2x / 1x Fibre Channel Small Form Factor Hot-Pluggable Transceiver

Features

- International Class 1 laser safety certified
- 1.0625Gb/s or 2.125Gb/s data rates
- 1x and 2x (ANSI) Fibre Channel compliant [1]
- Short wavelength (SW) (distance ≤ 500m)
- Long wavelength (LW) (distance ≤ 10,000m)
- Gigabit electrical serial interface
- Serial electrical ⇔ light conversion
- Receiver Loss of Signal Output
- AC coupling of PECL signals
- Single +3.3V Power Supply
- Serial ID module on MOD(0-2)
- UL & CSA approved
- Low bit error rate (< 10^{-12})
- High reliability: AFR < 0.01%/khr @50 C

Applications

- 2x Gigabit Fibre Channel
- Gigabit Fibre Channel
- Client/Server environments
- Distributed multi-processing
- Fault tolerant applications
- Visualization, real-time video, collaboration
- Channel extenders, data storage, archiving
- Data acquisition

Description

The 1.0625/2.125Gbps Serial Optical Converter (SFF-PGG-2125-SW/LW) is an integrated fiber optic transceiver that provides a high-speed serial link at a signaling rate up to 2.125Gb/s. The SFF-PGG-2125-SW/LW conforms to the American National Standards Institute's (ANSI) Fibre Channel, FC-PI specification for short and long wavelength operation (200-M5-SN-I,200-M6-SN-I, 100-M5-SN-I,100-M6-SN-I, 200-SM-LC-L, and 100-SM-LC-L).

The transceiver is insensitive to the data rate of the incoming electrical and optical signals. The transceiver complies with the 1.0625Gb/s Fibre Channel specification and 2.125Gb/s FC Standard without an external control signal.

The SFF-PGG-2125-SW/LW is ideally suited for Fibre Channel applications which include point to point links as well as Fibre Channel Arbitrated Loop (FC-AL). It can also be used for other serial applications where high data rates are required. This specification applies to a hot-pluggable (PGG) module which has a 2 by 10 electrical surface mount connector assembly.

The SFF-PGG-2125-SW/LW transceiver features a Serial ID module. The Serial ID module can store up to 128 bytes of vital product data.

The SFF-PGG-2125-SW uses a short wavelength (850nm) VCSEL (Vertical Cavity Surface Emitting Laser) source. This enables low cost data transmission over optical fibers at distances up to 550m at 1.0625Gb/s and 300m at 2.125Gb/s. 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.)

The SFF-PGG-2125-LW uses a long wavelength (1310nm) edge emitting laser. This enables data transmission over optical fibers at distances up to 10,000m on a single mode (9/125µm) optical fiber.

Encoded (8B/10B) [3], [4], gigabit/sec serial differential PECL signals traverse the connector interfacing the SFF-PGG-2125-SW/LW 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-PGG-2125-SW/LW 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 Definitions

Pin #	Pin Name	Type	Sequence	Pin #	Pin Name	Type	Sequence
1	Tx Ground	Ground	1	11	Rx Ground	Ground	1
2	Tx_Fault	Signal Out	3	12	-Rx_DAT	Data Out	3
3	Tx_Disable	Signal In	3	13	+Rx_DAT	Data Out	3
4	MOD_DEF(2)	Input/Output	3	14	Rx Ground	Ground	1
5	MOD_DEF(1)	Input/Output	3	15	Rx Power	Power	2
6	MOD_DEF(0)	Input/Output	3	16	Tx Power	Power	2
7	1_2Gbps	Not Connected	3	17	Tx Ground	Ground	1
8	Rx_LOS	Signal Out	3	18	+Tx_DAT	Data In	3
9	Rx Ground	Ground	1	19	-Tx_DAT	Data In	3
10	Rx Ground	Ground	1	20	Tx Ground	Ground	1

Laser Safety Compliance Requirements

The SFF-PGG-2125-SW/LW is designed and certified as a Class 1 laser product. If the power supply voltage exceeds 4.0 volts, the transceiver may no longer remain a Class 1 product. The system using the SFF-PGG-2125-SW/LW 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-PGG-2125-SW/LW 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.

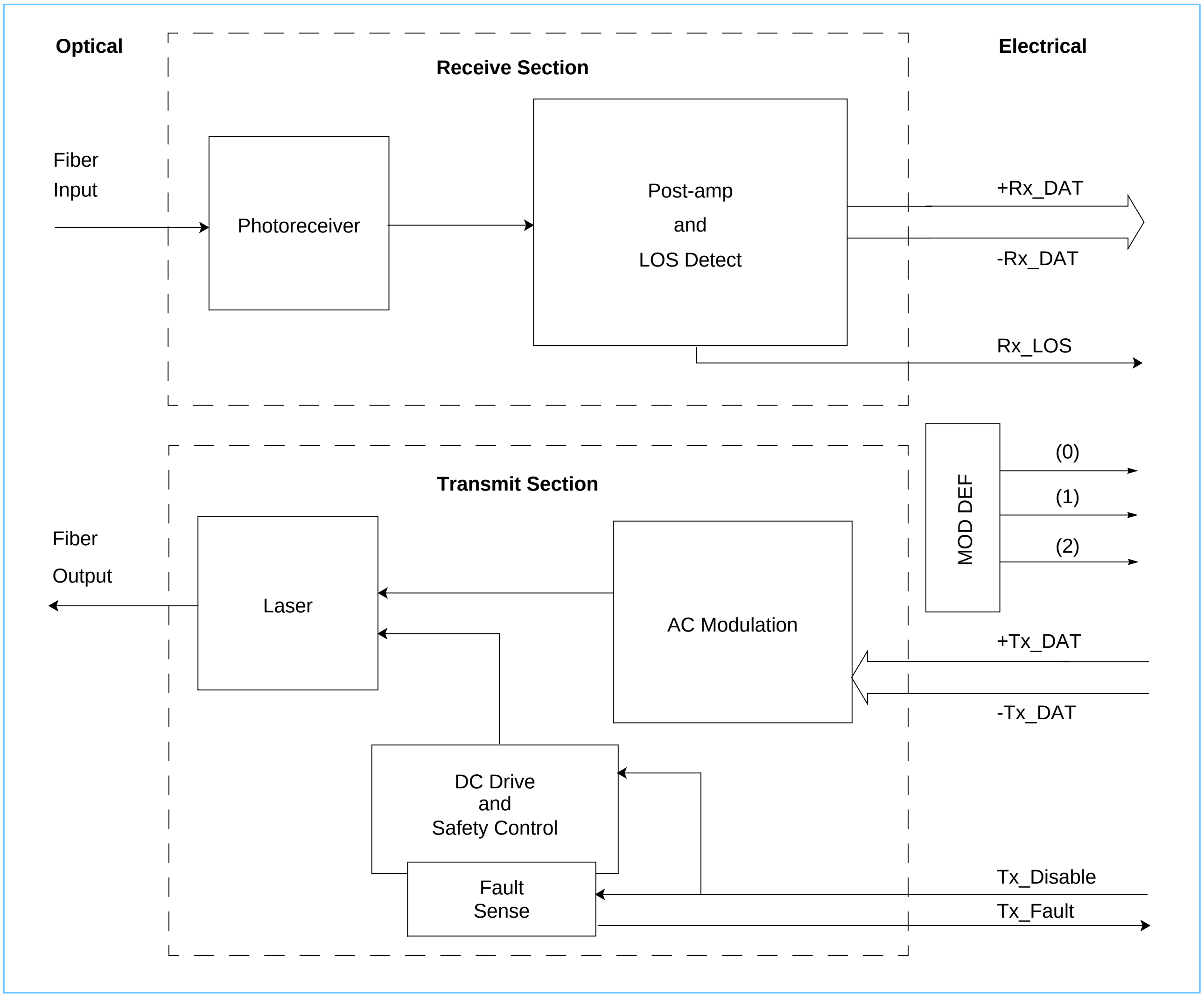
ESD Notice

It is advised that normal static precautions be taken in the handling and assembly of the SFF-PGG-2125-SW/LW to prevent damage and/or degradation which may be introduced by electrostatic discharge.

