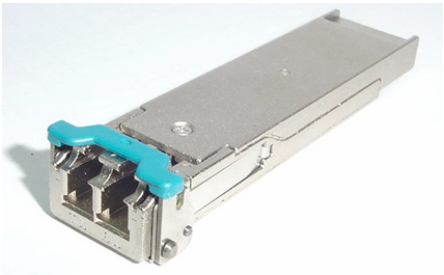
HFCT - 721 XPD

10GbE/10GFC 1310 nm XFP 10 Gbit/s Optical Transceiver

Data Sheet



Description

The 1310 nm XFP transceiver is a high performance, cost effective module for serial optical data communications applications specified for signal rates of 10.30 Gb/s to 10.52 Gb/s. It is compliant to XFP MSA Rev 4.5. The module is designed for single mode fiber and operates at a nominal wavelength of 1310 nm. The transmitter section incorporates Avago Technologies' uncooled directly modulated 1310 nm distributed feedback laser (DFB). The receiver section uses Avago Technologies' MOVPE grown planar SEDET PIN photodetector for low dark current and excellent responsivity. Integrated Tx and Rx signal conditioners provide high jitter-tolerance for full XFI compliance. The internally ac coupled high speed serial I/O simplifies interfacing to external circuitry. The electrical interface is made using an industry standard 0.8 mm pitch 30-pin right angle connector. Optical connection is made via the duplex LC connector.

Applications

- Fiber Channel Switches
- Host Bus Adapter Cards
- Mass Storage System and Server I/O
- Ethernet Switches
- Core Routers

Features

- Compliant to XFP MSA
- Compliant to IEEE 802.3ae 10GBASE-LR for 10GbE, 10.3125 Gb/s
- Compliant to 10GFC 1310 nm Serial PMD, type 1200-SM-LL-L, 10.51875 Gb/s
- Compatible with 11.3G operation for FEC functionality
- Avago Technologies' uncooled 1310 nm DFB Laser and PIN Photodiode
- Compliant XFI 10G Serial electrical interface
- LC Duplex optical connector interface conforming to ANSI TIA/EIA604-10 (FOCIS 10)
- 1.5W typical power dissipation
- Superior Thermal and EMI integrity performance to support high port densities
- Customizable clip-on heatsink to support a variety of line card environments
- -5 to +70 °C case operating temperature range
- Capable of extended temperature (-10C to +85C case) operation **
- Hardware pins are available for the following control signals:
  - Transmitter disable
  - Module power down/RESET
  - Receiver loss of signal
  - Module not ready
  - Programmable interrupt
- 2-wire serial management interface provides real time monitors of:
  - Transmitted Optical Power
  - Received Optical Power
  - Laser Bias Current
  - Module Temperature
- Link Lengths up to 10 km with 9 µm fiber
- IEC 60825-1 Class 1/CDRH Class 1 laser eye safety.

** Note: Long term reliability at elevated temperatures is not guaranteed.

The product also offers digital diagnostics using the 2-wire serial interface defined in the XFP MSA. The product provides real time temperature (module and laser), supply voltage, laser bias current, laser average output power and received input power. The digital diagnostic interface also adds the ability to disable the transmitter (TX_DIS), power down the module, monitor for module faults and monitor for Receiver Loss of Signal (RX_LOS). Transmitter disable, interrupt, power down/reset, receiver loss of signal and module not ready are also hard wired pins on the 30-pin right angle connector.

Installation

The HFCT-721XPD can be installed in any XFP port regardless of host equipment operating status. The HFCT-721XPD is hot-pluggable, allowing the module to be installed while the host system is operating and on-line. The clip-on heatsink is designed to clip on to the XFP cage without a module present.

Upon insertion, the transceiver housing makes initial contact with the host board XFP cage, mitigating potential damage due to Electro-Static Discharge (ESD). Once fully inserted into the XFP cage, the top surface of the XFP module makes contact with the heatsink through a cutout in the top of the cage ensuring an effective thermal path for module heat.

Functional Description

Transmitter Section

The transmitter section includes a 1310 nm DFB (Distributed Feedback Laser) light source, a transmitter driver circuit and a signal conditioner circuit on the TX data inputs. (see Figure 1) Optical connection to the transmitter is provided via a LC connector. The optical output is controlled by a custom IC that detects the laser output via the monitor photodiode. This IC provides both dc and ac current drive to the laser to ensure correct modulation, eye diagram and extinction ratio over temperature, supply voltage and operating life.

TX_DIS

Asserting pin 5, TX_DIS, will disable the transmitter optical output. The transmitter output can also be disabled and monitored via the two-wire serial interface.

Eye Safety Circuit

Under normal operating conditions laser power will be maintained below Class 1 eye-safety limits. Should a catastrophic laser fault occur and optical power become uncontrolled, the micro-controller will detect the fault, shut down the laser, power down the module and assert the hard-wired MOD_NR flag. The TX_FAULT output in the 2-wire serial interface will also be asserted.

