Noise			100	mV(pk-pk)

Transmit Signal Interface (from host to SFF-1063/1250N-SW)

Symbol	Parameter	Min	Max.	Unit	Notes
V_o	PECL Amplitude	400	2000	mV	1
$DJ_{elec\text{-}xmit}$	PECL Deterministic Jitter		0.10	UI	2
$TJ_{elec\text{-}xmt}$	PECL Total Jitter		0.24	UI	2
	PECL Rise/Fall	100	350	ps	3
	PECL Differential Skew		20	ps	

1. At 100Ω, differential peak-to-peak, the figure below shows the simplified circuit schematic for the SFF-1063/1250N-SW high-speed differential input lines. Note the PECL input data lines require AC coupling capacitors on the host. A 10nF value is recommended.

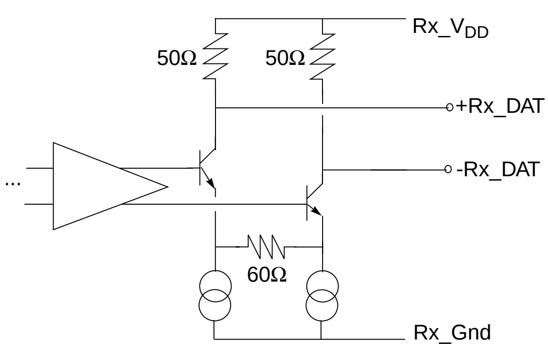


2. Deterministic jitter (DJ) and total jitter (TJ) values are measured according to those defined in Ref [1]. Jitter values at the output of a transmitter or receiver section assume worst case jitter values at its respective input. The Unit interval (UI) for 1062.5Mb/s is 941ps. The UI for 1250Mb/s is 800ps.
3. Rise and fall times are measured from 20 - 80%, 100Ω differential.

Receive Signal Interface (from SFF-1063/1250N-SW to host)

Symbol	Parameter	Min	Max.	Unit	Note(s)
V_o	PECL Amplitude	600	1000	mV	1
$DJ_{elec\text{-}rcv}$	PECL Deterministic Jitter		0.36	UI	2
$TJ_{elec\text{-}rcv}$	PECL Total Jitter		0.61	UI	2
	PECL Differential Skew		205	ps	

1. At 100Ω, differential peak-to-peak, the figure below shows the simplified circuit schematic for the SFF-1063/1250N-SW high-speed differential output lines. Note the PECL output data lines require AC coupling capacitors on the host. A 10NF capacitor is recommended.



2. Deterministic jitter (DJ) and total jitter (TJ) values are measured according to those defined in Ref [1]. Jitter values at the output of a transmitter or receiver section assume worst case jitter values at its respective input. The Unit interval (UI) for 1062.5Mb/s is 941ps. The UI for 1250Mb/s is 800ps.

Control Electrical Interface

Symbol	Parameter	Min	Max.	Unit	Note(s)
Voltage Levels					
V_{OL}	TTL Output (from SFF-1063/1250N-SW)	0.0	0.50	V	
V_{OH}		V_{CC}-0.5	V_{CC}+0.3	V	
V_{IL}	TTL Input (to SFF-1063/1250N-SW)	0	0.8	V	1
V_{IH}		2.0	V_{DD}T+0.3	V	
Timing Characteristics					
t_off	Tx_Disable Assert time		10	µs	2
t_on	Tx_Disable De-assert time		1	ms	2
t_reset	Tx_Disable Time to start reset	10		µs	2
t_init	Initialization Time		300	ms	3
t_SD_on	Rx_SD Assert Time		100	µs	4
t_SD_off	Rx_SD De-Assert Time		100	µs	4

1. A 1KΩ pull-down resistor to GND is present on the SFF-1063/1250N-SW to allow the laser to be active when no input signal is provided on Tx_Disable.
2. See Tx_Disable on page 4 and See “Operation / Initialization Timings” on page 5. for timing relationships.
3. See See “Operation / Initialization Timings” on page 5.
4. See Rx_SD on page 5 for timing relations.