Ordering Information

Product Descriptor	Part Number	Maximum Signaling Rate	Wavelength
SFF-PGG-2125-SW	IBM42P21SNYAA10	2.125Gb/s	850nm
SFF-PGG-2125-LW	IBM42P21LNYAA10	2.125Gb/s	1310nm

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 transceiver provides the AC coupling for the +Tx/-Tx lines.* No AC coupling capacitors are required on the host card for proper operation.

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 a minimum AC level of modulated light entering the photoreceiver. This signal is provided to the host as a loss-of-signal status line. *The transceiver provides the AC coupling for the +Rx/-Rx lines.* No AC coupling capacitors are required on the host card for proper operation.

Input Signal Definitions

Levels for the signals described in this section are listed in Transmit Signal Interface on page 11 and Control Electrical Interface on page 12.

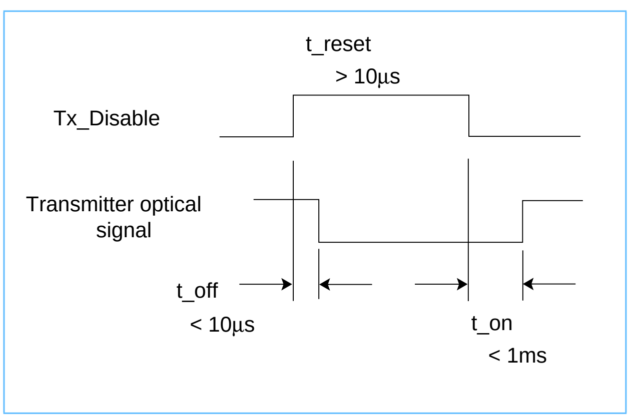
Tx_DAT

A differential PECL serial data stream is presented to the SFF-PGG-2125-SW/LW for transmission onto an optical fiber by modulating the optical output intensity of the 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.

Timing of Tx_Disable Function



Output Signal Definitions

Levels for the signals described in this section are listed in Receive Signal Interface on page 11 and Control Electrical Interface on page 12.

Rx_DAT

The incoming optical signal is converted and repowered as a differential PECL serial data stream. The Receive Signal Interface table on page 11 gives the voltage levels and timing characteristics for the Rx_DAT signals.

Rx_LOS

The Receive Loss of Signal line is high (a logical one) when the 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 an open drain TTL driver. A pull up resistor is required on the host side of the SFF connector. The recommended value for this resistor is 10 kΩ.

Tx_Fault

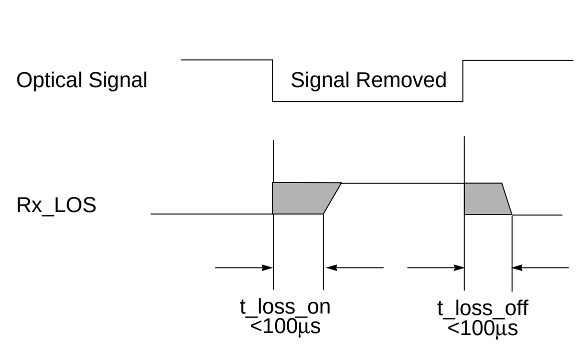
Upon sensing an improper power level in the laser driver, the SFF sets this signal high and turns off the laser. The Tx_Fault signal can be reset with the Tx_Disable line.

The laser is turned off within 100µs as shown in the Transmitter Fault Detection timing diagram below.

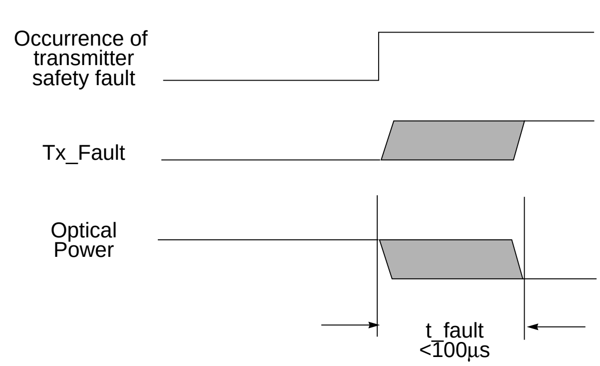
This signal has an open drain TTL driver. A pull up resistor is required on the host side of the SFF connector. The recommended value for this resistor is 10kΩ.

Output Signal Timings

Receive Loss of Signal Detection



Transmitter Fault Detection



MOD_DEF(0:2)

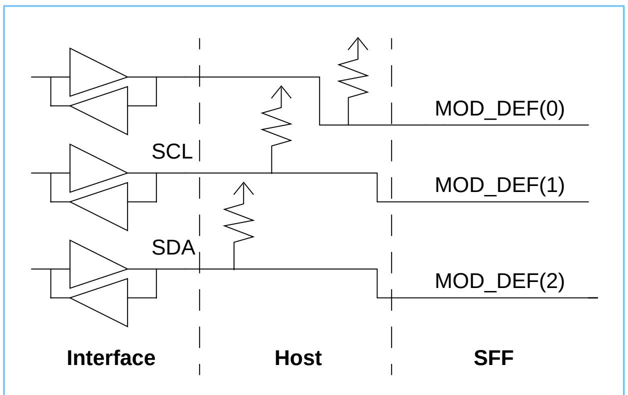
A two-wire serial EEPROM is used to hold 128 bytes of information that describe some of the capabilities, standard interfaces, manufacturer, and other information relevant to the product. The information stored in the EEPROM is protected so that it cannot be changed by the user. Tables describing the specific addresses and values of the Serial ID data are included in Serial ID Data and Descriptions on page 20. Operation of the Serial ID function is described in Serial Module Definition Protocol (Serial ID) on page 8. Signal timings necessary for proper operation of the Serial ID function are shown in Serial ID Timing Specifications on page 25.

The Serial ID module requires both serial clock (SCL) and serial data I/O (SDA) connections. These signals are required to have pull up resistors (4.7kΩ is the recommended value; however, a smaller value may be needed in order to meet the Serial ID's rise and fall time requirements). The following list and figure show the necessary connections from an interface to a SFF to ensure the capability of reading the Serial ID data.

MOD_DEF(0): Logic Low
MOD_DEF(1): SCL
MOD_DEF(2): SDA

The serial clock (SCL) and the serial data (SDA) lines appear as NC to the host system upon initial power up.

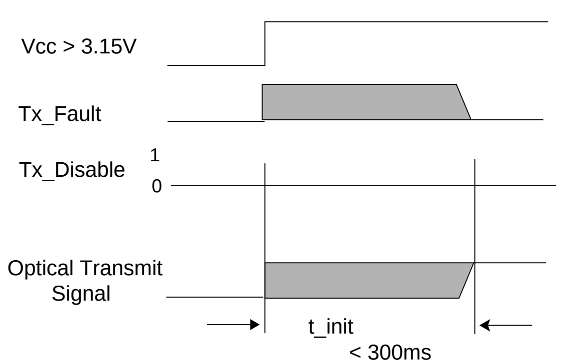
Expected Connections to SFF MOD_DEF Pins



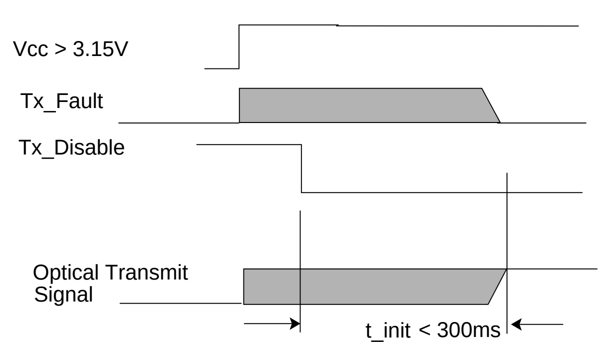
Operation

Initialization Timings

SFF-PGG-2125-SW/LW with Tx_Disable Deasserted



SFF-PGG-2125-SW/LW with Tx_Disable Asserted



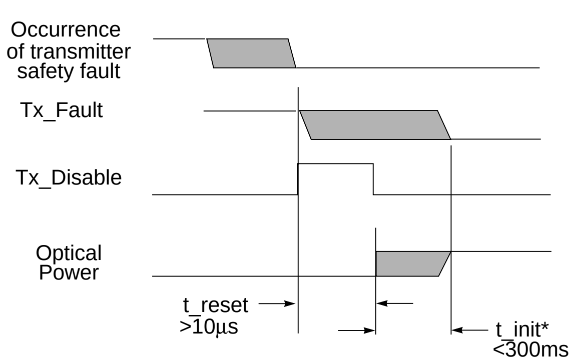
Resetting a Laser Fault

Resetting a laser fault by toggling the Tx_Disable input will permit the SFF-PGG-2125-SW/LW to attempt to power on the laser following a fault condition. *Continuous resetting and re-powering of the laser under a hard fault condition could cause a series of optical pulses with sufficient energy to violate laser safety standards.*

To alleviate the possibility of violating laser safety standards, the SFF-PGG-2125-SW/LW will turn off the laser if a second fault is detected within 25ms of the laser powering on. This lock is cleared during each power on cycle. Please refer to the timing diagrams below.