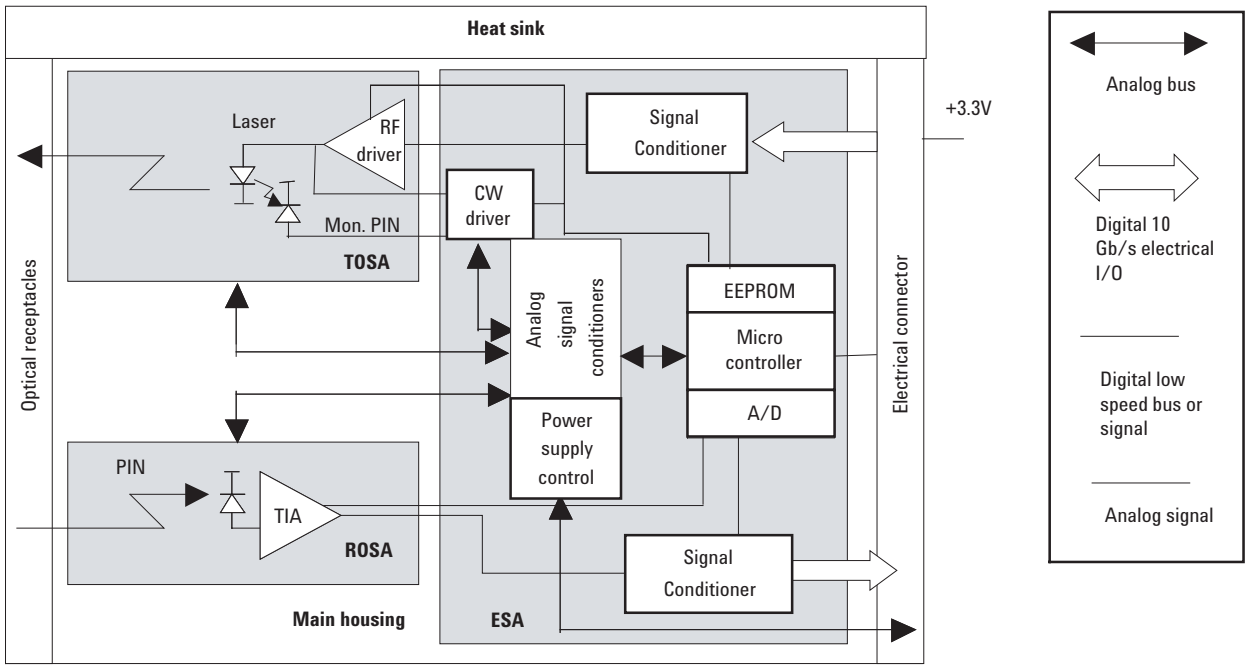


Figure 1. Transceiver Functional Diagram

Receiver Section

The receiver section includes a PIN detector with amplification quantization signal conditioner circuits. (see Figure 1) Optical connection to the receiver is provided via a LC optical connector.

RX_LOS

The receiver section contains a loss of signal (RX_LOS) circuit to indicate when the optical input signal power is insufficient for reliable signal detection. A high signal indicates loss of modulated signal, indicating link failure such as a broken fiber or nonfunctional remote transmitter. RX_LOS can also be monitored via the two-wire serial interface (byte 110, bit 1).

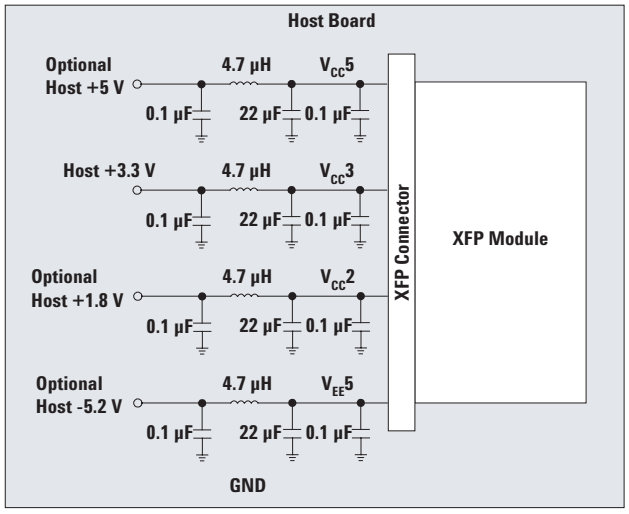


Figure 2. MSA recommended power supply filter

Functional Data I/O

Avago Technologies' HFCT-721XPD fiber-optic transceiver is designed to accept industry standard electrical input differential signals. The transceiver provides ac-coupled, internally terminated data input and output interfaces. Bias resistors and coupling capacitors have been included within the module to reduce the number of components required on the customer's board.

