FDDI, 100 Mbps ATM, and Fast Ethernet Transceivers in Low Cost 1x9 Package Style

Technical Data

HFBR-5103/-5103T
 1300 nm 2000 m
HFBR-5104/-5104T
 800 nm 500 m
HFBR-5105/-5105T
 1300nm 500 m

Features

- **Full Compliance with the Optical Performance Requirements of the FDDI PMD Standard**
- **Full Compliance with the FDDI LCF-PMD Standard**
- **Full Compliance with the Optical Performance Requirements of the ATM 100 Mbps Physical Layer**
- **Full Compliance with the Optical Performance Requirements of 100 Base-FX Version of IEEE 802.3u**
- **Very Low Cost 800 nm Alternative with FDDI and ATM Compliant Signaling**
- **Multisourced 1x9 Package Style with Choice of Duplex SC or Duplex ST* Receptacle**
- **Wave Solder and Aqueous Wash Process Compatible**
- **Manufactured in an ISO 9002 Certified Facility**

Applications

- **Multimode Fiber Backbone Links**
- **Multimode Fiber Wiring Closet to Desktop Links**
- **Very Low Cost Multimode Fiber 800 nm Links from Wiring Closet to Desktop**

*ST is a registered trademark of AT&T Lightguide Cable Connectors.

Description

The HFBR-5100 family of transceivers from Agilent Technologies provide the system designer with products to implement a range of FDDI and ATM (Asynchronous Transfer Mode) designs at the 100 Mbps/125 MBd rate.

The transceivers are all supplied in the new industry standard 1x9 SIP package style with either a duplex SC or a duplex ST* connector interface.

FDDI PMD, ATM and Fast Ethernet 2000 m Backbone Links

The HFBR-5103/-5103T are 1300 nm products with optical performance compliant with the FDDI PMD standard. The FDDI PMD standard is ISO/IEC 9314-3: 1990 and ANSI X3.166 - 1990.

These transceivers for 2000 meter multimode fiber backbones are supplied in the small 1x9 duplex SC or ST package style for those designers who want to avoid the larger MIC/R (Media Interface Connector/Receptacle) defined in the FDDI PMD standard.

Agilent Technologies also provides several other FDDI products compliant with the PMD
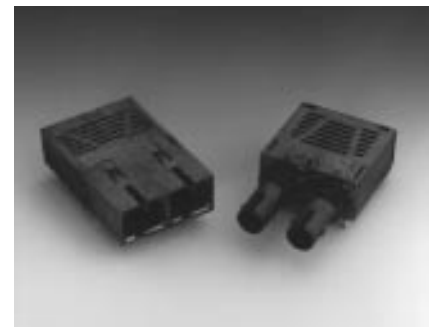
and SM-PMD standards. These products are available with MIC/R, ST© and FC connector styles. They are available in the 1x13 and 2x11 transceiver and 16 pin transmitter/receiver package styles for those designs that require these alternate configurations.

The HFBR-5103/-5103T is also useful for both ATM 100 Mbps interfaces and Fast Ethernet 100 Base-FX interfaces. The ATM Forum User-Network Interface (UNI) Standard, Version 3.0, defines the Physical Layer for 100 Mbps Multimode Fiber Interface for ATM in Section 2.3 to be the FDDI PMD Standard. Likewise, the Fast Ethernet Alliance defines the Physical Layer for 100 Base-FX for Fast Ethernet to be the FDDI PMD Standard.

Note: The "T" in the product numbers indicates a transceiver with a duplex ST connector receptacle.

Product numbers without a "T" indicate transceivers with a duplex SC connector receptacle.

ATM applications for physical layers other than 100 Mbps Multimode Fiber Interface are supported by Agilent. Products are available for both the single mode and the multimode fiber SONET OC-3c (STS-3c) ATM interfaces and the 155 Mbps/194 MBd multimode fiber ATM interface as specified in the ATM Forum UNI.

Contact your Agilent sales representative for information on these alternative FDDI and ATM products.

Low Cost 500 m Desktop Links

The HFBR-5105/-5105T are 1300 nm products which are fully compliant with the requirements of the FDDI LCF-PMD standard. The FDDI LCF-PMD standard is in the final approval stage as ISO/IEC WD 9314-9 and ANSI LCF-PMD Revision 1.3.

These multimode fiber transceivers can be used for 500 meter backbone and desktop links for FDDI, Fast Ethernet, or ATM 100 Mbps traffic.

The HFBR-5105 transceiver utilizes the duplex SC connector receptacle specified in the FDDI LCF-PMD standard.

Alternative 800 nm Low Cost 500 m Desktop Links

The HFBR-5104/-5104T are very low cost 800 nm alternative to the HFBR-5105/-5105T for FDDI, ATM or Fast Ethernet links from the wiring closet to the desktop. They comply with the performance requirements of the draft FDDI LCF-PMD document as translated by Agilent to the 800 nm wavelength. This transceiver will transfer the full range of FDDI signals at the required

1×10^{-12} Bit Error Rate over distances up to 500 meters using 62.5/125 µm multimode fiber cables.

This product is intended for use in cost sensitive applications where the benefits of fiber optic links are important.

Transmitter Sections

The transmitter sections of the HFBR-5103 and HFBR-5105 series utilize 1300 nm Surface Emitting InGaAsP LEDs and the HFBR-5104 series uses a low cost 820 nm AlGaAs LED. These LEDs are packaged in the optical subassembly portion of the transmitter section. They are driven by a custom silicon IC which converts differential PECL logic signals, ECL referenced (shifted) to a +5 Volt supply, into an analog LED drive current.

Receiver Sections

The receiver sections of the HFBR-5103 and HFBR-5105 series utilize InGaAs PIN photodiodes coupled to a custom silicon transimpedance preamplifier IC. The HFBR-5104 series

uses the same preamplifier IC in conjunction with an inexpensive silicon PIN photodiode. These are packaged in the optical subassembly portion of the receiver.

These PIN/preamplifier combinations are coupled to a custom quantizer IC which provides the final pulse shaping for the logic output and the Signal Detect function. The data output is differential. The signal detect output is single-ended. Both data and signal detect outputs are PECL compatible, ECL referenced (shifted) to a +5 Volt power supply.

Package

The overall package concept for the HP transceivers consists of the following basic elements; two optical subassemblies, an electrical subassembly and the housing as illustrated in Figure 1 and Figure 1a.

The package outline drawing and pin out are shown in Figures 2, 2a and 3. The details of this package outline and pin out are compliant with the multisource
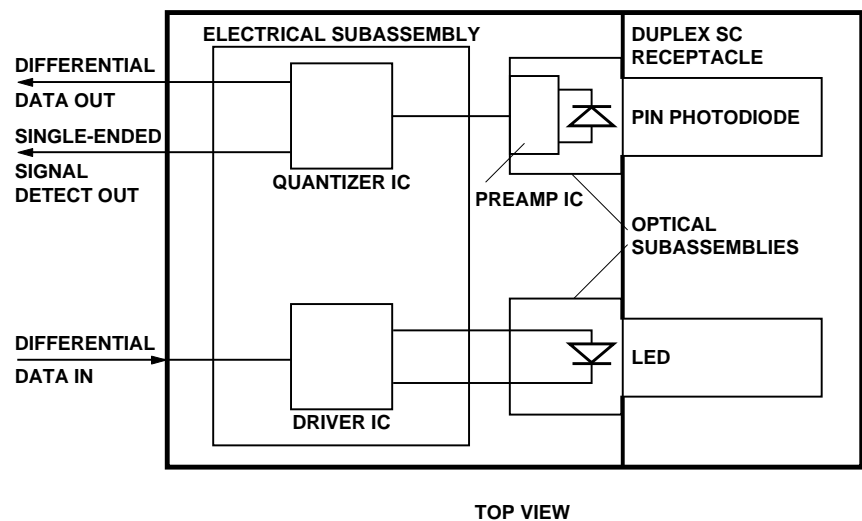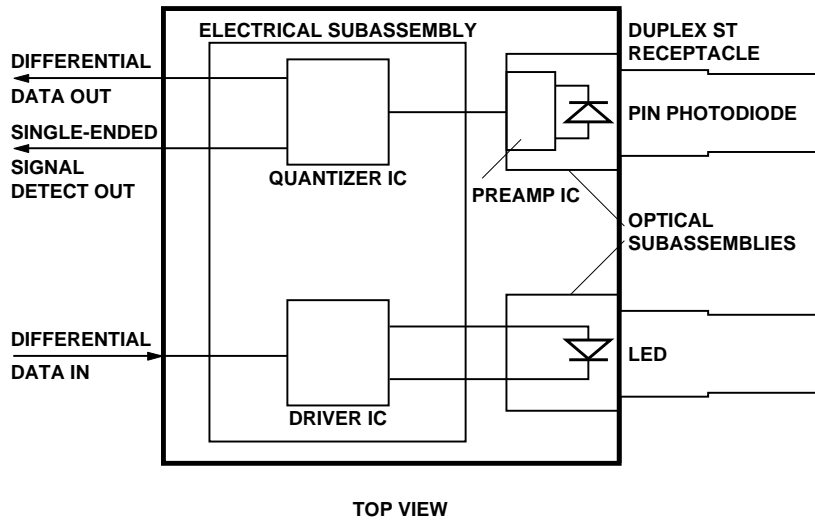