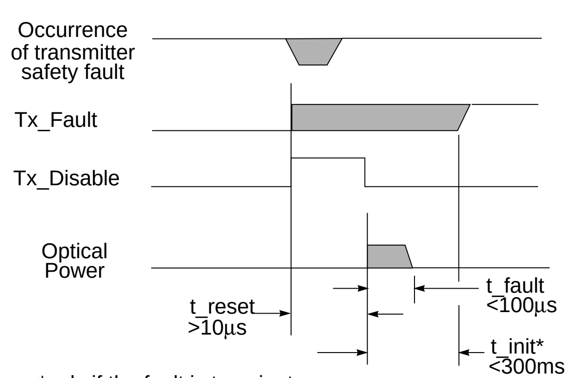
Fault Condition Recovery Timings

Successful Recovery from a Transmitter Safety Fault



*only if the fault is transient

Unsuccessful Recovery from a Transmitter Safety Fault



*only if the fault is transient

Serial Module Definition Protocol (Serial ID)

Product specific information is stored in a Serial ID EEPROM. To read the serial data from the Serial ID module, the following must occur (refer to Serial ID Figures 1, 2, and 3 throughout these steps):

1. Send a start sequence to the module.

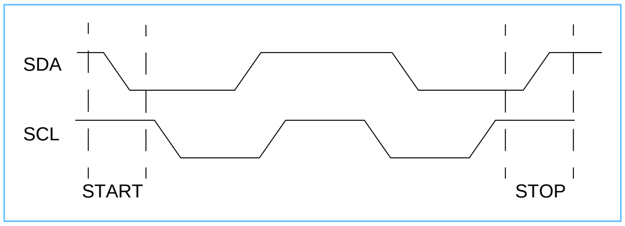
   This is done by changing the data line from high to low while the clock is high.

2. Send the set data address sequence.

   The set data address sequence is 10100000. This sequence will allow the user to set the memory address to start reading from.

   Note: Be sure to toggle the data line only when the clock is low. Toggling the data line while the clock is high indicates a start or stop condition.

Serial ID Figure 1 Start and Stop Timing



3. Receive an acknowledge signal.

   One zero bit is the acknowledge signal.

4. Send the address of the first byte to read.

   The most significant bit of the address byte is the first bit and is ignored.

5. Receive an acknowledge signal.
6. Send a start command.
7. Send the read data sequence.

   The read data sequence is 10100001. This sequence will allow the user to begin reading the data.

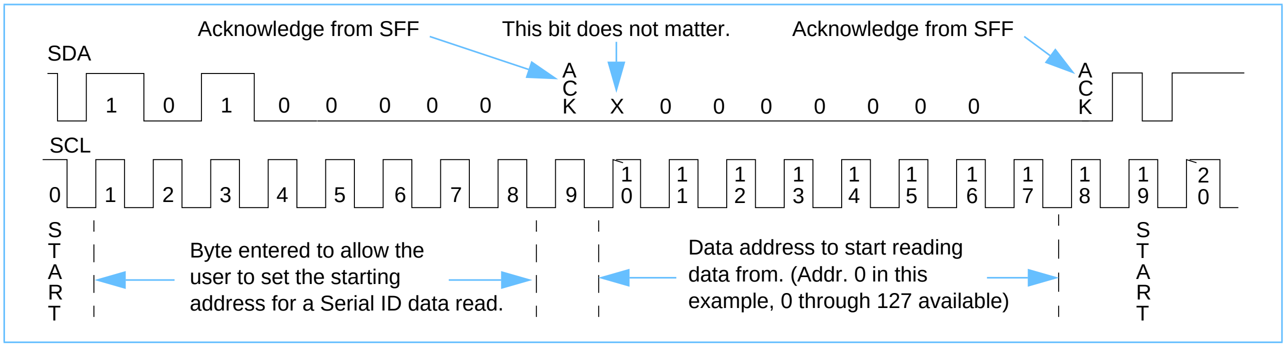
8. Receive an acknowledge signal.
9. Read a data word.
10. Send an acknowledge signal to receive the next data word or send a stop command to stop receiving data.

    A stop command is given by toggling the data from low to high while the clock is high.

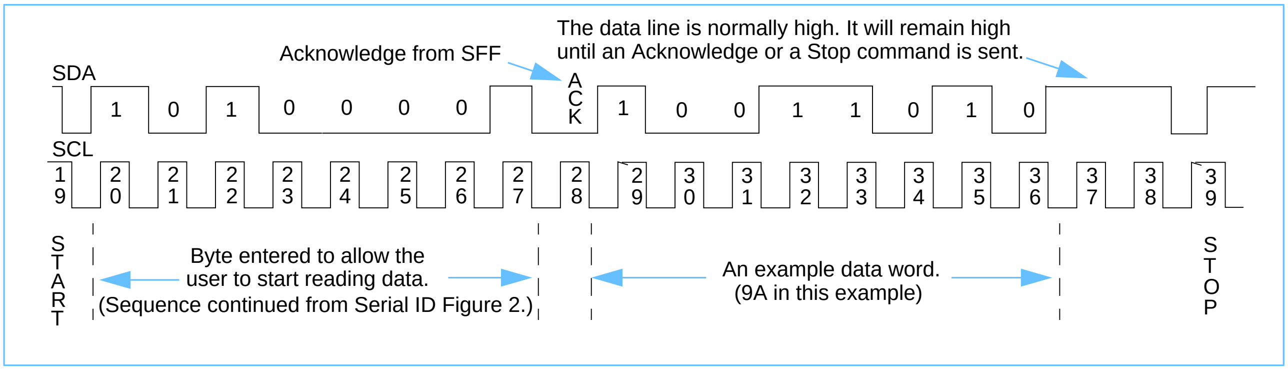
The critical timings for communicating to the Serial ID EEPROM are shown in Serial ID Figure 4 on page 9.

For more information on the Serial ID protocol, see Serial ID Timing Specifications on page 20.