Electrical Pinout

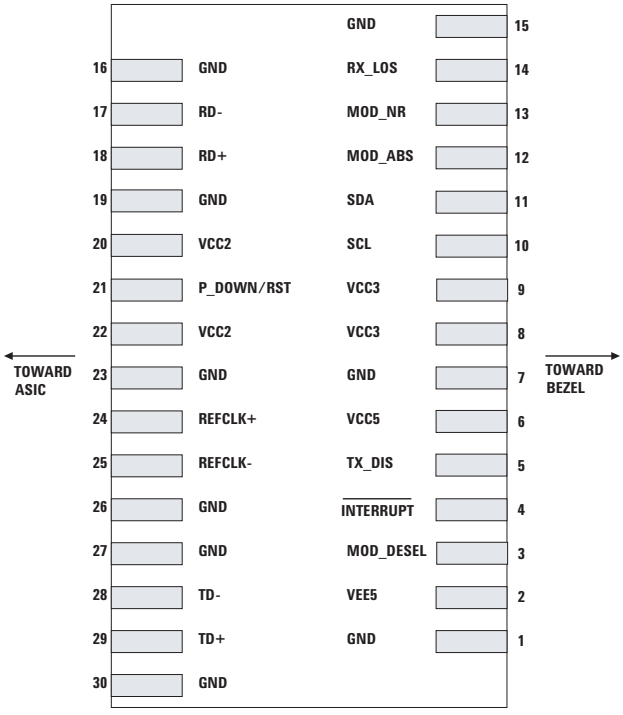


Figure 4. Host PCB XFP Pinout Top View

Table 1. Electrical Pin Definitions

Pin	Name	Logic	Function/Description	Notes
1	GND		Module Ground	1
2	$V_{EE}5$		-5.2 V power supply. Not internally connected.	
3	Mod-Desel	LVTTL-I	Module De-select; When held low allows the module to respond to 2-wire Serial interface commands	
4	Interrupt	LVTTL-O	Interrupt; Indicates presence of an important condition which can be readover the serial 2-wire interface	2
5	TX_DIS	LVTTL-I	Transmitter Disable; Transmitter Laser Source Turned Off	
6	$V_{CC}5$		5 V power supply. Not internally connected.	
7	GND		Module Ground	1
8	$V_{CC}3$		+3.3 V Power Supply	
9	$V_{CC}3$		+3.3 V Power Supply	
10	SCL	LVTTL-I	Two Wire Interface Clock	2
11	SDA	LVTTL-I/O	Two Wire Interface Data Line	2
12	Mod_Abs	LVTTL-O	LVTTL-O Mod_Abs Indicates Module is not present. Grounded in the Module	2
13	Mod_NR	LVTTL-O	Module Not Ready; Indicating Module Operational Fault	2
14	RX_LOS	LVTTL-O	Receiver Loss Of Signal Indicator	2
15	GND		Module Ground	1
16	GND		Module Ground	1
17	RD-	CML-O	Receiver Inverted Data Output	
18	RD+	CML-O	Receiver Non-Inverted Data Output	
19	GND		Module Ground	1
20	$V_{CC}2$		+1.8 V Power Supply. Not internally connected.	
21	P_Down/RST	LVTTL-I	Power down: When high, the module is put into a lower power mode. 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	$V_{CC}2$		+1.8 V Power Supply. Not internally connected.	1
23	GND		Module Ground	
24	RefCLK+	PECL-I	Reference Clock Non-Inverted Input, ac coupled on the host board	3
25	RefCLK-	PECL-I	Reference Clock Inverted Input, ac coupled on the host board	3
26	GND		Module Ground	1, 3
27	GND		Module Ground	1
28	TD-	CML-I	Transmitter Inverted Data Input	
29	TD+	CML-I	Transmitter Non-Inverted Data Input	
30	GND		Module Ground	1

Notes:
1. Module ground pins Gnd are isolated from the module case and chassis ground within the module.
2. Open Collector should be pulled up with 4.7 K-10 Kohms to a voltage between 3.15 V and 3.6 V on the host board.
3. RefCLK+/- are internally terminated (50Ω)

Absolute Maximum Ratings

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Notes
Storage Temperature (non-operating)	T_S	-40		+85	°C	1, 2
Ambient Operating Temperature	T_A	-40		+85	°C	1, 2
Relative Humidity	RH	10		90	%	1
Supply Voltage	$V_{CC}3$	0		3.6	V	1, 2
Low Speed Input Voltage	V_{IN}	-0.5		V_{CC}+0.5	V	1

Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Notes
Case Operating Temperature	T_C	-5		+70	°C	3
Supply Voltage	$V_{CC}3$	3.135		3.465	V	4, 5
Data Rate		9.953		10.52	Gb/s	4
Optical Input Power Max	Pinmax	6			dBm	1,2

Transceiver Electrical Characteristics

(T_C = -5 °C to +70 °C, $V_{CC}3$ = 3.3 V ± 5%)

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Notes
Power Supply Noise Rejection (peak-peak) under 1MHz	PSNR			2% of V_{CC}	mV	5
Power Supply Noise Rejection (peak-peak) 1MHz to 10 MHz	PSNR			3% of V_{CC}	mV	5
Module supply current	I_{CC}			680	mA	
Power Dissipation	P_{DISS}		1.5	2100	mW	
Low Speed Outputs: MOD_NR, RX_LOS, MOD_ABS, INTERRUPT	V_{OH} V_{OL}	Host_V_{CC}-0.5 0.0	 0.01	Host_V_{CC}+0.3 0.4	V V	6 7
Low Speed Inputs: TX_DIS, MOD_DESEL, P_DOWN/RST	V_{IH} V_{IL}	2.0 -0.3		$V_{CC}3$+0.3 0.8	V V	8 9

Notes:

1. Absolute Maximum Ratings are those values beyond which damage to the device may occur if these limits are exceeded for other than a short period of time. See Reliability Data Sheet for specific reliability performance.
2. Between Absolute Maximum Ratings and the Recommended Operating Conditions functional performance is not intended, device reliability is not implied, and damage to the device may occur over an extended period of time.
3. The Ambient Operating Temperature limitations are based on the Case Operating Temperature limitations and are subject to the host system thermal design.
4. Recommended Operating Conditions are those values for which functional performance and device reliability is implied
5. Vcc condition applies to supply voltage at the XFP module
6. Filter per XFP specification is required on the host board.
7. 4.7 k to 10 kW resistor pull-up to host_V_{CC}, measured at the host side of connector. I_{OH}(max) = - 2 mA.
8. 4.7 k to 10 kW resistor pull-up to host_V_{CC}, measured at the host side of connector. I_{OL}(max) = 2 mA.
9. 4.7 k to 10 kW resistor pull-up to host_V_{CC}, measured at the host side of connector. I_{OL}(max) = 10 µA.
10. 4.7 k to 10 kW resistor pull-up to host_V_{CC}, measured at the host side of connector. I_{IH}(max) = - 10 µA.