Figure 1. Block Diagram.
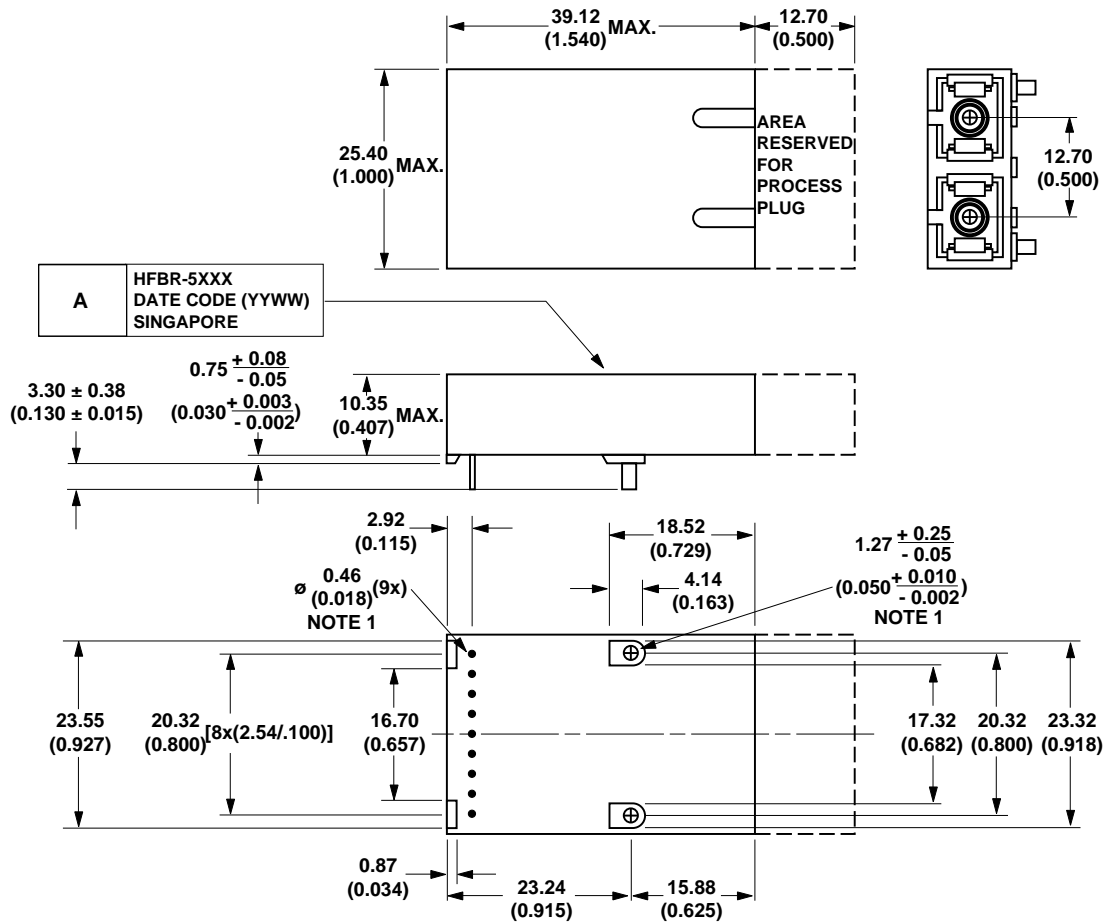
Figure 1a. ST Block Diagram.

NOTE 1: THE SOLDER POSTS AND ELECTRICAL PINS ARE PHOSPHOR BRONZE WITH TIN LEAD OVER NICKEL PLATING.

DIMENSIONS ARE IN MILLIMETERS (INCHES).

Figure 2. Package Outline Drawing.

NOTE 1: PHOSPHOR BRONZE IS THE BASE MATERIAL FOR THE POSTS & PINS WITH TIN LEAD OVER NICKEL PLATING.

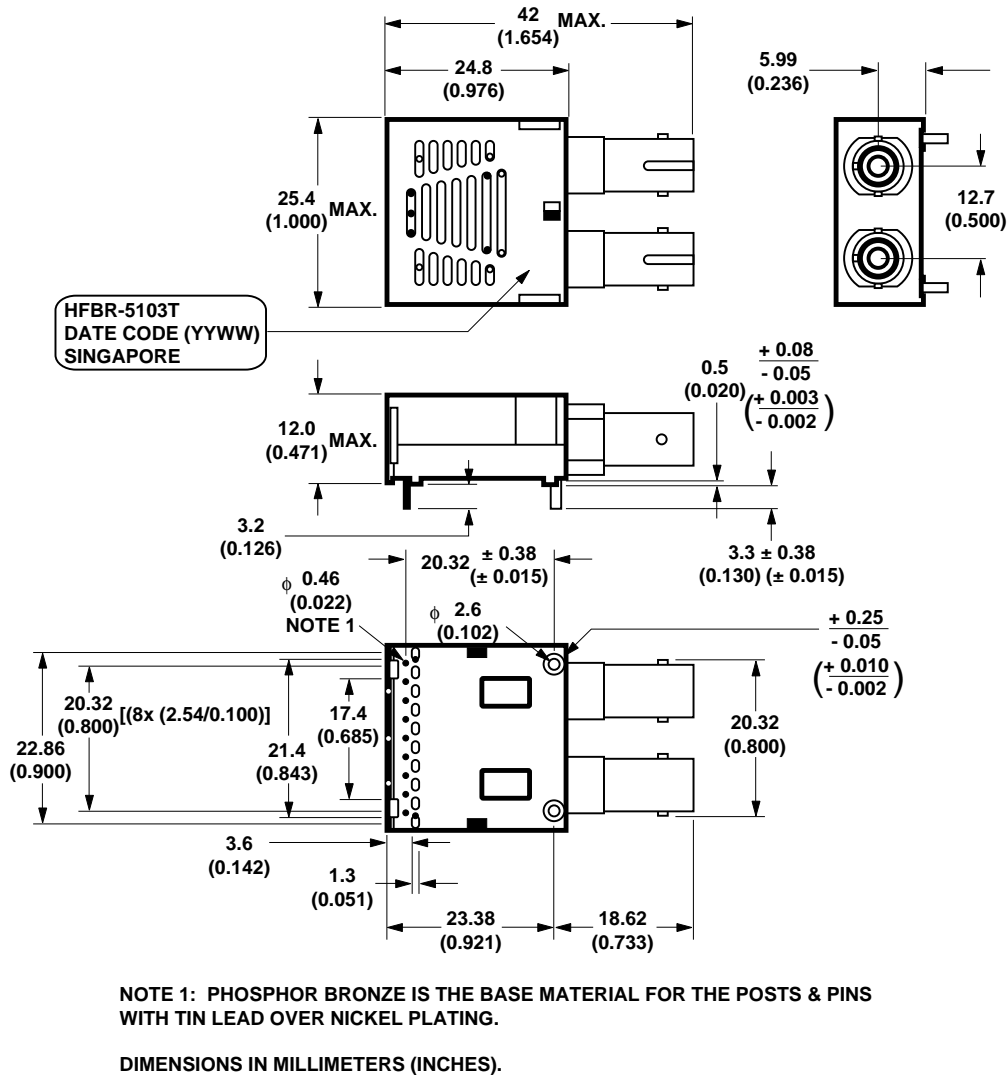DIMENSIONS IN MILLIMETERS (INCHES).

Figure 2a. ST Package Outline Drawing.
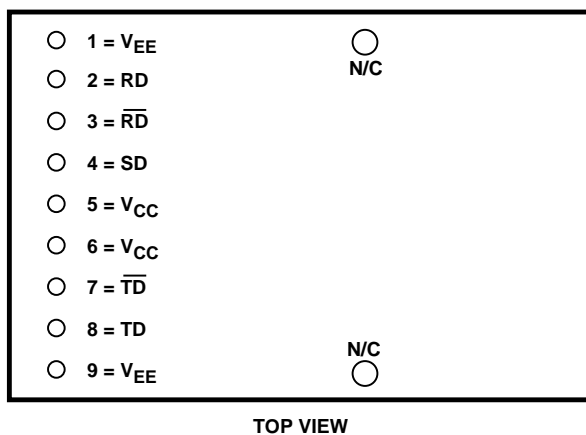
Figure 3. Pin Out Diagram.

definition of the 1x9 SIP. The low profile of the Agilent transceiver design complies with the maximum height allowed for the duplex SC connector over the entire length of the package.

The optical subassemblies utilize a high volume assembly process together with low cost lens elements which result in a cost effective building block.

The electrical subassembly consists of a high volume multilayer printed circuit board on which the IC chips and various surface-

mounted passive circuit elements are attached.

The package includes internal shields for the electrical and optical subassemblies to ensure low EMI emissions and high immunity to external EMI fields.

The outer housing including the duplex SC connector receptacle or the duplex ST ports is molded of filled non-conductive plastic to provide mechanical strength and electrical isolation. The solder posts of the Agilent design are isolated from the circuit design of the transceiver and do not require connection to a ground plane on the circuit board.

The transceiver is attached to a printed circuit board with the nine signal pins and the two solder posts which exit the bottom of the housing. The two solder posts provide the primary mechanical strength to withstand the loads imposed on the transceiver by mating with duplex or simplex SC or ST connectored fiber cables.