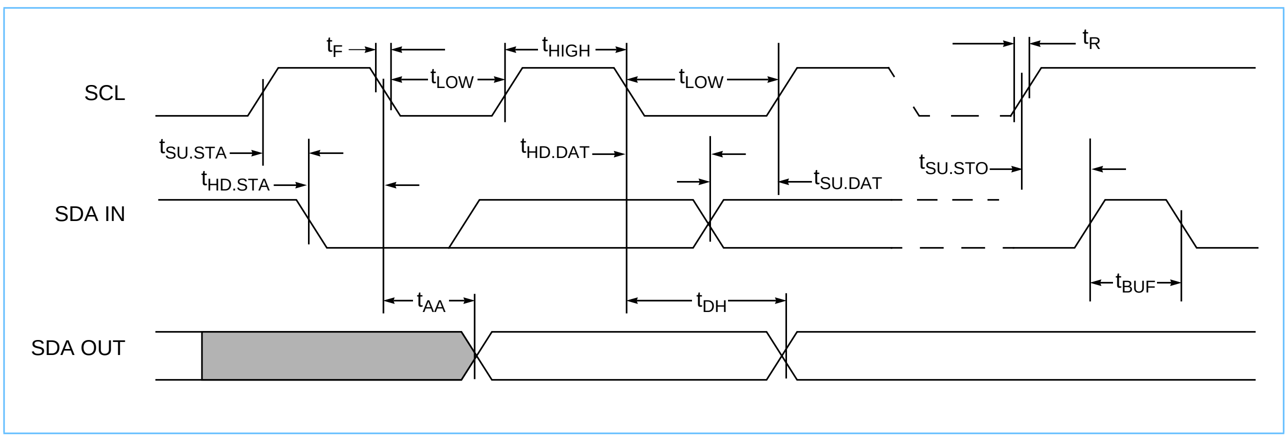
Serial ID Figure 2 Set Data Address Sequence Timing



Serial ID Figure 3 Read Data Sequence Timing



Serial ID Figure 4 Critical Timings
Parameters are defined in Serial ID Timing Specifications on page 25.



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

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.

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	%

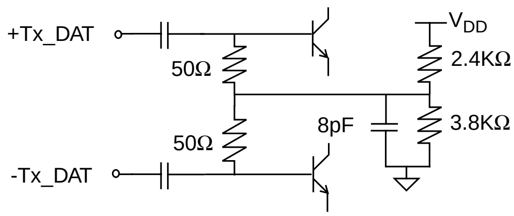
Power Supply Interface

Symbol	Parameter	Min	Typical	Max.	Unit
I_{Tx}	Tx Power Current (@ 3.3V)		75		mA
I_{Rx}	Rx Power Current (@ 3.3V)		75		mA
I_{Tx}	Tx Power Current (@3.465V)			100	mA
I_{Rx}	Rx Power Current (@3.465V)			100	mA
	Ripple & Noise			100	mV (pk-pk)

Transmit Signal Interface (from host to SFF-PGG-2125-SW/LW)

Symbol	Parameter	Min	Max.	Unit	Notes
V_o	PECL Amplitude	400	2000	mV	1
$DJ_{elec\text{-}xmit}$	PECL Deterministic Jitter		0.14	UI	2,4
$TJ_{elec\text{-}xmt}$	PECL Total Jitter		0.26	UI	2,4
	PECL Rise/Fall	50	200	ps	3,4
	PECL Differential Skew		20	ps	4

1. At 100Ω, differential peak-to-peak, the figure below shows the simplified circuit schematic for the SFF-PGG-2125-SW/LW high-speed differential input lines. The PECL input data lines have AC coupling capacitors. The capacitors are not required on the host card.

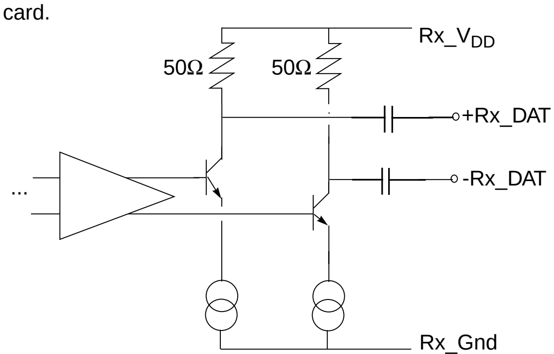


2. Deterministic jitter (DJ) and total jitter (TJ) values are measured according to the methods defined in [2]. Jitter values at the output of a transmitter or receiver section assume worst case jitter values at its respective input. [1UI(Unit Interval)=470.6ps at 2.125Gb/s]
3. Rise and fall times are measured from 20 - 80%, 100Ω differential.
4. When in 1Gb/s mode the transceiver is compliant with 1G specifications as defined in [1].

Receive Signal Interface (from SFF-PGG-2125-SW/LW to host)

Symbol	Parameter	Min	Max.	Unit	Note(s)
V_o	PECL Amplitude	600	1000	mV	1
$DJ_{elec\text{-}rcv}$	PECL Deterministic Jitter		0.39	UI	2,3
$TJ_{elec\text{-}rcv}$	PECL Total Jitter		0.64	UI	2,3
	PECL Differential Skew		102	ps	3

1. At 100Ω, differential peak-to-peak, the figure below shows the simplified circuit schematic for the SFF-PGG-2125-SW/LW high-speed differential output lines. The PECL output data lines have AC coupling capacitors. The capacitors are not required on the host card.



2. Deterministic jitter (DJ) and total jitter (TJ) values are measured according to the methods defined in [2]. Jitter values at the output of a transmitter or receiver section assume worst case jitter values at its respective input. [1UI(Unit Interval)=470.6ps at 2.125Gb/s]
3. When in 1Gb/s mode the transceiver is compliant with 1G specifications as defined in [1]. [1UI (Unit Interval)=941.2ps at 1.0625Gb/s.

Control Electrical Interface

Symbol	Parameter	Min	Max.	Unit	Note(s)
Voltage Levels					
V_{OL}	TTL Output (from SFF-PGG-2125-SW/LW)	0.0	0.50	V	1
V_{OH}		V_{CC}-0.5	V_{CC}+0.3	V	
V_{IL}	TTL Input (to SFF-PGG-2125-SW/LW)	0.0	0.8	V	2
V_{IH}		2.0	V_{DD}T+0.3	V	
V_{IL}	Serial ID SCL and SDA lines	0.0	V_{DD}T • 0.3	V	1
V_{IH}		V_{DD}T • 0.6	V_{DD}T +0.5	V	
Timing Characteristics					
t_off	Tx_Disable Assert time		10	µs	3
t_on	Tx_Disable De-assert time		1	ms	3
t_reset	Tx_Disable (time to start reset)	10		µs	3
t_init	Initialization Time		300	ms	4
t_fault	Tx_Fault Assert Time		100	µs	4
t_loss_on	Rx_LOS Assert Delay		100	µs	5
t_loss_off	Rx_LOS De-Assert Delay		100	µs	5

1. A 4.7K - 10KΩ pull-up resistor to host_V_{CC} is required.
2. A 10KΩ pull-up resistor to V_{DD}T is present on the SFF-PGG-2125-SW/LW.
3. See Tx_Disable on page 4 and Operation on page 7 for timing relationships.
4. See Operation on page 7.
5. See Rx_LOS on page 5 for timing relations.

Optical Specifications (Short Wavelength)

Receiver Specifications

Symbol	Parameter	Min	Typical	Max.	Unit	Notes
λ	Operating Wavelength	830		860	nm	
RL	Return Loss of Receiver	12			dB	
OMA	Optical Modulation Amplitude - 2.125Gb/s	49		2000	µW (pk-pk)	1, 2
OMA	Optical Modulation Amplitude - 1.0625Gb/s	31		2000	µW (pk-pk)	1, 2
P_{off}	Rx_LOS Assert Level	-27.0		-17.5	dBm (avg)	3
P_{on}	Rx_LOS De-Assert (negate) Level			-17.0	dBm (avg)	3
	Rx_LOS 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 logic level one and a logic level zero. The Optical Modulation Amplitude 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)). 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 2.125Gb/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_LOS has hysteresis to minimize “chatter” on the output line. In principle, hysteresis alone does not guarantee chatter-free operation. The SFF-PGG-2125-SW/LW, however, presents an Rx_LOS 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	-10.0		-4.0	dBm (avg)	1
T_{rise}/T_{fall}	Optical Rise/Fall Time			150	ps	2
OMA	Optical Modulation Amplitude (2.125Gb/s)	196			μW (pk-pk)	3
OMA	Optical Modulation Amplitude (1.0625Gb/s)	156			μW (pk-pk)	3
RIN_{12}	Relative Intensity Noise			-117	dB/Hz	4
	Eye Opening (2.125Gb/s)	0.56			UI	5
DJ	Deterministic Jitter (2.125Gb/s)			0.26	UI	6
CPR	Coupled Power Ratio	9			dB	7