Transmitter Electrical Input Characteristics

(T_C = -5 °C to +70 °C, $V_{CC}3$ = 3.3 V ± 5%)

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Notes
Differential Input Impedance	Z_d		100		W	
Termination Mismatch	DZ_M			5	%	
Differential Input Amplitude	DVQDO	120		820	mV	peak to peak (1)
Differential Input Return Loss	SDD11	20			dB	0.05 to 0.1 GHz
Differential Input Return Loss	SDD11			8	dB	0.1 to 5.5 GHz
Differential Input Return Loss	SDD11			8 - 20.66 log10(f/5.5) f in GHz	dB	5.5 - 12 GHz
Common Mode Input Return Loss	SCC11	3			dB	0.1 to 15 GHz
Differential to Common Mode Conversion	SCD11			-10	dB	0.1 to 15 GHz
Jitter and Eye Mask						XFP MSA Compliant

Receiver Electrical Output Characteristics

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Notes
Differential Input Impedance	Z_d		100		W	
Termination Mismatch	DZ_M			5	%	
Differential Output Amplitude		340		850	mV	peak to peak (1)
DC Common Mode Potential	V_{cm}	0		3.6	V	
Output AC Common Mode Voltage				15	mV	RMS
Output Rise/Fall time (20% to 80%)	t_{RH}, t_{FH}	24			ps	
Common mode output return loss	SCC22	3				0.1 to 15 GHz
Differential output return loss	SDD22	20			dB	0.05 to 0.1 GHz
Differential output return loss	SDD22			8	dB	0.1 to 5.5 GHz
Differential output return loss	SDD22			8 - 20.66 log10(f/5.5) f in GHz	dB	5.5 - 12 GHz
Jitter and Eye Mask						XFP MSA Compliant

Note:

1. The differential input and output amplitudes are per XFP MSA mask at points B′ and C′.

Transmitter Optical Characteristics 10 GbE/10GFC
(T_C = -5 °C to +70 °C, $V_{CC}3$ = 3.3 V ± 5%)

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Notes
Optical Output Power	P_{out}	-5.2			dBm OMA	1, 2
Average Optical Output Power	P_{out}	-8.2		0.5	dBm	1, 2, 3
Extinction Ratio	ER	3.5			dB	1, 2
Spectral Width - rms	σ, rms			0.2	nm RMS	3
Center Wavelength	λC	1260	1310	1355	nm	
Transmitter and dispersion penalty	TDP			3.2	dB	1, 3
Side mode suppression ratio		30			dB	1
Optical output power (min) in OMA - TDP		-6.2			dBm OMA	1, 3
RIN_{12} (OMA)	RIN			-128	dB/Hz	1
Optical Eye Mask	Compliant with IEEE 802.3ae 10GBASE-L XFP MSA					

Receiver Optical Characteristics 10 GbE/10GFC
(T_C = -5 °C to +70 °C, $V_{CC}3$ = 3.3 V ± 5%)

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Notes
Average Receive power		-14.4		0.5	dBm mean	1
Stressed receiver sensitivity		-10.3			dBm OMA	1
Receiver sensitivity	P_{IN}	-12.6			dBm OMA	3
Max Receiver Reflectance		-12			dB	1
Wavelength	λC	1260	1310	1355	nm	

Notes:
1. 10GFC 1200-SM-LL-L / IEEE 802.3ae 10BASE-LR compliant
2. These parameters are interrelated: see IEEE 802.3ae
3. For information only

Transceiver Timing Characteristics
(T_C = -5 °C to +70 °C, $V_{CC}3$ = 3.3 V ± 5%)

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Notes
TX_DIS Assert Time	t_off			10	µs	Time from rising edge of TX_DIS to when the optical output falls below 10% of nominal.
TX_DIS Negate Time	t_on			2	ms	Time from falling edge of TX_DIS to when the modulated optical output rises above 90% of nominal.
Time to initialize	t_init			300	ms	From power on or hot plug after meeting power supply specs
Interrupt assert delay	Interrupt_on			200	ms	From occurrence of the condition triggering interrupt
Interrupt negate delay	Interrupt_off			500	us	From clear on read interrupt flags
P_Down/ RST assert delay	P_Down/ RST_on			100	us	From Power down initiation
P-Down negate delay	P_Down/ RST_off			300	ms	Max delay from negate to completion of power up and reset
Mod_NR assert delay	Mod_nr_on			1	ms	From Occurrence of fault to assertion of TX_NR
Mod_NR negate delay	Mod_nr_off			1	ms	From Occurrence of signal to negation of TX_NR
Mod_DeSel assert time	T_Mod_DeSel			2	ms	Maximum delay between assertion ofMod_DeSel and end of module response to 2-wire interface communications
Mod_DeSel de-assert time	T_Mod_Sel			2	ms	Maximum delay between de-assertion of Mod_DeSel and proper module response to 2-wire interface communications
P_Down reset time	t_reset	10			µs	Min length of P-Down assert to initial reset
RX_LOS Assert delay	T_loss_on			100	µs	From Occurrence of loss of signal to assertion of RX_LOS
RX_LOS negate delay	T_loss_off	2.3		100	µs	From Occurrence of presence of signal to negation of RX_LOS
Serial ID Clock Rate	f_serial_clock	0		400	kHz	

Digital Diagnostic Interface and Serial Identification

The 2-wire serial interface is explicitly defined in the XFP MSA Rev 4.0. 2-wire timing specifications and the structure of the memory map are per XFP MSA Rev 2.0. The normal 256 Byte I2C address space is divided into lower and upper blocks of 128 Bytes. The lower block of 128 Bytes is always directly available and is used for diagnostic information providing the opportunity for Predictive Failure Identification, Compliance Prediction, Fault Isolation and Component Monitoring. The upper address space tables are used for less frequently accessed functions such as serial ID, user writeable EEPROM, reserved EEPROM and diagnostics and control spaces for future standards definition, as well as Avago Technologies-specific functions.