Application Information

The Applications Engineering group in the Agilent Optical Communication Division is available to assist you with the technical understanding and design trade-offs associated with these transceivers. You can contact them through your Agilent sales representative.

The following information is provided to answer some of the most common questions about the use of these parts.

Transceiver Optical Power Budget versus Link Length

Optical Power Budget (OPB) is the available optical power for a

fiber optic link to accommodate fiber cable losses plus losses due to in-line connectors, splices, optical switches, and to provide margin for link aging and unplanned losses due to cable plant reconfiguration or repair.

Figure 4 illustrates the predicted OPB associated with the three transceiver series specified in this data sheet at the Beginning of Life (BOL). These curves represent the attenuation and chromatic plus modal dispersion losses associated with the 62.5/125 µm and 50/125 µm fiber cables only. The area under the curves represents the remaining OPB at any link length, which is available for overcoming non-fiber cable related losses.

Agilent LED technology has produced 800 nm LED and 1300 nm LED devices with lower aging characteristics than normally associated with these technologies in the industry. The industry convention is 3 dB aging for 800 nm and 1.5 dB aging for 1300 nm LEDs. The HP 1300 nm

LEDs will experience less than 1 dB of aging over normal commercial equipment mission life periods. Contact your Hewlett-Packard sales representative for additional details.

Figure 4 was generated with an Agilent fiber optic link model containing the current industry conventions for fiber cable specifications and the FDDI PMD and LCF-PMD optical parameters. These parameters are reflected in the guaranteed performance of the transceiver specifications in this data sheet. This same model has been used extensively in the ANSI and IEEE committees, including the ANSI X3T9.5 committee, to establish the optical performance requirements for various fiber optic interface standards. The cable parameters used come from the ISO/IEC JTC1/SC 25/WG3 Generic Cabling for Customer Premises per DIS 11801 document and the EIA/TIA-568-A Commercial Building Telecommunications Cabling Standard per SP-2840.
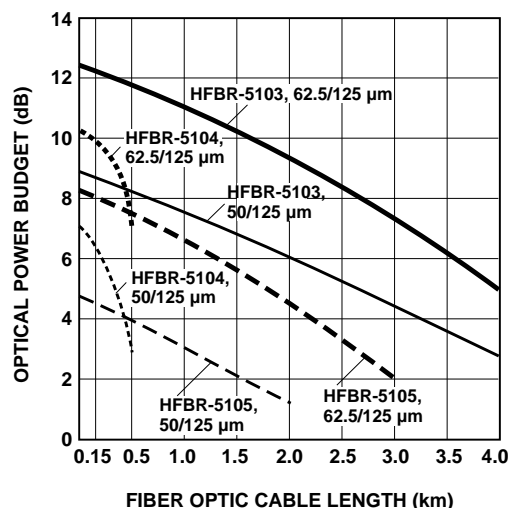

Figure 4. Optical Power Budget at BOL versus Fiber Optic Cable Length.

The HFBR-5104 series 800 nm transceiver curve in Figure 4 was generated based on extensive empirical test data of typical 800 nm transmitter and receiver performance. The curve includes the effect of typical fiber attenuation, plus receiver sensitivity loss due to chromatic and metal dispersion losses through the fiber.

Transceiver Signaling Operating Rate Range and BER Performance

For purposes of definition, the symbol (Baud) rate, also called signaling rate, is the reciprocal of the shortest symbol time. Data rate (bits/sec) is the symbol rate divided by the encoding factor used to encode the data (symbols/bit).

When used in FDDI and ATM 100 Mbps applications the performance of the 1300 nm transceivers is guaranteed over the signaling rate of 10 MBd to 125 MBd to the full conditions listed in individual product specification tables.

The transceivers may be used for other applications at signaling rates outside of the 10 MBd to 125 MBd range with some penalty in the link optical power budget primarily caused by a reduction of receiver sensitivity. Figure 5 gives an indication of the typical performance of these 1300 nm products at different rates.

These transceivers can also be used for applications which require different Bit Error Rate (BER) performance. Figure 6 illustrates the typical trade-off between link BER and the receivers input optical power level.

Transceiver Jitter Performance

The Agilent 1300 nm transceivers are designed to operate per the system jitter allocations stated in Tables E1 of Annexes E of the FDDI PMD and LCF-PMD standards.

The HP 1300 nm transmitters will tolerate the worst case input electrical jitter allowed in these tables without violating the worst case output jitter requirements of Sections 8.1 Active Output Interface of the FDDI PMD and LCF-PMD standards.

The HP 1300 nm receivers will tolerate the worst case input optical jitter allowed in Sections 8.2 Active Input Interface of the FDDI PMD and LCF-PMD standards without violating the worst case output electrical jitter allowed in the Tables E1 of the Annexes E.
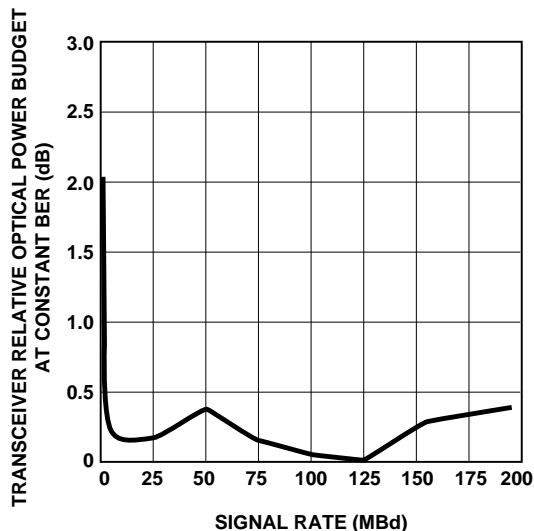
CONDITIONS:
1. PRBS 2^7-1
2. DATA SAMPLED AT CENTER OF DATA SYMBOL.
3. BER = 10^{-6}
4. T_A = 25° C
5. V_{CC} = 5 V_{dc}
6. INPUT OPTICAL RISE/FALL TIMES = 1.0/2.1 ns.

Figure 5. Transceiver Relative Optical Power Budget at Constant BER vs. Signaling Rate.
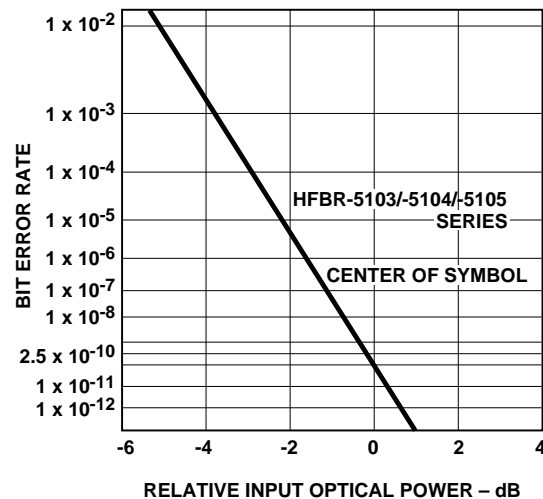
CONDITIONS:
1. 125 MBd
2. PRBS 2^7-1
3. CENTER OF SYMBOL SAMPLING.
4. T_A = 25° C
5. V_{CC} = 5 V_{dc}
6. INPUT OPTICAL RISE/FALL TIMES = 1.0/2.1 ns.

Figure 6. Bit Error Rate vs. Relative Receiver Input Optical Power.

The jitter specifications stated in the following 1300 nm transceiver specification tables are derived from the values in Tables E1 of Annexes E. They represent the worst case jitter contribution that the transceivers are allowed to make to the overall system jitter without violating the Annex E allocation example. In practice the typical contribution of the Agilent transceivers is well below these maximum allowed amounts.

Recommended Handling Precautions

Agilent recommends that normal static precautions be taken in the handling and assembly of these transceivers to prevent damage which may be induced by electrostatic discharge (ESD). The HFBR-5100 series of transceivers meet MIL-STD-883C Method 3015.4 Class 2 products.

Care should be used to avoid shorting the receiver data or signal detect outputs directly to ground without proper current limiting impedance.

Solder and Wash Process Compatibility

The transceivers are delivered with protective process plugs inserted into the duplex SC or duplex ST connector receptacle. This process plug protects the optical subassemblies during wave solder and aqueous wash processing and acts as a dust cover during shipping.

These transceivers are compatible with either industry standard wave or hand solder processes.

Shipping Container

The transceiver is packaged in a shipping container designed to protect it from mechanical and ESD damage during shipment or storage.