Optical Specifications

Receiver Specifications

Symbol	Parameter	Min	Typical	Max.	Unit	Notes
λ	Operating Wavelength	770		860	nm	
RL	Return Loss of Receiver	12			dB	
	Average Received Power	-17.0		0.0	dBm(avg)	1
OMA	Optical Modulation Amplitude (1.0625Gb/s)	31		2000	µW (pk-pk)	1,2
P_{off}	Rx_SD De-Assert (negate) Level	-27.0		-17.5	dBm(avg)	3
P_{on}	Rx_SD Assert Level			-17.0	dBm(avg)	3
	Rx_SD Hysteresis	0.5	2.5	5.0	dB(optical)	3

1. The minimum and maximum values of the average received power in dBm give the input power range to maintain a BER < 10^{-12} when the data is sampled in the center of the receiver eye. These values take into account power penalties caused by the use of a laser transmitter with a worst-case combination of spectral width, extinction ratio and pulse shape characteristics.
2. Optical Modulation Amplitude (OMA) is defined as the difference in optical power between a logical level one and a logical level zero. The OMA is defined in terms of average optical power (P_{AVG} in µW) and extinction ratio (ER) as given by $OMA=2P_{AVG}((ER-1)/(ER+1))$. In this expression the extinction ratio, defined as the ratio of the average optical power (in µW) in a logic level one to the average optical power in a logic level zero measured under fully modulated conditions in the presence of worst case reflections, must be the absolute (unitless linear) ratio and not expressed in dB.The specified Optical Modulation Amplitude at 1.25Gb/s is equivalent to an average power of -15 dBm at an extinction ratio of 9 dB. At 1.0625Gb/s, the specified OMA is equivalent to an average power of -17 dBm at an ER of 9 dB.
3. The Rx_SD has hysteresis to minimize “chatter” on the output line. In principle, hysteresis alone does not guarantee chatter-free operation. The SFF-1063/1250N-SW, however, presents an Rx_SD line without chatter, where chatter is defined as a transient response having a voltage level of greater than 0.5 volts (in the case of going from the negate level to the assert level) and of any duration that can be sensed by the host logic.

Transmitter Specifications

Symbol	Parameter	Min	Typical	Max.	Unit	Notes
λ_C	Spectral Center Wavelength	830		860	nm	
$\Delta\lambda$	Spectral Width			0.85	nm(rms)	
PT	Launched Optical Power	-9.5		-4.0	dBm(avg)	1
T_{rise}/T_{fall}	Optical Rise/Fall Time			260	ps	2
	Optical Extinction Ratio (1.25Gb/s)	9			dB	3
OMA	Optical Modulation Amplitude (1.0625Gb/s)	156			µW (pk-pk)	4
RIN_{12}	Relative Intensity Noise			-117	dB/Hz	5
	Eye Opening	0.57			UI	6
DJ	Deterministic Jitter			0.20	UI	7
CPR	Coupled Power Ratio	9			dB	8

1. Launched optical power is measured at the end of a two meter section of a 50/125m fiber (N.A.=0.20). The maximum and minimum of the allowed range of average transmitter power coupled into the fiber are worst case values to account for manufacturing variances, drift due to temperature variations, and aging effects. The minimum launched optical power specified assumes an infinite extinction ratio at the minimum specified OMA.
2. Optical rise time is the time interval required for the rising edge of an optical pulse to transition between the 20% and 80% point of the signal amplitude measured using an oscilloscope and 4th order Bessel Thompson filter having a 3 dB bandwidth of 1592MHz and then correcting the measurement to the full bandwidth value. Optical fall times are measured using a 6GHz photodetector followed by a 22GHz sampling oscilloscope. No corrections due to filtering or system bandwidth limitations are made on the measured value.
3. Extinction Ratio is the ratio of the average optical power (in dB) in a logical level one to the average optical power in a logical level zero measured under fully modulated conditions in the presence of worst case reflections.
4. Optical Modulation Amplitude (OMA) is defined as the difference in optical power between a logical level one and a logical level zero. The OMA is defined in terms of average optical power (P_{AVG} in µW) and extinction ratio (ER) as given by OMA=$2P_{AVG}$((ER-1)/(ER+1)). In this expression, the extinction ratio, defined as the ratio of the average optical power (in µW) in a logic level one to the average optical power in a logic level zero measured under fully modulated conditions in the presence of worst case reflections, must be the absolute (unitless linear) ratio and not expressed in dB. At 1.0625Gb/s, the specified OMA is equivalent to an average power of -9 dBm at an extinction ratio of 9 dB.
5. RIN_{12} is the laser noise, integrated over a specified bandwidth, measured relative to average optical power with 12dB return loss. See Ref [1], Annex A.
6. Eye opening is the portion of the bit time where the bit error rate (BER) $\leq 10^{-12}$. The general laser transmitter pulse shape characteristics are specified in the form of a mask of the transmitter eye diagram. These characteristics include pulse overshoot, pulse undershoot, and ringing, all of which should be controlled to prevent excessive degradation of the receiver sensitivity. For the purpose of an assessment of the transmit signal, it is important to consider not only the eye opening, but also the overshoot and undershoot limitations.
7. Deterministic Jitter is defined in Ref [1].
8. Coupled Power Ratio is the ratio of the average power coupled into a multimode fiber to the average power coupled into a single mode fiber. This measurement is defined in EIA/TIA-526-14A.