Predictive Failure Identification

The diagnostic information allows the host system to identify potential link problems. Once identified, a "fail over" technique can be used to isolate and replace suspect devices before system uptime is impacted.

Compliance Prediction

The real-time diagnostic parameters can be monitored to alert the system when operating limits are exceeded and compliance cannot be ensured. As an example, the real time average receive optical power can be used to assess the compliance of the cable plant and remote transmitter.

Fault Isolation

The diagnostic information can allow the host to pinpoint the location of a link problem and accelerate system servicing and minimize downtime.

Component Monitoring

As part of host system qualification and verification, real time transceiver diagnostic information can be combined with system level monitoring to ensure performance and operating environment are meeting application requirements.

Transceiver Internal Temperature

Temperature is measured on the HFCT-721XPD using sensing circuitry mounted on the internal PCB. The measured temperature will generally be cooler than laser junction and warmer than XFP case and can be indirectly correlated to XFP case or laser junction temperature using thermal resistance and capacitance modeling. This measurement can be used to observe drifts in thermal operating point or to detect extreme temperature fluctuations such as a failure in the system thermal control. For more information on correlating internal temperature to case or laser junction contact Avago Technologies.

Transmitter Laser dc Bias Current

Laser bias current is measured using sensing circuitry located on the transmitter laser driver IC. Normal variations in laser bias current are expected to accommodate the impact of changing transceiver temperature and supply voltage operating points. The HFCT-721XPD uses a closed loop laser bias feedback circuit to maintain constant optical power. This circuit compensates for normal laser parametric variations in quantum efficiency, forward voltage and lasing threshold due to changing transceiver operating points.

Transmitted Average Optical Output Power

Variations in average optical power are not expected under normal operation because the HFCT-721XPD uses a closed loop laser bias feedback circuit to maintain constant optical power. This circuit compensates for normal laser parametric variations due to changing transceiver operating points. Only under extreme laser bias conditions will significant drifting in transmitted average optical power be observable. Therefore it is recommended Tx average optical power be used for fault isolation, rather than predictive failure purposes.

Received Average Optical Input Power

Received average optical power measurements are a valuable asset for installers to verify cable plant compliance. Drifts in average power can be observed from the cable plant and remote transmitter for potential predictive failure use. Received average optical power can be used for fault isolation.