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 transition time is the time interval required for the rising or falling edge of an optical pulse to transition between the 20% and 80% amplitudes relative to the logical 1 and 0 levels. This is measured through a 4th order Bessel -Thompson filter with 0.75 * Data Rate 3-dB bandwidth and corrected to the full bandwidth value.
3. Optical Modulation Amplitude (OMA) is defined as the difference in optical power between a logic level one and a logic level zero. The Optical Modulation Amplitude 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, 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 is equivalent to an average power of -9dBm at an extinction ratio of 9dB.
4. RIN_{12} is the laser noise, integrated over a specified bandwidth, measured relative to average optical power with 12dB return loss. See ANSI Fibre Channel Specification Annex A.5.
5. Eye opening is the portion of the bit time where the bit error rate (BER) $\leq 10^{-12}$. 1.0625Gb/s values meet the criteria listed in Ref [1].
6. Deterministic Jitter is measured as the peak-to-peak timing variation of the 50% optical signal crossings when transmitting repetitive K28.5 characters. It is defined in FC-PH, version 4.3, clause 3.1.87 as:

   Timing distortions caused by normal circuit effects in the transmission system. Deterministic jitter is often subdivided into duty cycle distortion (DCD) caused by propagation differences between the two transitions of a signal and data dependent jitter (DDJ) caused by the interaction of the limited bandwidth of the transmission system components and the symbol sequence. 1.0625Gb/s values meet the criteria listed in Ref [1].
7. 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 Specifications (Long Wavelength)

Receiver Specifications

Symbol	Parameters	Min	Typical	Max	Units	Notes
λ	Operating Wavelength	1270		1355	nm	
RL	Return Loss of Receiver	12			dB	
OMA	Optical Modulation Amplitude (2.125Gb/s and 1.0625Gb/s)	15		1000	μW	1,2
P_{off}	Rx_LOS Assert Level	-30.0		-20.0	dBm (avg)	3
P_{on}	Rx_LOS De-Assert (negate) Level			-20.5	dBm (avg)	3
	Rx_LOS Hysteresis	0.5	2.5	5.0	dB (optical)	3

1. The minimum and maximum values of the average received power in dBm allow 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 logic level one and a logic level zero. The Optical Modulation Amplitude 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)). 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 2.125Gb/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_LOS has hysteresis to minimize “chatter” on the output line. In principle, hysteresis alone does not guarantee chatter-free operation. These SFFs, however, present an RX_LOS 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	Units	Notes
λ_C	Spectral Center Wavelength	1290		1335	nm	
$\Delta\lambda$	Spectral Width			2.5	nm (rms)	
PT	Launched Optical Power	-9.2		-3.0	dBm (avg)	1
T_{rise}/T_{fall}	Optical Rise/Fall Time			150	ps	2
OMA	Optical Modulation Amplitude	189			μW	3
RIN_{12}	Relative Intensity Noise			-117	dB/Hz	4
	Eye Opening (2.125Gb/s)	0.56			UI	5
DJ	Deterministic Jitter (2.125Gb/s)			0.26	UI	6

1. Launched optical power is measured at the end of a two meter section of a 9/125μm fiber for the SFF-PGG-2125-LW. 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 transition time is the time interval required for the rising or falling edge of an optical pulse to transition between the 20% and 80% amplitudes relative to the logical 1 and 0 levels. This is measured through a 4th order Bessel -Thompson filter with 0.75 * Data Rate 3-dB bandwidth and corrected to the full bandwidth value.
3. Optical Modulation Amplitude (OMA) is defined as the difference in optical power between a logic level one and a logic level zero. The Optical Modulation Amplitude 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, 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 is equivalent to an average power of -9dBm at an extinction ratio of 9dB.
4. RIN_{12} is the laser noise, integrated over a specified bandwidth, measured relative to average optical power with 12 dB return loss. See ANSI Fibre Channel Specification Annex A.5.
5. Eye opening is the portion of the bit time where the bit error rate (BER) is < 10^{-12}. 1.0625Gb/s values meet the criteria listed in Ref [1].
6. Deterministic Jitter is measured as the peak-to-peak timing variation of the 50% optical signal crossings when transmitting repetitive K28.5 characters. It is defined in FC-PC, version 4.3, clause 3.1.87 as: *Timing distortions caused by normal circuit effects in the transmission system. Deterministic jitter is often subdivided into duty cycle distortion (DCD) caused by propagation differences between the two transitions of a signal and data dependent jitter (DDJ) caused by the interaction of the limited bandwidth of the transmission system components and the symbol sequence.* 1.0625Gb/s values meet the criteria listed in Ref [1].

Optical Cable and Connector Specifications (Short Wavelength)

Symbol	Parameter	Min	Typical	Max.	Unit	Notes
50/125 μm Cable Specifications (Multimode 850nm, 400MHz-km)						
L	Length - 2.125Gb/s	2		260	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 - 2.125Gb/s	2		300	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)						
	Length - 2.125Gb/s	2		120	m	
	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)						
	Length - 2.125Gb/s	2		150	m	
	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 Specifications (Multimode)						
μ_{con}	Nominal Attenuation		0.25	0.4	dB	1
σ_{con}	Attenuation Standard Deviation		0.15		dB	1
	Connects/Disconnects			250	cycles	1

1. The optical interface connector dimensionally conforms to the industry standard LC type connector documented in [1]. A dual keyed LC receptacle mechanically aligns the optical transmission fiber to the SFF-PGG-2125-SW/LW.

Optical Cable and Connector Specifications (Long Wavelength)

Symbol	Parameter	Min	Typical	Max.	Unit	Notes
9/125μm Cable Specifications (Singlemode 1310nm)						
L	Length - 2.125Gb/s			10000	m	
L	Length - 1.0625Gb/s			10000	m	
μ_c	Attenuation @ λ = 1310nm			0.5	dB/km	
LC Optical Connector (Singlemode)						
μ_{con}	Nominal Attenuation		0.2	0.4	dB	1
σ_{con}	Attenuation Standard Deviation		0.1		dB	1
	Connects/Disconnects			250	cycles	1

1. The optical interface connector dimensionally conforms to the industry standard LC type connector documented in [1]. A dual keyed LC receptacle mechanically aligns the optical transmission fiber to the SFF-PGG-2125-SW/LW.

Reliability Projections

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

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

ESD Compliance

Symbol	Parameter	Compliance	Notes
ESD_{EP}	HBM ESD Rating to Electrical Pads	Class I	1
ESD_{LC}	Air Discharge into Front Bezel	Class IV	2

1. The HBM (human body model) is a 100pF capacitor discharged through a 1.5KΩ resistor into each pin per JESD22-A114-B.
2. Complies with European ESD Immunity Test (C-B-2-0001-034).

Dust Plug

The SFF transceiver comes with a dust plug. The purpose of the dust plug is to keep the optical port clean.

Serial ID Timing Specifications

Parameter	Symbol	Min	Typical	Max	Units	Notes
Clock Frequency	f_{SID}			100	kHz	1
Clock Pulse Width Low	t_{LOW}	1.2			µs	1
Clock Pulse Width High	t_{HIGH}	0.6			µs	1
Clock Low to Data Out Valid	t_{AA}	0.1		0.9	µs	1
Time the data line must be free before a new transmission can start	t_{BUF}	1.2			µs	1
Start Hold Time	$t_{HD.STA}$	0.6			µs	1
Start Set-up Time	$t_{SU.STA}$	0.6			µs	1
Data In Hold Time	$t_{HD.DAT}$	0			µs	1
Data In Set-up Time	$t_{SU.DAT}$	100			ns	1
Inputs Rise Time	t_R			0.3	µs	1
Inputs Fall Time	t_F			300	ns	1
Stop Set-up Time	$t_{SU.STO}$	0.6			µs	1
Data Out Hold Time	t_{DH}	50			ns	1

1. See Serial ID Figure 4 on page 9 for timing relationships. See Serial Module Definition Protocol (Serial ID) on page 8 and Serial ID Data and Descriptions on page 26 for more information on Serial ID implementation.