Board Layout - Decoupling Circuit and Ground Planes

It is important to take care in the layout of your circuit board to achieve optimum performance from these transceivers. Figure 7 provides a good example of a schematic for a power supply decoupling circuit that works well with these parts. It is further recommended that a contiguous ground plane be provided in the circuit board directly under the transceiver to provide a low inductance ground for signal return current. This recommendation is in keeping with good high frequency board layout practices.
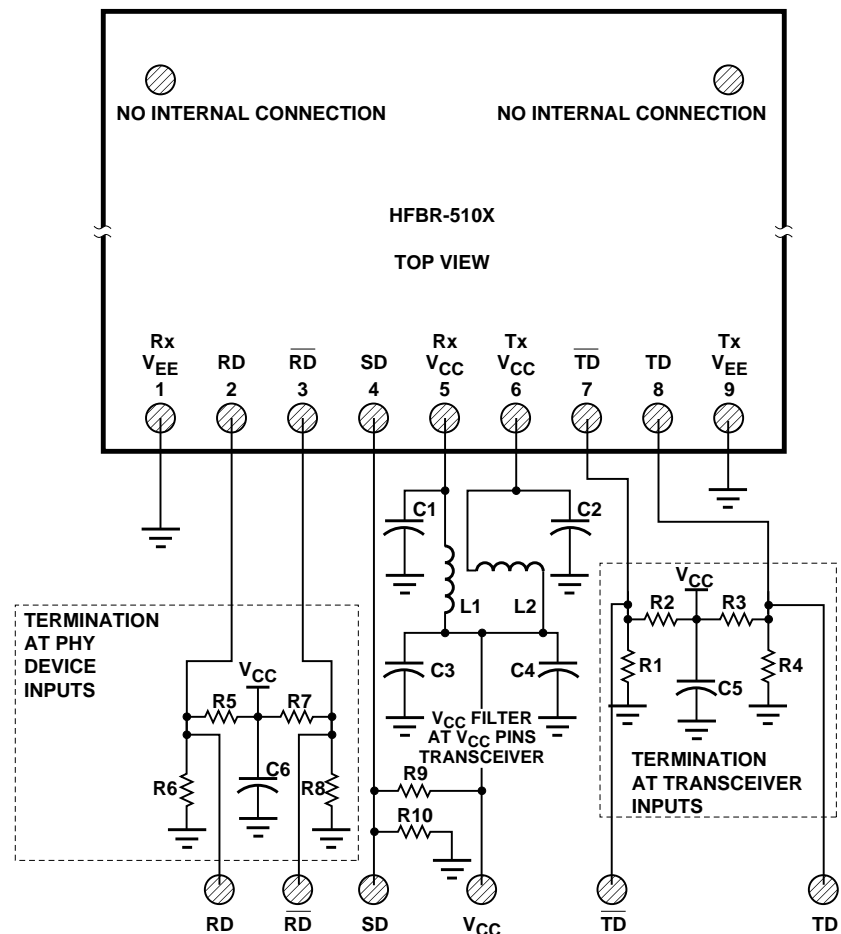
NOTES:
THE SPLIT-LOAD TERMINATIONS FOR ECL SIGNALS NEED TO BE LOCATED AT THE INPUT OF DEVICES RECEIVING THOSE ECL SIGNALS. RECOMMEND 4-LAYER PRINTED CIRCUIT BOARD WITH 50 OHM MICROSTRIP SIGNAL PATHS BE USED.
R1 = R4 = R6 = R8 = R10 = 130 OHMS.
R2 = R3 = R5 = R7 = R9 = 82 OHMS.
C1 = C2 = C3 = C5 = C6 = 0.1 µF.
C4 = 10 µF.
L1 = L2 = 1 µH COIL OR FERRITE INDUCTOR.

Figure 7. Recommended Decoupling and Termination Circuits

Board Layout - Hole Pattern

The Agilent transceiver complies with the circuit board "Common Transceiver Footprint" hole pattern defined in the original multisource announcement which defined the 1x9 package style. This drawing is reproduced in Figure 8 with the addition of ANSI Y14.5M compliant dimensioning to be used as a guide in the mechanical layout of your circuit board.

Board Layout - Art Work

The Applications Engineering group has developed Gerber file artwork for a multilayer printed circuit board layout incorporating the recommendations above. Contact your local Agilent sales representative for details.

Board Layout - Mechanical

For applications providing a choice of either a duplex SC or a duplex ST connector interface, while utilizing the same pinout on the printed circuit board, the ST port needs to protrude from the chassis panel a minimum of 9.53 mm for sufficient clearance to install the ST connector.

Please refer to Figure 8a for a mechanical layout detailing the recommended location of the duplex SC and duplex ST transceiver packages in relation to the chassis panel.

Regulatory Compliance

These transceiver products are intended to enable commercial system designers to develop equipment that complies with the various international regulations governing certification of Information Technology Equipment. See the Regulatory Compliance Table for details. Additional information is available from your Agilent sales representative.

Electrostatic Discharge (ESD)

There are two design cases in which immunity to ESD damage is important.

The first case is during handling of the transceiver prior to mounting it on the circuit board. It is important to use normal ESD handling precautions for ESD sensitive devices. These precautions include using grounded wrist straps, work benches, and floor mats in ESD controlled areas.
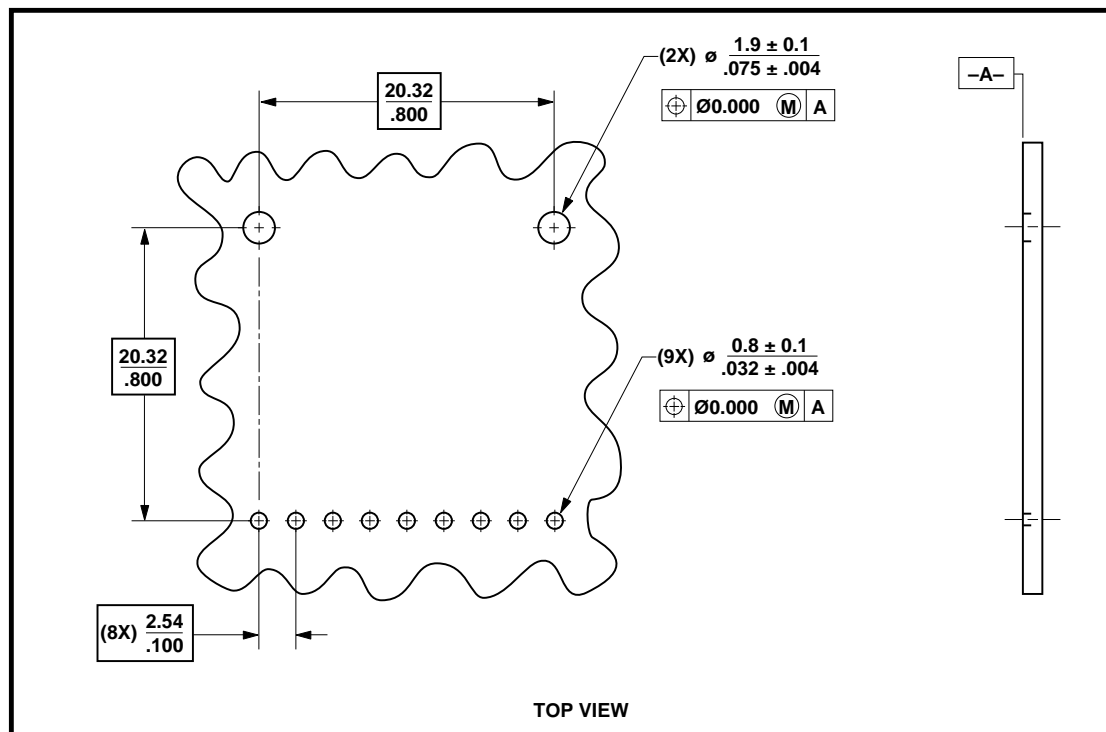
Figure 8. Recommended Board Layout Hole Pattern

42.0

9.53
(NOTE 1)

24.8

12.0

0.51

12.09

25.4

25.4

11.1

0.75

39.12

6.79

25.4

NOTE 1: MINIMUM DISTANCE FROM FRONT
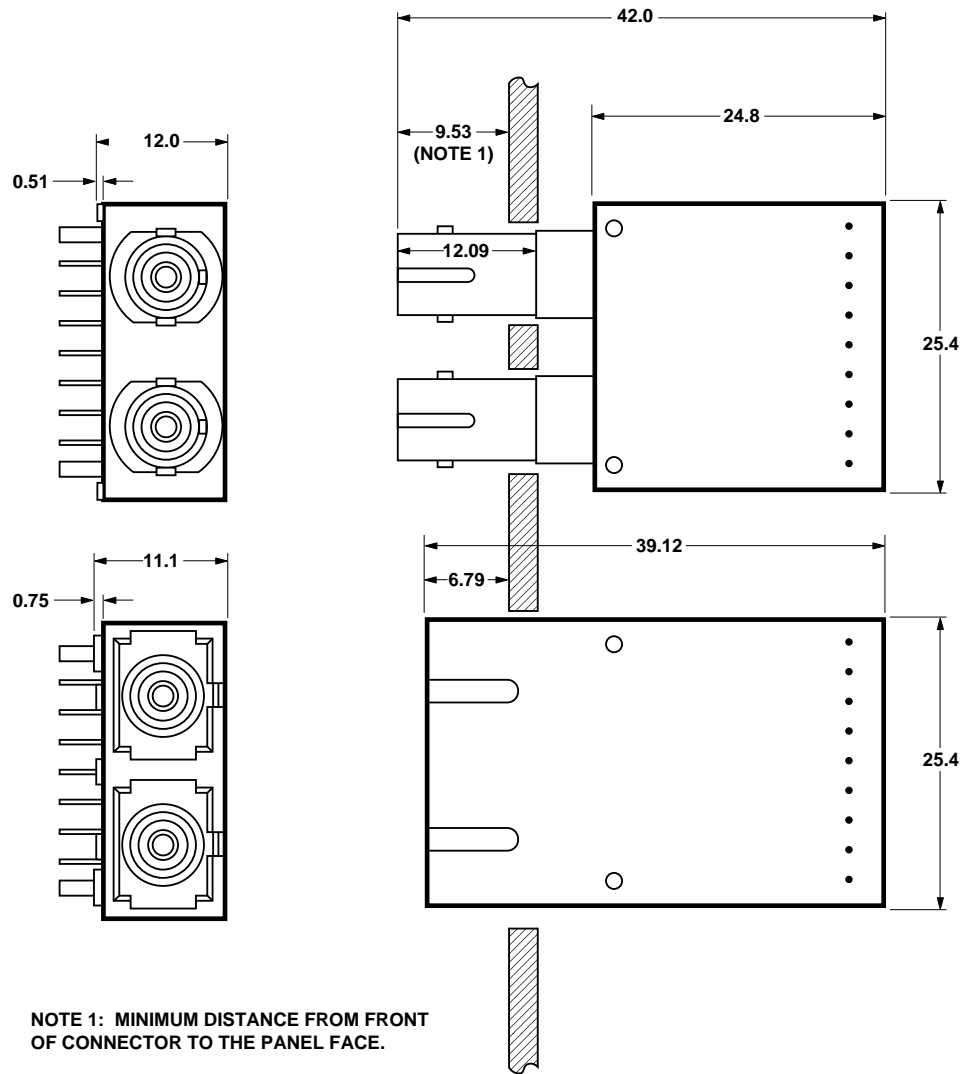**OF CONNECTOR TO THE PANEL FACE.**

Figure 8a. Recommended Common Mechanical Layout for SC and ST 1x9 Connectored Transceivers.