Mechanical Specifications

Package Dimensions

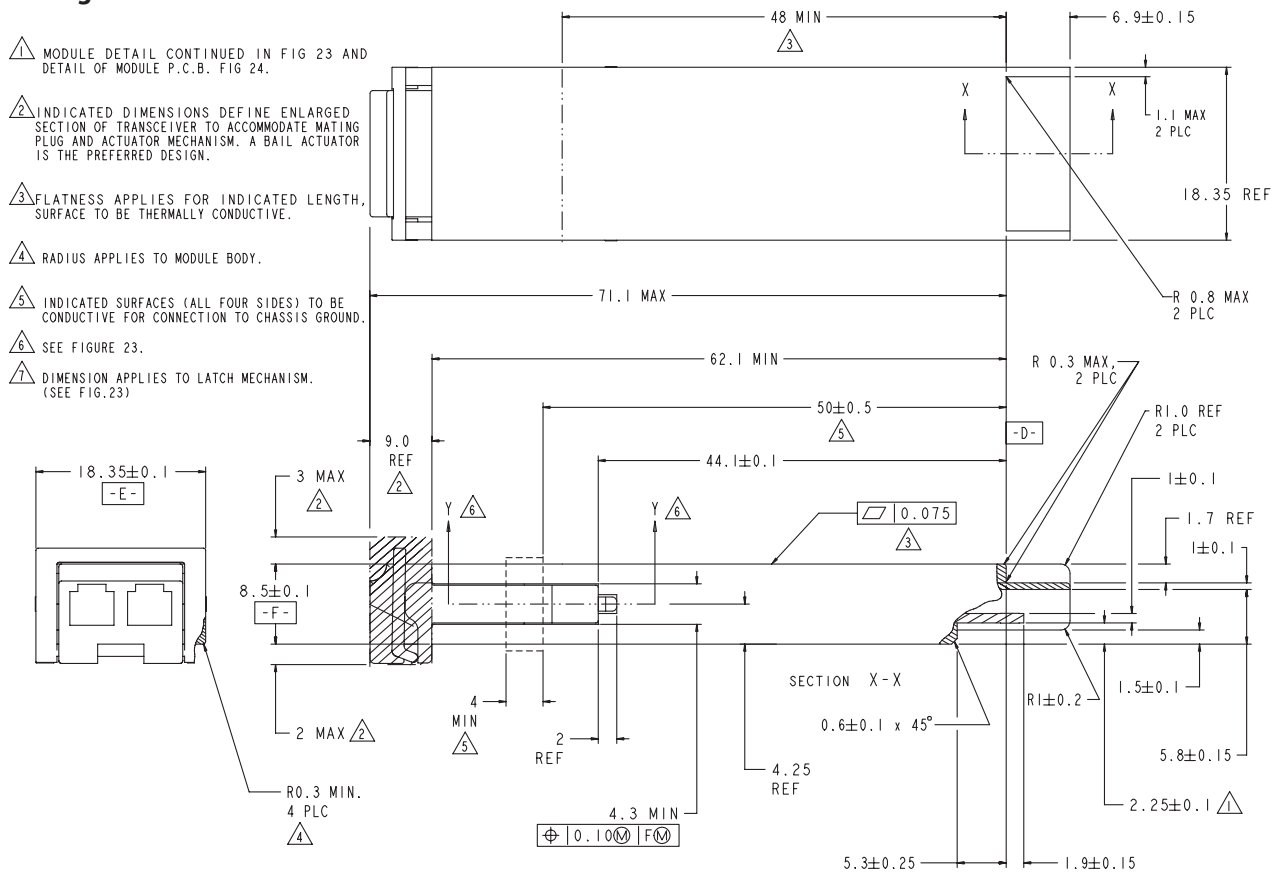


Figure 5a. Module Drawing

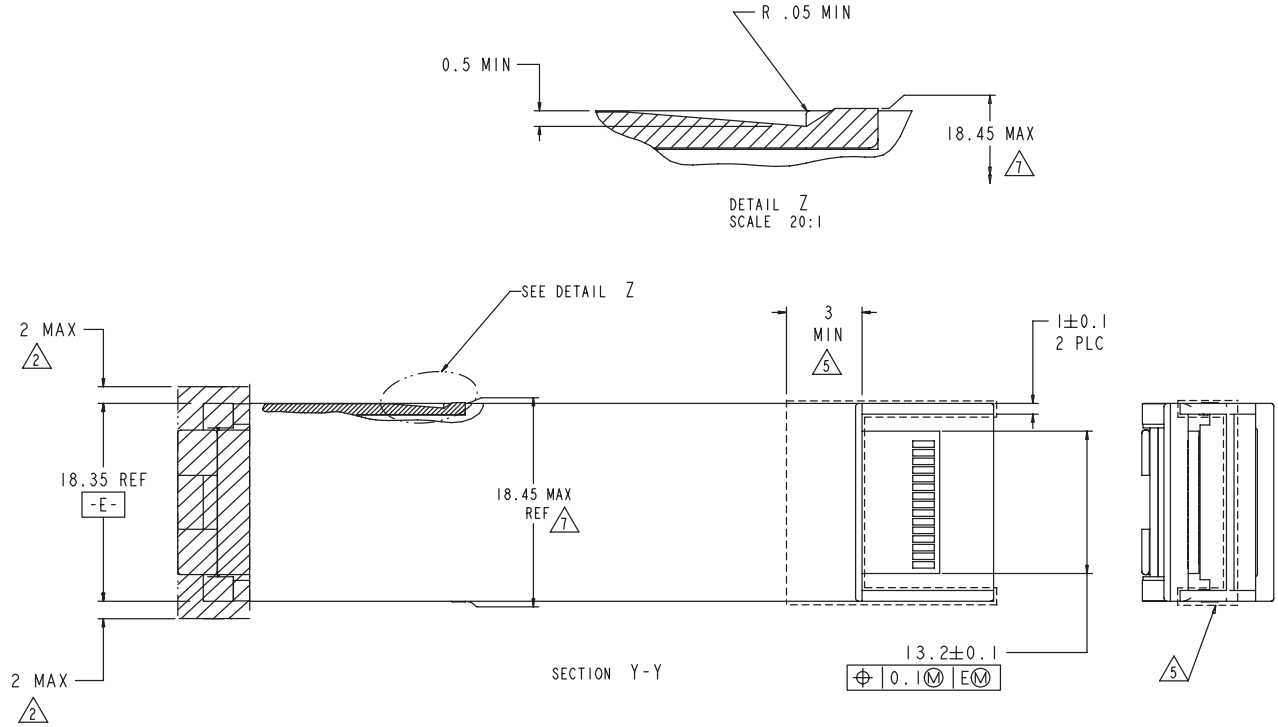


Figure 5b. Module Drawing

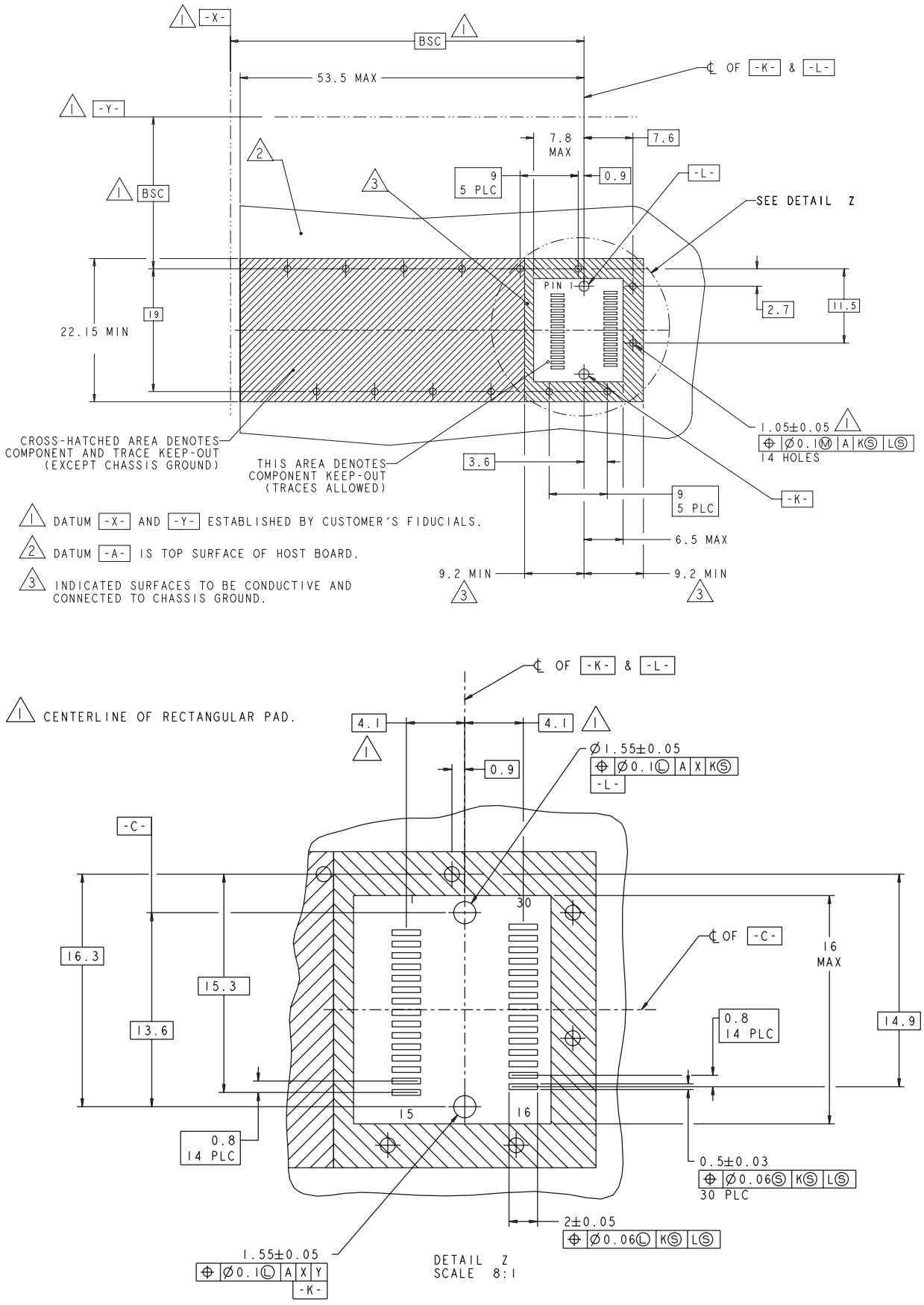


Figure 6. XFP host board mechanical layout

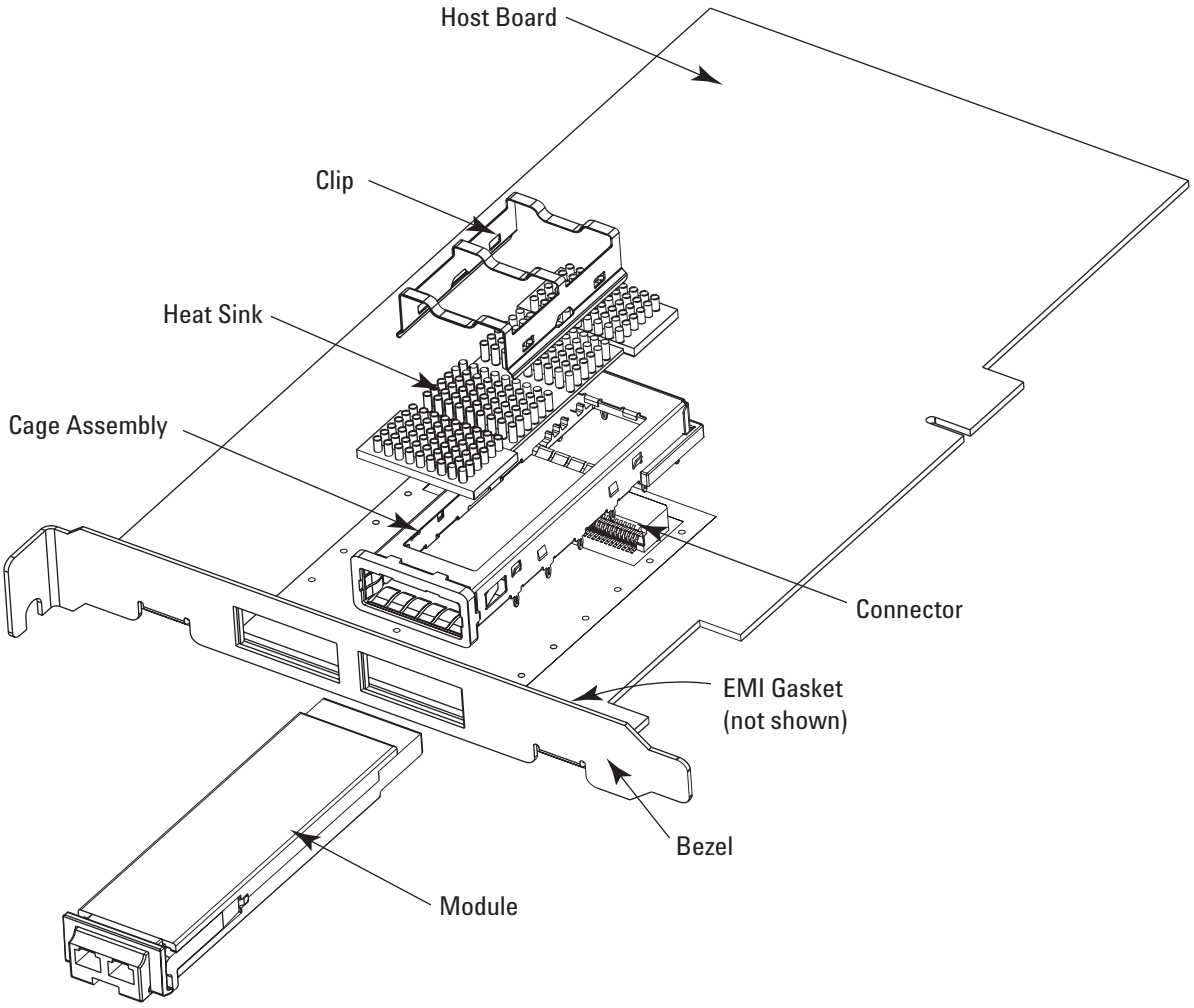


Figure 7. XFP Assembly Drawing

Application Support

An Evaluation Kit and Reference Designs are available to assist in evaluation of the HFCT-721XPD. Please contact your local Field Sales representative for availability and ordering details.

Regulatory Compliance

The transceiver Regulatory Compliance performance is provided in Table 2 as a figure of merit to assist the designer. The overall equipment design will determine the certification level.

Electrostatic Discharge (ESD)

There are two conditions in which immunity to ESD damage is important. Table 13 documents the ESD immunity to both of these conditions.

The first condition is static discharge to the transceiver during handling such as when the transceiver is inserted into the transceiver port. To protect the transceiver, it is important to use normal ESD handling precautions including the use of grounded wrist straps, work benches, and floor mats in ESD controlled areas. The ESD sensitivity of the HFCT-721XPD is compatible with typical industry production environments.

The second condition is static discharge to the exterior of the host equipment chassis after installation. To the extent that the duplex LC optical interface is exposed to the outside of the host equipment chassis, it may be subject to system-level ESD requirements.

The ESD performance of the HFCT-721XPD exceeds typical industry standards.

Regulatory Compliance

Feature	Test Method	Performance