Serial ID Data and Descriptions

The Serial ID tables on the following pages contain specific information about the data contained within the Serial ID EEPROM. Serial ID Table 1 on page 21 is a summary of all of the data fields in the Serial ID EEPROM. Tables 2-6 contain translations of data words for each specific data field. Tables 1 list actual Serial ID Data for the short wave products.

All ID information is stored in eight-bit parameters addressed from 00h to 7Fh. All numeric information fields have the lowest address in the memory space storing the highest order byte. The highest order bit is always transmitted first. All numeric fields will be padded on the left with zeros. All character strings are ordered with the first character to be displayed located in the lowest address of the memory space. All character strings will be padded on the right with ASCII spaces (20h) to fill empty bytes.

Check Codes

The check codes contained within the identification data are one byte codes that can be used to verify that the data in previous addresses is valid. CCID check code is the lower eight bits of the sum of the contents of bytes 0-62. CCEX check code is the lower eight bits of the sum of the contents of bytes 64-94.

Serial ID Table 1 Data Fields

Data Address	Length (Bytes)	Name of Field	Description of Field
Base ID Fields			
0	1	Identifier	Indicated the type of serial transceiver. See Serial ID Table 2, page 19
1	1	Ext. Identifier	Extended identifier of type of serial transceiver
2	1	Connector	Code for connector type. See Serial ID Table 3, page 19
3-10	8	Transceiver	Code for electronic compatibility or optical compatibility, see Serial ID Table 4, page 20
11	1	Encoding	Code for encoding scheme, see Serial ID Table 5, page 24
12	1	BR, Nominal	Nominal baud rate, units of 100MHz
13	1	Reserved	
14	1	9µ, Distance	Distance supported for 9/125µm fiber, units of km
15	1	9µ, Distance	Distance supported for 9/125µm fiber, units of 100m (Zero indicates not supported)
16	1	50µ, Distance	Distance supported for 50/125µm fiber, units of 10m (Zero indicates not supported)
17	1	60µ, Distance	Distance supported for 62.5/125µm fiber, units of 10m (Zero indicates not supported)
18	1	CU, Distance	Distance supported for copper, units of meters (Zero indicates not supported)
19	1	Reserved	
20-35	16	Vendor name	Vendor name (ASCII)
36	1	Reserved	
37-39	3	Vendor OUI	Vendor IEEE company ID
40-55	16	Vendor PN	Vendor part number (ASCII)
56-59	4	Vendor rev	Vendor revision level (ASCII)
60-62	3	Reserved	
63	1	CCID	Check code for Identifier section of Serial ID data (Addresses 0-62)
Extended ID Fields			
64-65	2	Options	Indicates which SFF control/sense signals are implemented, see Serial ID Table 6, page 24
66	1	BR, max	Upper baud rate margin, units of% (Zero indicates unspecified)
67	1	BR, min	Lower baud rate margin, units of% (Zero indicates unspecified)
68-83	16	Vendor SN	Serial number provided by vendor (ASCII)
84-91	8	Date code	Vendor date code (ASCII' yymmddll' yy=year mm=month dd=day ll=lot number)
92-94	3	Reserved	
95	1	CCEX	Check code for the extended data section (Addresses 64-94)
Vendor Specific ID Fields			
96-127	32	Readable	Vendor specific data, read only

Serial ID Table 2 Byte 0, Type of Serial Transceiver

Value	Description of Physical Device
00h	Unknown or unspecified
01h	GBIC
02h	Module/connector soldered to motherboard
03h	SFP
04-7Fh	Reserved
80-FFh	Vendor specific

Serial ID Table 3 Byte 2, Connector Code

Value	Description of Connector
00h	Unknown or unspecified
01h	SC
02h	Fibre Channel Style 1 copper connector
03h	Fibre Channel Style 2 copper connector
04h	BNC/TNC
05h	Fibre Channel coaxial headers
06h	FiberJack
07h	LC
08h	MT-RJ
09h	MU
0Ah	SG
0Bh	Optical Pigtail
0C-1Fh	Reserved
20h	HSSDC II
21h	Copper Pigtail
22h-7Eh	Reserved
7Fh	Connector Name in Bytes 128-143
80-FFh	Vendor Specific

Serial ID Table 4 Bytes 3-10, Transceiver Code for Electronic or Optical Compatibility

Note: Bit Position 7 is the highest order bit and is transmitted first in each byte

Data Address	Bit Position	Description of Transceiver Device	Data Address	Bit Position	Description of Transceiver Device
Reserved Standard Compliance Codes			**Fibre Channel Link Length (Bits 28-31)**		
3	7-0	Reserved	7	7	Reserved
4	7-4	Reserved	7	6	S (Short)
SONET Compliance Codes			7	5	I (Intermediate)
4	3	Reserved	7	4	L (Long)
4	2	OC 48, long reach	**Fibre Channel Transmitter Type**		
4	1	OC 48, intermediate reach	7	3-2	Reserved
4	0	OC 48 short reach	7	1	LC (Low cost long wavelength laser)
5	7	Reserved	7	0	EL (Electrical intercabinet)
5	6	OC 12, single mode long reach	8	7	EL (Electrical intracabinet)
5	5	OC 12, single mode intermediate reach	8	6	SN (Short wave laser without OFC)
5	4	OC 12, multi-mode short reach	8	5	SL (Short wave laser with OFC)
5	3	Reserved	8	4	LL (Long wave laser)
			8	3	LL-V (Long Distance)
			8	0-2	Reserved
5	2	OC 3, single mode long reach	**Fibre Channel Media Type**		
5	1	OC 3, single mode intermediate reach	9	7	TW (Twin Axial Pair)
5	0	OC 3, multi-mode short reach	9	6	TP (Shielded Twisted Pair)
Gigabit Ethernet Compliance Codes			9	5	MI (Miniature Coax)
6	7-4	Reserved	9	4	TV (Video Coax)
6	3	1000BASE-T	9	3	M6 (Multi-mode 62.5µ fiber
6	2	1000BASE-CX	9	2	M5 (Multi-mode 50µ fiber)
6	1	1000BASE-LX	9	1	Reserved
6	0	1000BASE-SX	9	0	SM (Single mode fiber)
			Fibre Channel Speed		
			10	7-5	Reserved
			10	4	400MB/s
			10	3	Reserved
			10	2	200MB/s
			10	1	Reserved
			10	0	100MB/s

Serial ID Table 5 Byte 11, Type of Encoding Scheme

Value	Description of Encoding Mechanism
00h	Unspecified
01h	8B10B
02h	4B5B
03h	NRZ
04h	Manchester
05h-FFh	Reserved for future use

Serial ID Table 6 Bytes 64-65, Options

Data Address	Bit Position	Control / Sense Signal
64	7-0	Reserved
65	7-6	Reserved
65	5	Rate_Select is implemented. Note: Lack of implementation does not indicate lack of simultaneous compliance with multiple standard rates.
65	4	Tx_Disable is implemented and disables the serial output.
65	3	Tx_Fault signal is implemented.
65	2	Loss of Signal is implemented (Signal inverted from definition)
65	1	Loss of Signal is implemented (Signal as defined)
65	0	Reserved
Note: Bit Position 7 is the highest order bit and is transmitted first in each byte.		