Optical Cable and Connector Specifications

Symbol	Parameter	Min	Typical	Max.	Unit	Notes
50/125 µm Cable Specifications (Multimode 850nm, 400MHz-km)						
L	Length - 1.25Gb/s	2		500	m	
L	Length - 1.0625Gb/s	2		450	m	
BW	Bandwidth @ λ = 850nm	400			MHz-km	
μ_c	Attenuation @ λ = 850nm			3.5	dB/km	
N.A.	Numerical Aperture		0.20			
50/125 µm Cable Specifications (Multimode 850nm, 500MHz-km)						
L	Length - 1.25Gb/s	2		550	m	
L	Length - 1.0625Gb/s	2		500	m	
BW	Bandwidth @ λ = 850nm	500			MHz-km	
μ_c	Attenuation @ λ = 850nm			3.5	dB/km	
N.A.	Numerical Aperture		0.20			
62.5/125 µm Cable Specifications (Multimode 850nm, 160MHz-km)						
L	Length - 1.25Gb/s	2		220	m	
L	Length -1.0625Gb/s	2		250	m	
BW	Bandwidth @ λ = 850nm	160			MHz-km	
	Attenuation @ λ = 850nm			3.75	dB/km	
N.A.	Numerical Aperture		0.275			
62.5/125 µm Cable Specifications (Multimode 850nm, 200MHz-km)						
L	Length - 1.25Gb/s	2		275	m	
L	Length - 1.0625Gb/s	2		300	m	
BW	Bandwidth @ λ = 850nm	200			MHz-km	
	Attenuation @ λ = 850nm			3.75	dB/km	
N.A.	Numerical Aperture		0.275			
LC Optical Connector						
μ_{con}	Nominal Attenuation		0.3	0.5	dB	1
σ_{con}	Attenuation Standard Deviation		0.2		dB	1
	Connects/Disconnects			250	cycles	1

1. The optical interface connector dimensionally conforms to the industry standard LC type connector documented in Ref [1]. A dual keyed LC receptacle mechanically aligns the optical transmission fiber to the SFF-1063/1250N-SW.