Regulatory Compliance Table

Feature	Test Method	Performance
Electrostatic Discharge (ESD) to the Electrical Pins	MIL-STD-883C Method 3015.4	Meets Class 2 (2000 to 3999 Volts) Withstand up to 2200 V applied between electrical pins.
Electrostatic Discharge (ESD) to the Duplex SC Receptacle	Variation of IEC 801-2	Typically withstand at least 25 kV without damage when the Duplex SC Connector Receptacle is contacted by a Human Body Model probe.
Electromagnetic Interference (EMC)	FCC Class B CENELEC CEN55022 Class B (CISPR 22B) VCCI Class 2	Typically provide a 13 dB margin (with duplex SC package) or a 9 dB margin (with duplex ST package) to the noted standard limits when tested at a certified test range with the transceiver mounted to a circuit card without a chassis enclosure.
Immunity	Variation of IEC 801-3	Typically show no measurable effect from a 10 V/m field swept from 10 to 450 MHz applied to the transceiver when mounted to a circuit card without a chassis enclosure.
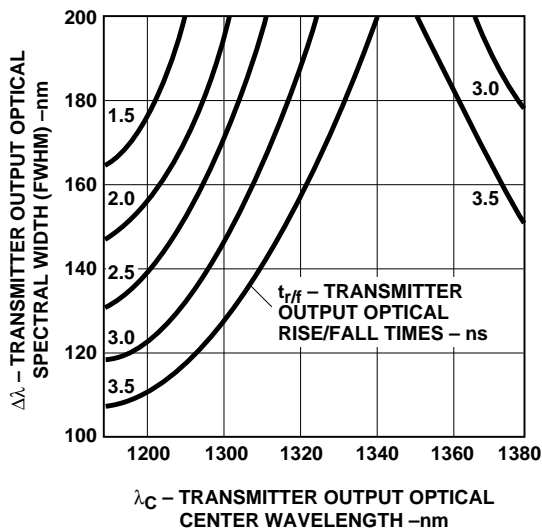
Figure 9. Transmitter Output Optical Spectral Width (FWHM) vs. Transmitter Output Optical Center Wavelength and Rise/Fall Times.

The second case to consider is static discharges to the exterior of the equipment chassis containing the transceiver parts. To the extent that the duplex SC connector is exposed to the outside of the equipment chassis it may be subject to whatever ESD system level test criteria that the equipment is intended to meet.

Electromagnetic Interference (EMI)

Most equipment designs utilizing these high speed transceivers from Agilent will be required to meet the requirements of FCC in the United States, CENELEC EN55022 (CISPR 22) in Europe and VCCI in Japan.

These products are suitable for use in designs ranging from a desktop computer with a single transceiver to a concentrator or switch product with a large number of transceivers.

In all well-designed chassis, two 0.5" holes for ST connectors to protrude through will provide 4.6 dB more shielding than one 1.2" duplex SC rectangular cutout. Thus, in a well-designed chassis, the duplex ST 1x9 transceiver emissions will be identical to the duplex SC 1x9 transceiver emissions.

Immunity

Equipment utilizing these transceivers will be subject to radio-frequency electromagnetic fields in some environments. These transceivers have a high immunity to such fields.

For additional information regarding EMI, susceptibility, ESD and conducted noise testing procedures and results on the 1x9 Transceiver family, please refer to Applications Note 1075, *Testing and Measuring Electromagnetic Compatibility Performance of the HFBR-510X/-520X Fiber Optic Transceivers.*

Transceiver Reliability and Performance Qualification Data

The 1x9 transceivers have passed Agilent reliability and performance qualification testing

and are undergoing ongoing quality monitoring. Details are available from your Hewlett-Packard sales representative.

These transceivers are manufactured at the Agilent Singapore location which is an ISO 9002 certified facility.

Ordering Information

The HFBR-5103/-5103T and HFBR-5105/-5105T 1300 nm products and the HFBR-5104/-5104T 800 nm products are available for production orders through the Agilent Component Field Sales Offices and Authorized Distributors world wide.
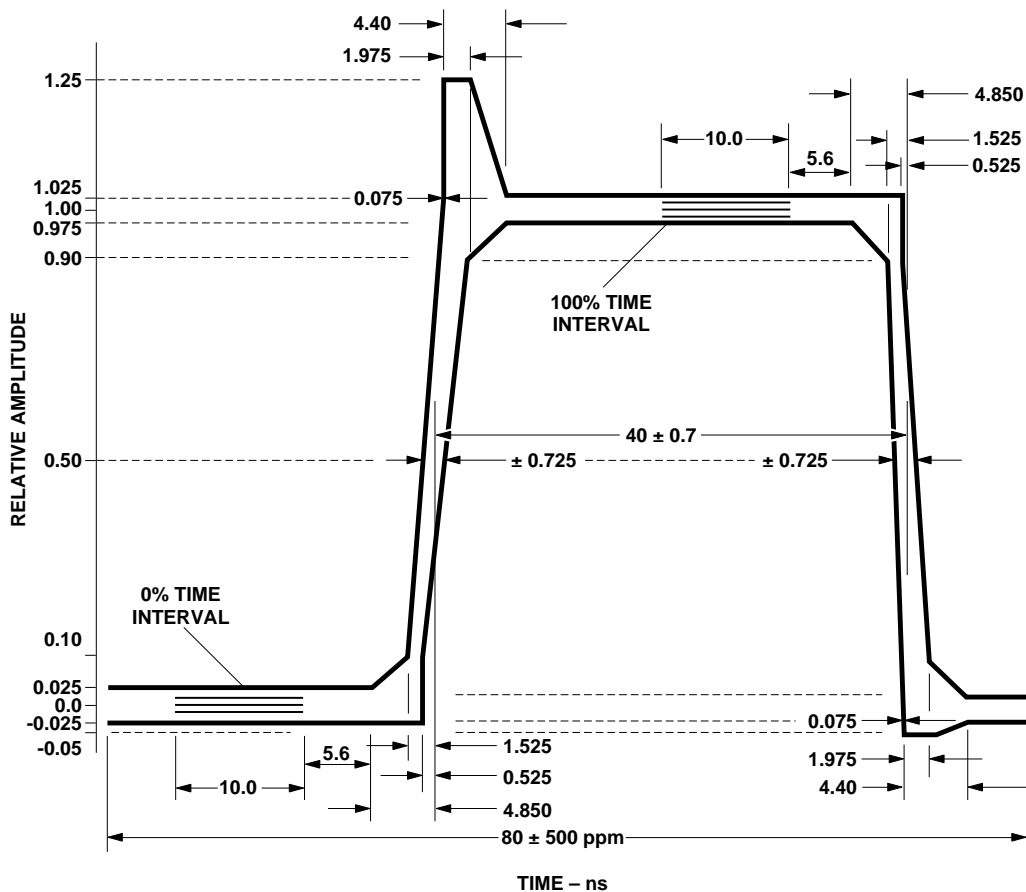
THE HFBR-5103 OUTPUT OPTICAL PULSE SHAPE SHALL FIT WITHIN THE BOUNDARIES OF THE PULSE ENVELOPE FOR RISE AND FALL TIME MEASUREMENTS.

Figure 10. Output Optical Pulse Envelope.

Applications Support Materials

Contact your local Agilent Component Field Sales Office for information on how to obtain PCB layouts, test boards and demo boards for the 1x9 transceivers.

Evaluation Kits

Agilent has available three evaluation kits for the 1x9 transceivers. The purpose of these kits is to provide the necessary materials to evaluate the performance of the HFBR-510X family in a pre-existing 1x13 or 2x11 pinout system design configuration or when connectored to various test equipment.

1. HFBR-0305 - ATM Evaluation Kit
   This kit consists of one HFBR-5205, one 1x13 to 1x9 pinout adapter card, and one three meter duplex SC to duplex ST connectored 62.5/125 µm fiber optic cable.