Serial ID Table 7 Short wavelength Serial ID Data Entries

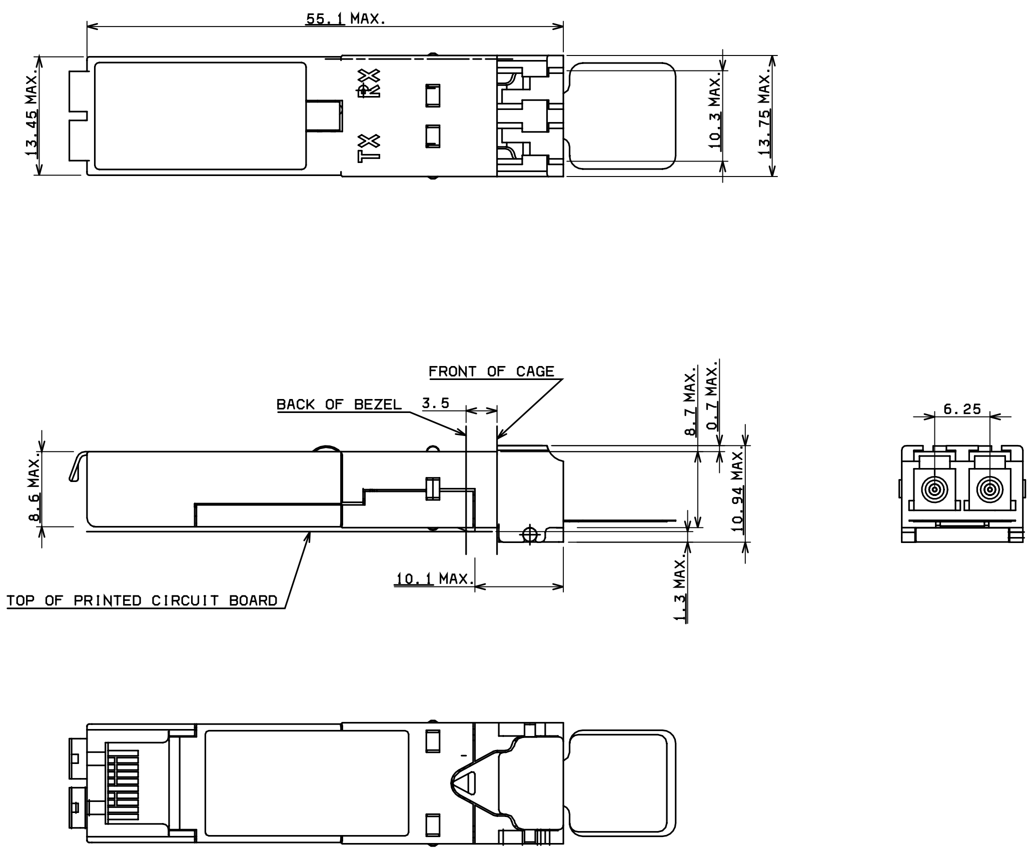
Data Address	Length (Bytes)	Name of Field	Data to be Included in the Field for SW
Base ID Fields			
0	1	Identifier	03h = SFP
1	1	Ext Identifier	00h
2	1	Connector	07h = LC Optical Connector
3-10	8	Transceiver	"0000000000000000000000000000000000100000010000000000110000000101" = 200/100-M5/M6-SN-I (Fibre Channel Compliance code for Optical Compatibility)
11	1	Encoding	01h = 8B10B Encoding
12	1	BR, Nominal	15h = 100MHz x 21= 2.1GHz
13	1	Reserved	0000h
14	1	9µ, Distance	
15	1	9µ, Distance	00h=Not Supported
16	1	50µ, Distance	1Eh = 30 x 10m = 300m on 50/125µm fiber
17	1	60µ, Distance	0Fh = 15x 10m = 150m on 62.5/125µm fiber
18	1	CU, Distance	00h = Copper is not supported
19	1	Reserved	00h
20-35	16	Vendor name	"IBM " (ASCII)
36	1	Reserved	
37-39	3	Vendor OUI	0008005Ah = IBM OUI "08005A"
40-55	16	Vendor PN	"xxxxxxx..." = current IBM part number (ASCII)
56-59	4	Vendor rev	"xx" = current IBM revision number (ASCII)
60-62	3	Reserved	000000h
63	1	CCID	Least significant byte of sum of data in addresses 0-62
Extended ID Fields			
64-65	2	Options	"0000000000011010" = LOS, Tx_Fault, Tx_Disable all supported
66	1	BR, max	05h = 5% Upper baud rate margin
67	1	BR, min	05h = 5% Lower baud rate margin
68-83	16	Vendor SN	"xxxxxxxxxxxxxxxx" = IBM Serial number (ASCII)
84-91	8	Date code	"xxxxxxxx" = IBM date code (ASCII' yymmddll' yy=year mm=month dd=day ll=lot number (yy=00 is year 2000))
92-94	3	Reserved	000000h
95	1	CCEX	Least significant byte of sum of data in addresses 64-94
IBM Specific ID Field			
96-127	32	Readable	"IBM SFPS ARE CLASS 1 LASER SAFE" (ASCII)

Serial ID Table 8 Long wavelength Serial ID Data Entries

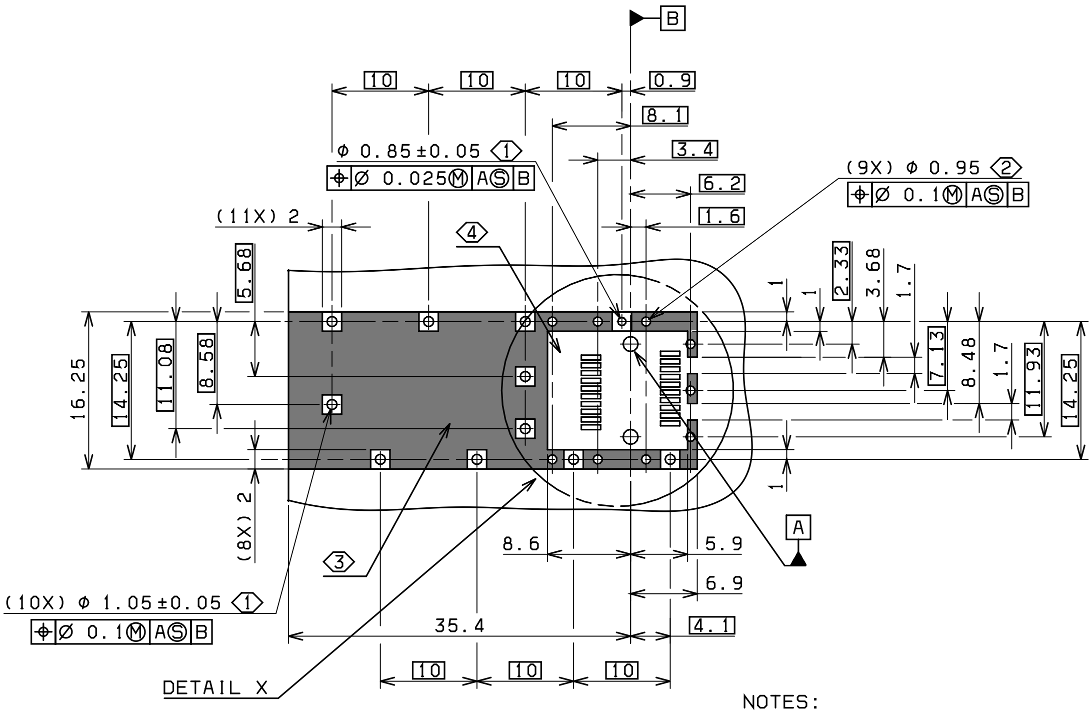
Data Address	Length (Bytes)	Name of Field	Data to be Included in the Field for LW
Base ID Fields			
0	1	Identifier	03h = SFP
1	1	Ext Identifier	00h
2	1	Connector	07h = LC Optical Connector
3-10	8	Transceiver	“0000000000000000000000000000000001001000000000000000100000101” = 200/100-SM-LC-L (Fibre Channel Compliance code for Optical Compatibility)
11	1	Encoding	01h = 8B10B Encoding
12	1	BR, Nominal	15h = 100MHz x 21= 2.1GHz
13	1	Reserved	0000h
14	1	9µ, Distance	
15	1	9µ, Distance	64h = 100 x 100m = 10000m
16	1	50µ, Distance	00h=Not Supported
17	1	60µ, Distance	00h=Not Supported
18	1	CU, Distance	00h = Copper is not supported
19	1	Reserved	00h
20-35	16	Vendor name	“IBM ” (ASCII)
36	1	Reserved	
37-39	3	Vendor OUI	0008005Ah = IBM OUI “08005A”
40-55	16	Vendor PN	“xxxxxxx...” = current IBM part number (ASCII)
56-59	4	Vendor rev	“xx” = current IBM revision number (ASCII)
60-62	3	Reserved	000000h
63	1	CCID	Least significant byte of sum of data in addresses 0-62
Extended ID Fields			
64-65	2	Options	“0000000000011010” = LOS, Tx_Fault, Tx_Disable all supported
66	1	BR, max	05h = 5% Upper baud rate margin
67	1	BR, min	05h = 5% Lower baud rate margin
68-83	16	Vendor SN	“xxxxxxxxxxxxxxxx” = IBM Serial number (ASCII)
84-91	8	Date code	“xxxxxxxx” = IBM date code (ASCII’ yymmddll’ yy=year mm=month dd=day ll=lot number (yy=00 is year 2000))
92-94	3	Reserved	000000h
95	1	CCEX	Least significant byte of sum of data in addresses 64-94
IBM Specific ID Field			
96-127	32	Readable	“IBM SFPS ARE CLASS 1 LASER SAFE” (ASCII)