Reliability Projections

Parameter	Symbol	Max.	Unit	Note
Average Failure Rate	AFR	0.0100	%/khr	1

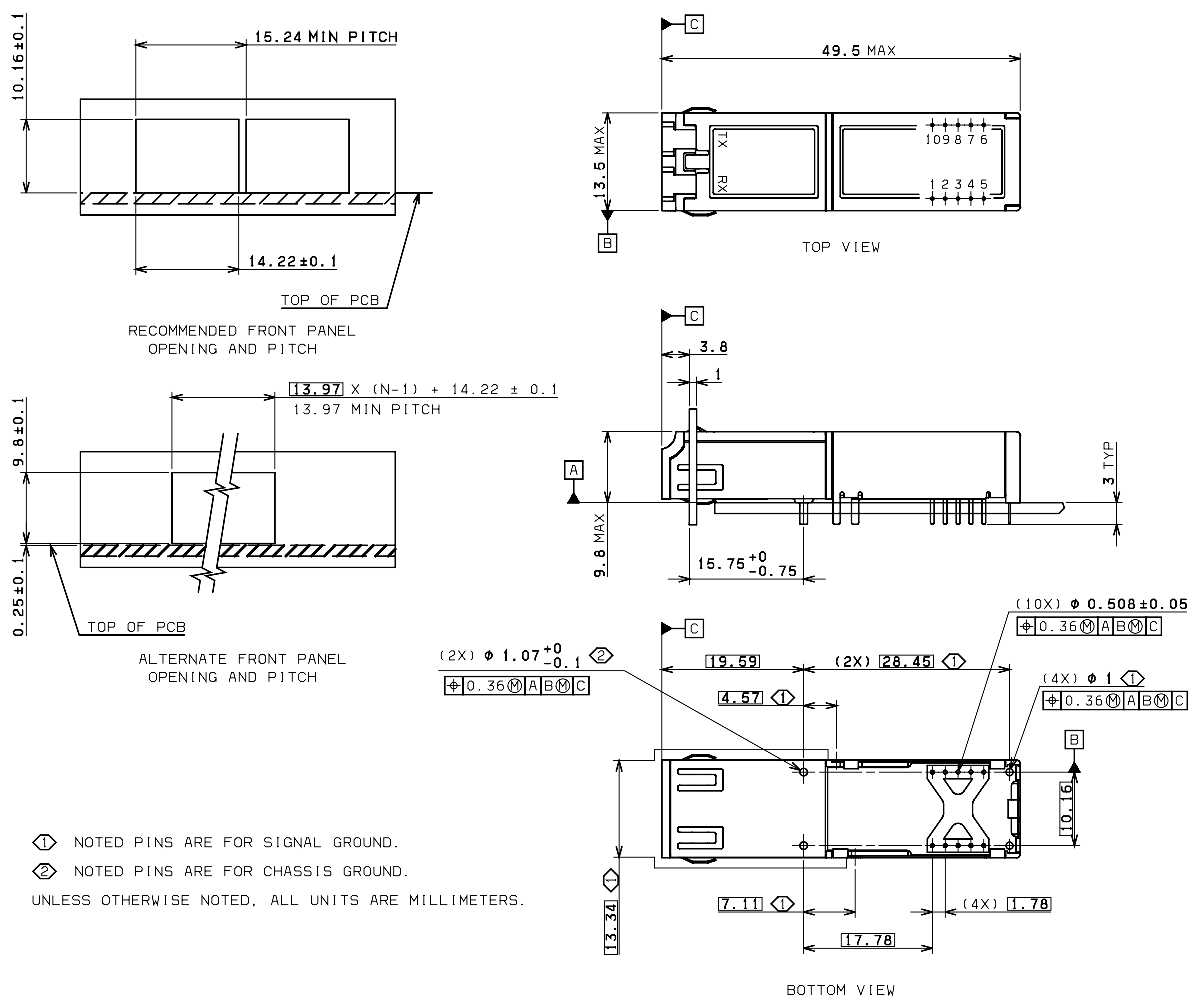
1. AFR specified over 44 khours at 50 C, with minimum airflow of 100 fpm.

Soldering Information

The SFF comes with a dust plug. The purpose of the dust plug is to keep the optical port clean and can be used during a wave soldering process. The SFF module is NOT washable. Any soldering process is allowed as long as it meets the temperature criteria in the Absolute Maximum Ratings table and uses only a “no clean” flux process. That way, the SFF will not get wet any time during the attachment process.