2. HFBR-0303 - FDDI Evaluation Kit
   This kit consists of one HFBR-5103, one 2x11 to 1x9 pinout adapter card, one 1x13 to 1x9 pinout adapter card, and one three meter duplex SC to MIC/Receptacle connectored 62.5/125 µm fiber optic cable.

3. HFBR-0319 Evaluation Test Fixture Board
   This test fixture converts +5 V ECL 1x9 transceivers to –5 V ECL BNC coax connections so that direct connections to industry standard fiber optic test equipment can be accomplished.

Accessory Duplex SC Connectored Cable Assemblies

Agilent recommends for optimal coupling the use of flexible-body duplex SC connectored cable. Agilent offers two such compatible Duplex SC connectored jumper cable assemblies to assist you in the evaluation of these transceiver products. These cables may be purchased from Agilent with the following part numbers.

1. HFBR-BKD001
   A duplex cable 1 meter long assembled with 62.5/125 µm fiber and Duplex SC connector plugs on both ends.

2. HFBR-BKD010
   A duplex cable 10 meters long assembled with 62.5/125 µm fiber and Duplex SC connector plugs on both ends.

Accessory Duplex ST Connectored Cable Assemblies

Agilent recommends the use of Duplex Push-Pull connectored cable for the most repeatable optical power coupling performance.

Agilent offers two such compatible Duplex Push-Pull ST connectored jumper cable assemblies to assist you in your evaluation of these products.

These cables may be purchased from Agilent with the following part numbers.

1. HFBR-XXX001
   A duplex cable 1 meter long, assembled with 62.5/125 µm fiber and Duplex Push-Pull ST connector plugs on both ends.

2. HFBR-XXX010
   A duplex cable 10 meters long assembled with 62.5/125 µm fiber and Duplex Push-Pull ST connector plugs on both ends.

CONDITIONS:
1. T_A = 25° C
2. V_{CC} = 5 Vdc
3. INPUT OPTICAL RISE/FALL TIMES = 1.0/2.1 ns.
4. INPUT OPTICAL POWER IS NORMALIZED TO CENTER OF DATA SYMBOL.
5. NOTE 20 AND 21 APPLY.
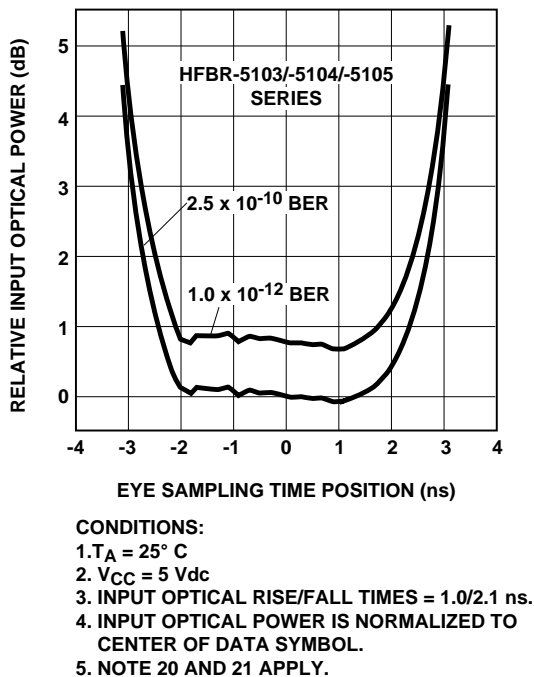
Figure 11. Relative Input Optical Power vs. Eye Sampling Time Position.

AS ‒ MAX — MAXIMUM ACQUISITION TIME (SIGNAL).
    AS ‒ MAX IS THE MAXIMUM SIGNAL ‒ DETECT ASSERTION TIME FOR THE STATION.
    AS ‒ MAX SHALL NOT EXCEED 100.0 µs. THE DEFAULT VALUE OF AS ‒ MAX IS 100.0 µs.

ANS ‒ MAX — MAXIMUM ACQUISITION TIME (NO SIGNAL).
    ANS ‒ MAX IS THE MAXIMUM SIGNAL ‒ DETECT DEASSERTION TIME FOR THE STATION.
    ANS ‒ MAX SHALL NOT EXCEED 350 µs. THE DEFAULT VALUE OF AS ‒ MAX IS 350 µs.
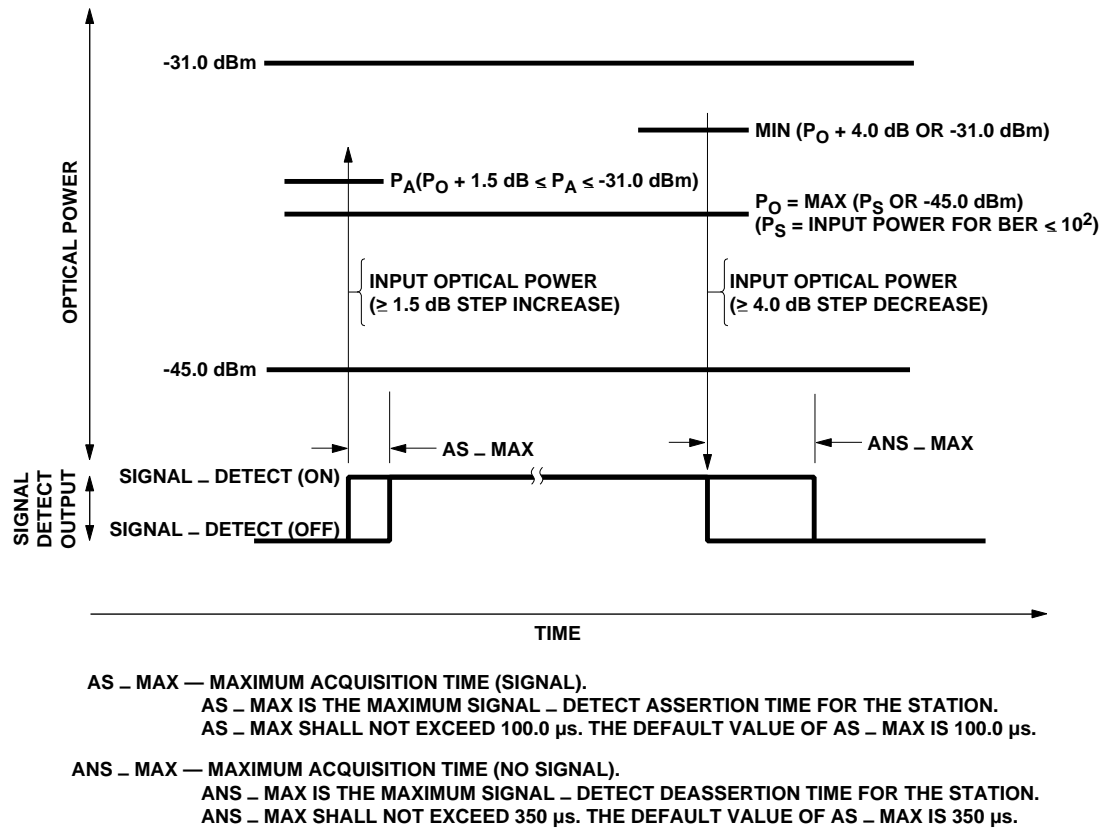
Figure 12. Signal Detect Thresholds and Timing.

HFBR-5103, -5104, and -5105 Series
Absolute Maximum Ratings

Parameter	Symbol	Min.	Typ.	Max.	Unit	Reference
Storage Temperature	T_S	-40		100	°C	
Lead Soldering Temperature	T_{SOLD}			260	°C	
Lead Soldering Time	t_{SOLD}			10	sec.	
Supply Voltage	V_{CC}	-0.5		7.0	V	
Data Input Voltage	V_I	-0.5		V_{CC}	V	
Differential Input Voltage	V_D			1.4	V	Note 1
Output Current	I_O			50	mA	

HFBR-5103, -5104 and -5105 Series
Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Reference
Ambient Operating Temperature	T_A	0		70	°C	
Supply Voltage	V_{CC}	4.75		5.25	V	
Data Input Voltage - Low	V_{IL} - V_{CC}	-1.810		-1.475	V	
Data Input Voltage - High	V_{IH} - V_{CC}	-1.165		-0.880	V	
Data and Signal Detect Output Load	R_L		50		Ω	Note 2

Transmitter Electrical Characteristics
(T_A = 0°C to 70°C, V_{CC} = 4.75 V to 5.25 V)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Reference
Supply Current	I_{CC}		145	185	mA	Note 3
Power Dissipation	P_{DISS}		0.76	0.97	W	
Data Input Current - Low	I_{IL}	-350	0		μA	
Data Input Current - High	I_{IH}		14	350	μA	

Receiver Electrical Characteristics
(T_A = 0°C to 70°C, V_{CC} = 4.75 V to 5.25 V)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Reference
Supply Current	I_{CC}		82	145	mA	Note 4
Power Dissipation	P_{DISS}		0.3	0.5	W	Note 5
Data Output Voltage - Low	V_{OL} - V_{CC}	-1.840		-1.620	V	Note 6
Data Output Voltage - High	V_{OH} - V_{CC}	-1.045		-0.880	V	Note 6
Data Output Rise Time	t_r	0.35		2.2	ns	Note 7
Data Output Fall Time	t_f	0.35		2.2	ns	Note 7
Signal Detect Output Voltage - Low	V_{OL} - V_{CC}	-1.840		-1.620	V	Note 6
Signal Detect Output Voltage - High	V_{OH} - V_{CC}	-1.045		-0.880	V	Note 6
Signal Detect Output Rise Time	t_r	0.35		2.2	ns	Note 7
Signal Detect Output Fall Time	t_f	0.35		2.2	ns	Note 7