Mechanical Description

Package Diagram

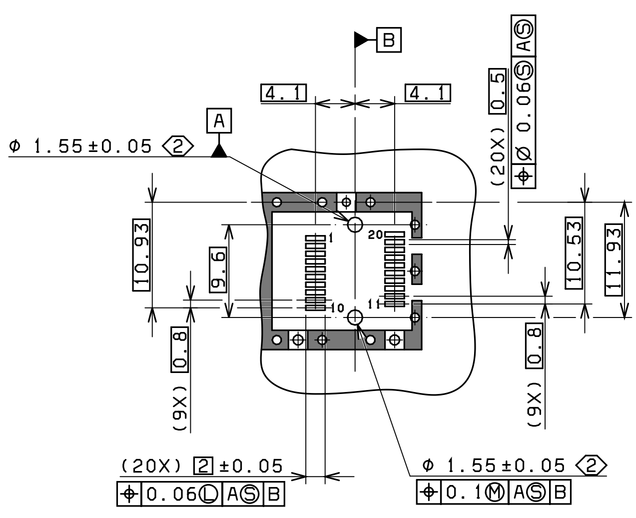


Host Card Footprint (Page 1 of 2)



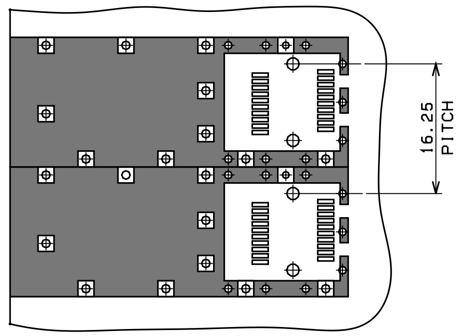
NOTES:

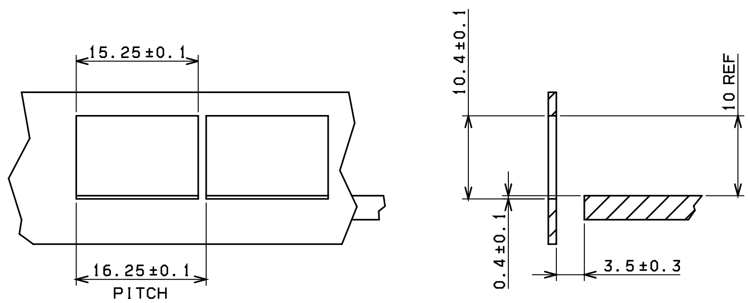
1. PADS AND VIAS ARE CHASSIS GROUND.
2. THROUGH HOLES. PLATING TO CHASSIS GROUND OPTIONAL.
3. CROSS-HATCHED AREA DENOTES COMPONENT AND TRACE KEEPOUT (EXCEPT CHASSIS GROUND).
4. THIS AREA DENOTES COMPONENT KEEP-OUT (TRACES ALLOWED).



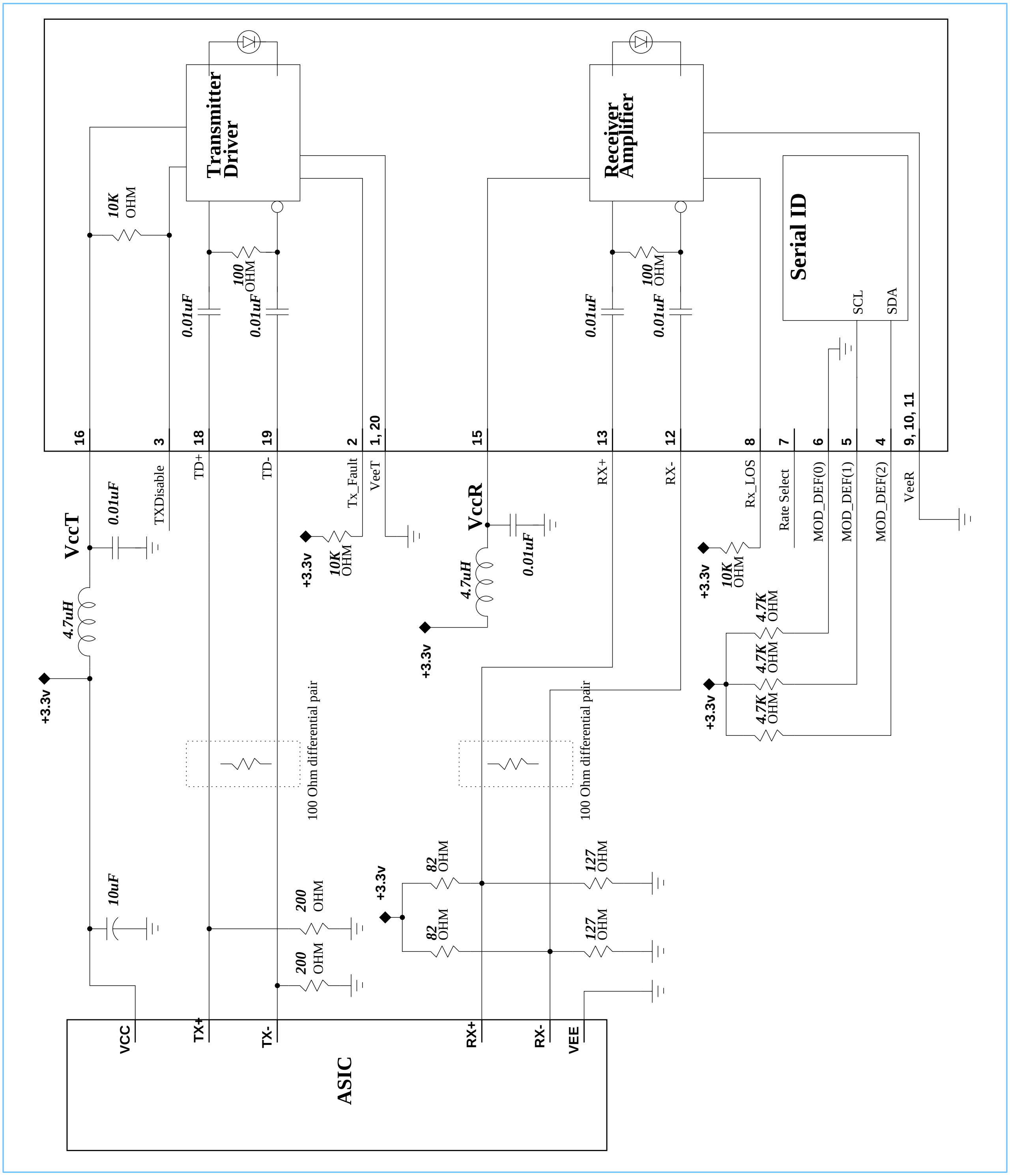
DETAIL X

Host Card Footprint (Page 2 of 2)





Suggested Transceiver/Host Interface



References

Standards

1. American National Standards Institute Inc. (ANSI), T11/Project 1235-DT/Rev 10, 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. American National Standards Institute Inc. (ANSI), T11.2/Project 1230/Rev10, Fibre Channel-Methodologies for Jitter Specifications (MJS). 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@network.com

   containing the line:

   subscribe T11 <your email address>

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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08/15/00	Initial Release

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The IBM home page can be found at
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1/2Gbps SFF PGG.01
08/15/00