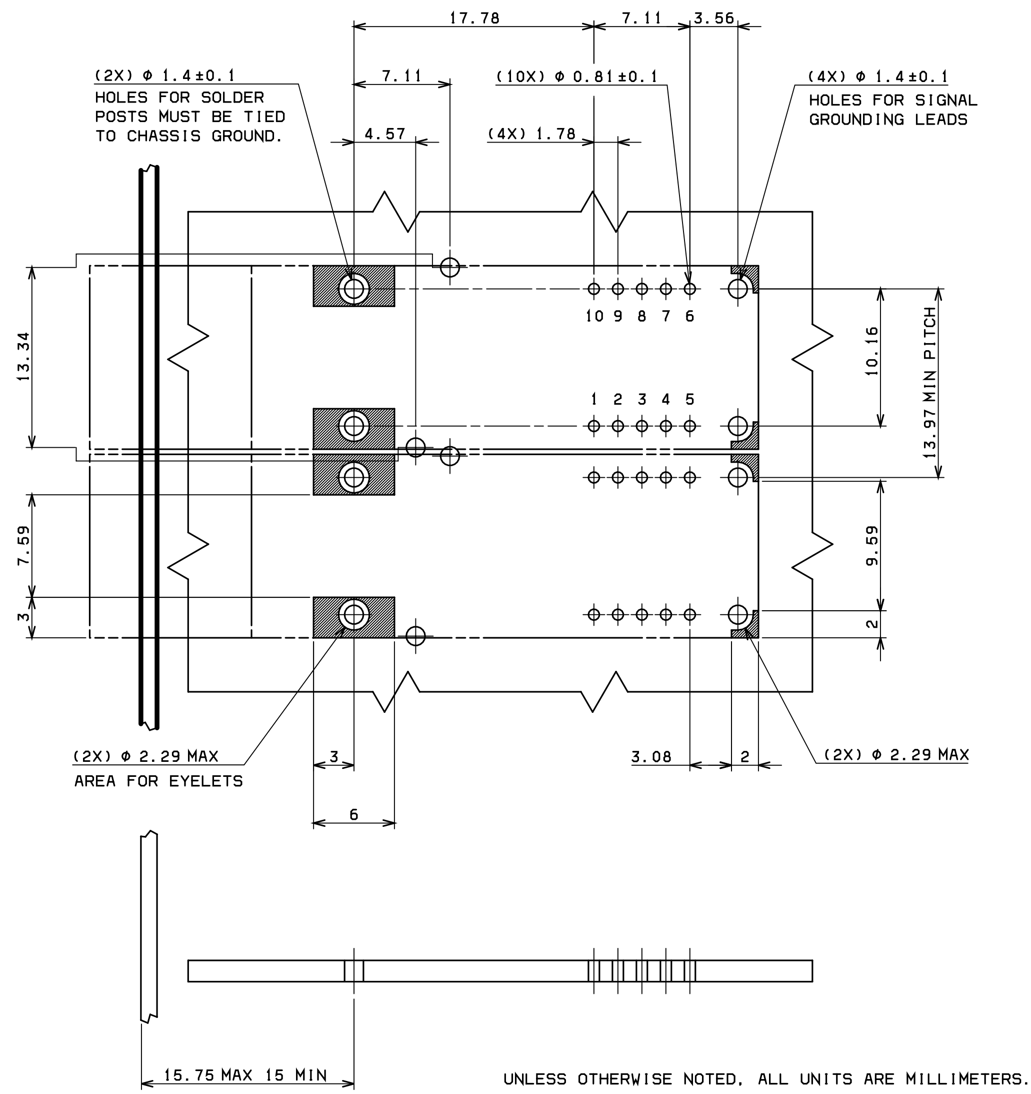
Mechanical Description

Package Diagram



The SFF-1063/1250N-SW is intended to be used on a host card having a thickness of 0.062" to 0.100”. The host card footprint with essential keepouts and drill holes is shown in Host Card Footprint on page 14.

Host Card Footprint



References

Standards

1. American National Standards Institute Inc. (ANSI), T11/Project 1235-DT/Rev 8.0, Fibre Channel-Physical Interface (FC-PI). Drafts of this standard are available to members of the standards working committee. For further information see the T11.2 website at www.t11.org. To be added to the email reflector, send an E-mail to:

   majordomo@dpt.com

   containing the line:

   subscribe t11.2 <your email address>

2. IEEE 802.3z Draft 5.0. Drafts of this standard are available to members of the standards working committee. For further information see IEEE 802.3z public reflector at stds-802-3-hssg@mail.ieee.org. To be added to the reflector, send an E-mail to:

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   The ftp site is

   ftp://stdsbbs.ieee.org/pub/802_main/802.3/gigabit

Industry Specifications

3. A.X. Widmer and P.A. Franaszek, “A DC-Balanced, Partitioned-Block, 8B/10B Transmission Code,” *IBM Journal of Research and Development*, vol. 27, no. 5, pp. 440-451, September 1983. This paper fully defines the 8B/10B code. It is primarily theoretical.

4. A.X. Widmer, The ANSI Fibre Channel Transmission Code, *IBM Research Report, RC 18855 (82405)*, April, 23 1993. Copies may be requested from:

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01/24/00	Initial release (00).
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