HFBR-5103/-5103T
Transmitter Optical Characteristics

$(T_A = 0°C$ to $70°C$, $V_{CC} = 4.75$ V to 5.25 V)

Parameter		Symbol	Min.	Typ.	Max.	Unit	Reference
Output Optical Power 62.5/125 μm, NA = 0.275 Fiber	BOL EOL	P_O	-19 -20	-16.8	-14	dBm avg.	Note 11
Output Optical Power 50/125 μm, NA = 0.20 Fiber	BOL EOL	P_O	-22.5 -23.5	-20.3	-14	dBm avg.	Note 11
Optical Extinction Ratio				0.001 -50	0.03 -35	% dB	Note 13
Output Optical Power at Logic "0" State		P_O ("0")			-45	dBm avg.	Note 14
Center Wavelength		λ_C	1270	1308	1380	nm	Note 15 Figure 9
Spectral Width - FWHM		$\Delta\lambda$		137	170	nm	Note 15 Figure 9
Optical Rise Time		t_r	0.6	1.0	3.0	ns	Note 15, 16 Figure 9, 10
Optical Fall Time		t_f	0.6	2.1	3.0	ns	Note 15, 16 Figure 9, 10
Duty Cycle Distortion Contributed by the Transmitter		DCD		0.02	0.6	ns p-p	Note 17
Data Dependent Jitter Cobntributed by the Transmitter		DDJ		0.02	0.6	ns p-p	Note 18
Random Jitter Contributed by the Transmitter		RJ		0	0.69	ns p-p	Note 19

HFBR-5103/-5103T
Receiver Optical and Electrical Characteristics
(T_A = 0°C to 70°C, V_{CC} = 4.75 V to 5.25 V)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Reference
Input Optical Power Minimum at Window Edge	$P_{IN\ Min.}$ (W)		-33.5	-31	dBm avg.	Note 20 Figure 11
Input Optical Power Minimum at Eye Center	$P_{IN\ Min.}$ (C)		-34.5	-31.8	dBm avg.	Note 21 Figure 11
Input Optical Power Maximum	$P_{IN\ Max.}$	-14	-11.8		dBm avg.	Note 20
Operating Wavelength	λ	1270		1380	nm	
Duty Cycle Distortion Contributed by the Receiver	DCD		0.02	0.4	ns p-p	Note 8
Data Dependent Jitter Contributed by the Receiver	DDJ		0.35	1.0	ns p-p	Note 9
Random Jitter Contributed by the Receiver	RJ		1.0	2.14	ns p-p	Note 10
Signal Detect - Asserted	P_A	P_D + 1.5 dB		-33	dBm avg.	Note 22, 23 Figure 12
Signal Detect - Deasserted	P_D	-45			dBm avg.	Note 24, 25 Figure 12
Signal Detect - Hysteresis	P_A - P_D	1.5	2.4		dB	Figure 12
Signal Detect Assert Time (off to on)	AS_Max	0	55	100	µs	Note 22, 23 Figure 12
Signal Detect Deassert Time (on to off)	ANS_Max	0	110	350	µs	Note 24, 25 Figure 12

HFBR-5104/-5104T
Transmitter Optical Characteristics

(T_A = 0°C to 70°C, V_{CC} = 4.75 V to 5.25 V)

Parameter		Symbol	Min.	Typ.	Max.	Unit	Reference
Output Optical Power BOL 62.5/125 µm, NA = 0.275 Fiber EOL		P_O	-17 -20		-12	dBm avg.	Note 12
Output Optical Power BOL 50/125 µm, NA = 0.20 Fiber EOL		P_O	-20.8 -23.8		-12	dBm avg.	Note 12
Optical Extinction Ratio					0.01 -40	% dB	Note 13
Output Optical Power at Logic "0" State		P_O ("0")			-45	dBm avg.	Note 14
Center Wavelength		λ_C	800		900	nm	
Spectral Width - FWHM		$\Delta\lambda$			100	nm	
Optical Rise Time		t_r			4.5	ns	Note 16a
Optical Fall Time		t_f			4.5	ns	Note 16a
Systematic Jitter Contributed by the Transmitter		SJ			1.7	ns p-p	Note 26
Random Jitter Contributed by the Transmitter		RJ			0.69	ns p-p	Note 27

HFBR-5104/-5104T
Receiver Optical and Electrical Characteristics
(T_A = 0°C to 70°C, V_{CC} = 4.75 V to 5.25 V)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Reference
Input Optical Power Minimum at Window Edge	$P_{IN\,Min.}$ (W)			-27.5	dBm avg.	Note 20b
Input Optical Power Minimum at Eye Center	$P_{IN\,Min.}$ (C)			-28	dBm avg.	Note 21a
Input Optical Power Maximum	$P_{IN\,Max.}$	-12			dBm avg.	Note 20b
Operating Wavelength	λ	800		900	nm	
Systematic Jitter Contributed by the Receiver	SJ			1.2	ns p-p	Note 26
Random Jitter Contributed by the Receiver	RJ			2.6	ns p-p	Note 27
Signal Detect - Asserted	P_A	P_D + 1.5 dB		-29.5	dBm avg.	Note 22
Signal Detect - Deasserted	P_D	-45			dBm avg.	Note 24
Signal Detect - Hysteresis	P_A - P_D	1.5			dB	
Signal Detect Assert Time (off to on)	AS_Max	0	55	100	μs	Note 22
Signal Detect Deassert Time (on to off)	ANS_Max	0	110	350	μs	Note 24

HFBR-5105/-5105T
Transmitter Optical Characteristics

(T_A = 0°C to 70°C, V_{CC} = 4.75 V to 5.25 V)

Parameter		Symbol	Min.	Typ.	Max.	Unit	Reference
Output Optical Power	BOL	P_O	-21		-14	dBm avg.	Note 11
62.5/125 μm, NA = 0.275 Fiber	EOL		-22				
Output Optical Power	BOL	P_O	-24.5		-14	dBm avg.	Note 11
50/125 μm, NA = 0.20 Fiber	EOL		-25.5				
Optical Extinction Ratio				0.001	0.03	%	Note 13
				-50	-35	dB	
Output Optical Power at Logic "0" State		P_O ("0")			-45	dBm avg.	Note 14
Center Wavelength		λ_C	1270	1308	1380	nm	
Spectral Width - FWHM		$\Delta\lambda$		137	250	nm	
Optical Rise Time		t_r			4	ns	Note 16a
Optical Fall Time		t_f			4	ns	Note 16a
Duty Cycle Distortion Contributed by the Transmitter		DCD		0.02	0.6	ns p-p	Note 17
Data Dependent Jitter Contributed by the Transmitter		DDJ		0.02	0.6	ns p-p	Note 18
Random Jitter Contributed by the Transmitter		RJ		0	0.69	ns p-p	Note 19

HFBR-5105/-5105T
Receiver Optical and Electrical Characteristics

$(T_A = 0°C$ to $70°C$, $V_{CC} = 4.75$ V to 5.25 V)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Reference
Input Optical Power Minimum at Window Edge	$P_{IN\,Min.}$ (W)			-29	dBm avg.	Note 20a Figure 11
Input Optical Power Minimum at Eye Center	$P_{IN\,Min.}$ (C)			-29.8	dBm avg.	Note 21a Figure 11
Input Optical Power Maximum	$P_{IN\,Max.}$	-14			dBm avg.	Note 20a
Operating Wavelength	λ	1270		1380	nm	
Duty Cycle Distortion Contributed by the Receiver	DCD		0.02	0.4	ns p-p	Note 8
Data Dependent Jitter Contributed by the Receiver	DDJ		0.35	1.0	ns p-p	Note 9
Random Jitter Contributed by the Receiver	RJ		1.0	2.9	ns p-p	Note 10
Signal Detect - Asserted	P_A	P_D + 1.5 dB		-31	dBm avg.	Note 22, 23a
Signal Detect - Deasserted	P_D	-45			dBm avg.	Note 24, 25a
Signal Detect - Hysteresis	$P_A - P_D$	1.5	2.4		dB	
Signal Detect Assert Time (off to on)	AS_Max	0	55	100	µs	Note 22, 25a
Signqal Detect Deassert Time (on to off)	ANS_MAX	0	110	350	µs	Note 24, 25a

Notes:

1. This is the maximum voltage that can be applied across the Differential Transmitter Data Inputs to prevent damage to the input ESD protection circuit.

2. The outputs are terminated with 50 Ω connected to V_{CC} -2 V.

3. The power supply current needed to operate the transmitter is provided to differential ECL circuitry. This circuitry maintains a nearly constant current flow from the power supply. Constant current operation helps to prevent unwanted electrical noise from being generated and conducted or emitted to neighboring circuitry.

4. This value is measured with the outputs terminated into 50 Ω connected to V_{CC} - 2 V and an Input Optical Power level of -14 dBm average.

5. The power dissipation value is the power dissipated in the receiver itself. Power dissipation is calculated as the sum of the products of supply voltage and currents, minus the sum of the products of the output voltages and currents.

6. This value are measured with respect to V_{CC} with the output terminated into 50 Ω connected to V_{CC} - 2 V.

7. The output rise and fall times are measured between 20% and 80% levels with the output connected to V_{CC} -2 V through 50 Ω.