Electrostatic Discharge (ESD) to the exterior of the XFP module	JEDEC JESD22-A114-B	500 Volts to the high speed pins, 2000 Volts to the low speed pins
Electrostatic Discharge (ESD) to the Duplex LC Receptacle	Variation of IEC 61000-4-2	Typically, no damage occurs with 25 kV when the duplex LC connector receptacle is contacted by a Human Body Model probe.
Electrostatic Discharge (ESD) to the Optical Connector	GR1089	10 contacts of 8 KV on the electrical faceplate with device inserted into a panel.
Electrostatic Discharge (ESD) to the Optical Connector	Variation of IEC 801-2	Air discharge of 15 kV(min) contact to connector w/o damage
Electromagnetic Interference (EMI)	FCC Class B CENELEC EN55022 Class B (CISPR 22A) VCCI Class 1	System margins are dependent on customer board and chassis design.
Immunity	Variation of IEC 61000-4-3	Less than 0.5 dB of Rx sensitivity degradation and less than 10% margin reduction of Tx mask at 10 V/m, 10 MHZ to 1 GHz w/o chassis enclosure
Laser Eye Safety and Equipment Type Testing	US FDA CDRH AEL Class 1 US21 CFR, Subchapter J per Paragraphs 1002.10 and 1002.12. (IEC) EN60825-1: 1994 + A11+A2 (IEC) EN60825-2: 1994 + A1 (IEC) EN60950: 1992 + A1 + A2 + A3 + A4 + A11	CDRH certification # TBD TUV file # 933/510312/02
Component Recognition	Underwriters Laboratories and Canadian Standards Association Joint Component Recognition for Information Technology Equipment Including Electrical Business Equipment	UL certificate number 05012004-E173874

Immunity

The transceivers have a shielded design to provide excellent immunity to radio-frequency electromagnetic fields which may be present in some operating environments.

Electromagnetic Interference (EMI)

Most equipment designs using the HFCT-721XPD are subject to the requirements of the FCC in the United States, CENELEC EN55022 (CISPR 22) in Europe and VCCI in Japan. The metal housing and shielded design of the HFCT-721XPD minimizes EMI and provides excellent EMI performance.

Eye Safety

The HFCT-721XPD transceivers provide Class 1 eye safety by design. Avago Technologies has tested the transceiver design for regulatory compliance, under normal operating conditions and under single fault conditions. See Table 2.

Flammability

The HFCT-721XPD is compliant to UL 94V-0.

Caution

The HFCT-721XPD contains no user serviceable parts. Tampering with or modifying the performance of the HFCT-721XPD will result in voided product warranty. It may also result in improper operation of the HFCT-721XPD circuitry, and possible overstress of the laser source. Device degradation or product failure may result. Connection of the HFCT-721XPD to a non-approved optical source, operating above the recommended absolute maximum conditions may be considered an act of modifying or manufacturing a laser product. The person(s) performing such an act is required by law to recertify and reidentify the laser product under the provisions of U.S. 21 CFR (Subchapter J) and the TUV.

Ordering Information

Please contact your local field sales engineer or one of Avago Technologies franchised distributors for ordering information. For technical information, please visit Avago Technologies' WEB page at www.avagotech.com or contact Avago Technologies Semiconductor Products Customer Response Center at 1-800-235-0312. For information related to XFP MSA documentation visit www.xfpmsa.org

For product information and a complete list of distributors, please go to our web site: **www.avagotech.com**

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