8. Duty Cycle Distortion contributed by the receiver is measured at the 50% threshold using an IDLE Line State, 125 MBd (62.5 MHz square-wave), input signal. The input

optical power level is -20 dBm average. See Application Information - Transmitter Jitter Section for further information.

9. Data Dependent Jitter contributed by the receiver is specified with the FDDI DDJ test pattern described in the FDDI PMD Annex A.5. The input optical power level is -20 dBm average. See Application Information - Transmitter Jitter Section for further information.

10. Random Jitter contributed by the receiver is specified with an IDLE Line State, 125 MBd (62.5 MHz square-wave), input signal. The input optical power level is at maximum "$P_{IN\,Min.}$ (W)". See Application Information - Transmitter Jitter Section for further information.

11. These optical power values are measured with the following conditions:
    - The Beginning of Life (BOL) to the End of Life (EOL) optical power degradation is typically 1.5 dB per the industry convention for long wavelength LEDs. The actual degradation observed in Agilent's 1300 nm LED products is < 1 dB, as specified in this data sheet.
    - Over the specified operating voltage and temperature ranges.
    - With HALT Line State, (12.5 MHz square-wave), input signal.
    - At the end of one meter of noted optical fiber with cladding modes removed.

    The average power value can be converted to a peak power value by adding 3 dB. Higher output optical power transmitters are available on special request.

12. The same comments of note 11 apply except that industry convention for short wavelength LED (800 nm) BOL to EOL aging is 3 dB. This value for Output Optical Power will provide a minimum of a 6 dB optical power budget at the EOL, which will provide at least 500 meter link lengths with margin left over for overcoming normal passive losses, such as in line connectors, in the cable plant. The actual degradation observed in normal commercial environments will be considerably less than this amount with Hewlett-Packard's 800 nm LED products. Please consult with your local HP sales representative for further details.

13. The Extinction Ratio is a measure of the modulation depth of the optical signal. The data "0" output optical power is compared to the data "1" peak output optical power and expressed as a percentage. With the transmitter driven by a HALT Line State (12.5 MHz square-wave) signal, the average optical power is measured. The data "1" peak power is then calculated by adding 3 dB to the measured average optical power. The data "0" output optical power is found by measuring the optical power when the transmitter is driven by a logic "0" input. The extinction ratio is the ratio of the optical power at the "0" level compared to the optical power at the "1" level expressed as a percentage or in decibels.

14. The transmitter provides compliance with the need for Transmit_Disable commands from the FDDI SMT layer by providing an Output Optical Power level of < -45 dBm average in response to a logic "0" input. This specification applies to either 62.5/125 µm or 50/125 µm fiber cables.

15. This parameter complies with the FDDI PMD requirements for the tradeoffs between center wavelength, spectral width, and rise/fall times shown in Figure 9.

16. This parameter complies with the optical pulse envelope from the FDDI PMD shown in Figure 10. The optical rise and fall times are measured from 10% to 90% when the transmitter is driven by the FDDI HALT Line State (12.5 MHz square-wave) input signal.

16a. The optical rise and fall times are measured from 10% to 90% when the transmitter is driven by the FDDI HALT Line State (12.5 MHz square-wave) input signal.

17. Duty Cycle Distortion contributed by the transmitter is measured at a 50% threshold using an IDLE Line State, 125 MBd (62.5 MHz square-wave), input signal. See Application Information - Transceiver Jitter Performance Section of this data sheet for further details.

18. Data Dependent Jitter contributed by the transmitter is specified with the FDDI test pattern described in FDDI PMD Annex A.5. See Application Information - Transceiver Jitter Performance Section of this data sheet for further details.

19. Random Jitter contributed by the transmitter is specified with an IDLE Line State, 125 MBd (62.5 MHz square-wave), input signal. See Application Information - Transceiver Jitter Performance Section of this data sheet for further details.

20. This specification is intended to indicate the performance of the receiver section of the transceiver when Input Optical Power signal characteristics are present per the following definitions. The Input Optical Power dynamic range from the minimum level (with a window time-width) to the maximum level is the range over which the receiver is guaranteed to provide output data with a Bit Error Ratio (BER) better than or equal to 2.5×10^{-10}.
    - At the Beginning of Life (BOL)

- Over the specified operating temperature and voltage ranges
- Input symbol pattern is the FDDI test pattern defined in FDDI PMD Annex A.5 with 4B/5B NRZI encoded data that contains a duty cycle base-line wander effect of 50 kHz. This sequence causes a near worst case condition for inter-symbol interference.
- Receiver data window time-width is 2.13 ns or greater and centered at mid-symbol. This worst case window time-width is the minimum allowed eye-opening presented to the FDDI PHY PM._Data indication input (PHY input) per the example in FDDI PMD Annex E. This minimum window time-width of 2.13 ns is based upon the worst case FDDI PMD Active Input Interface optical conditions for peak-to-peak DCD (1.0 ns), DDJ (1.2 ns) and RJ (0.76 ns) presented to the receiver.

To test a receiver with the worst case FDDI PMD Active Input jitter condition requires exacting control over DCD, DDJ and RJ jitter components that is difficult to implement with production test equipment. The receiver can be equivalently tested to the worst case FDDI PMD input jitter conditions and meet the minimum output data window time-width of 2.13 ns. This is accomplished by using a nearly ideal input optical signal (no DCD, insignificant DDJ and RJ) and measuring for a wider window time-width of 4.6 ns. This is possible due to the cumulative effect of jitter components through their superposition (DCD and DDJ are directly additive and RJ components are rms additive). Specifically, when a nearly ideal input optical test signal is used and the maximum receiver peak-to-peak jitter contributions of DCD (0.4 ns), DDJ (1.0 ns), and RJ (2.14 ns) exist, the minimum window time-width becomes 8.0 ns -0.4 ns - 1.0 ns - 2.14 ns = 4.46 ns, or conservatively 4.6 ns. This wider window time-width of 4.6 ns guarantees the FDDI PMD Annex E minimum window time-width of 2.13 ns under worst case input jitter conditions to the Hewlett-Packard receiver.

- Transmitter operating with an IDLE Line State pattern, 125 MBd (62.5 MHz square-wave),

input signal to simulate any cross-talk present between the transmitter and receiver sections of the transceiver.

20a. All the conditions of Note 20 apply except that the BER requirement is tightened to 1×10^{-12} and the minimum window time-width test condition is narrowed from 4.6 ns to 3.7 ns to reflect the lesser amount of worst case input optical jitter as a result of shorter optical cable lengths and lower BER which are both attributes of the FDDI LCF-PMD.

20b. All the conditions of Note 20 apply except that the BER requirement is tightened to 1×10^{-12} and the minimum window time-width test condition is adjusted to 4.2 ns to reflect the HFBR-5104 transmitter contributed jitter values per the specification table.

21. All conditions of Note 20 apply except that the measurement is made at the center of the symbol with no window time-width.

21a. All the conditions of Note 21 apply accept that the BER requirement is tightened to 1×10^{-12}.

22. This value is measured during the transition from low to high levels of input optical power.

23. The Signal Detect output shall be asserted within 100 µs after a step increase of the Input Optical Power. The step will be from a low Input Optical Power, ≤ -45 dBm, into the range between greater than P_A, and -

14 dBm. The BER of the receiver output will be 10^{-2} or better during the time, LS_Max (15 µs) after Signal Detect has been asserted. See Figure 12 for more information.

23a. The Signal Detect output shall be asserted within 100 µs after a step increase of the Input Optical Power. The step will be from a low Input Optical Power, ≤ -45 dBm, into the range -27 dBm ± 2 dB. The BER of the receiver output will be 10^{-2} or better during the time, LS_Max (15 µs) after Signal Detect has been asserted.

24. This value is measured during the transition from high to low levels of input optical power. The maximum value will occur when the input optical power is either -45 dBm average or when the input optical power yields a BER of 10^{-2} or better, whichever power is higher.

25. Signal detect output shall be de-asserted within 350 µs after a step decrease in the Input Optical Power from a level which is the lower of; -31 dBm or P_D + 4 dB (P_D is the power level at which signal detect was deasserted), to a power level of -45 dBm or less. This step decrease will have occurred in less than 8 ns. The receiver output will have a BER of 10^{-2} or better for a period of 12 µs or until signal detect is deasserted. The input data stream is the Quiet Line State. Also, signal detect will be deasserted within a maximum of 350 µs after the BER of the receiver

output degrades above 10^{-2} for an input optical data stream that decays with a negative ramp function instead of a step function. See Figure 12 for more information.

25a. Signal detect output shall be de-asserted within 350 µs after a step decrease in the Input Optical Power. The step decrease signal shall have an on level of -27 dBm ± 2 dB and an off power level of -45 dBm or less. This step decrease will have occurred in less than 8 ns. The receiver outputs within 12 µs after the step decrease in the optical power will not reproduce with an accuracy greater than 90% any spurious signals (e.g. symbols from adjacent physical link components or power supply ripple). The input data stream is the Quiet Line State. Signal detect will also be deasserted within a maximum of 350 µs after the BER of the receiver output degrades above 10^{-2} for an input optical data stream that decays with a negative ramp function with a response time > 8 ns.

26. Systematic Jitter (SJ) contributed by the 800 nm transmitter is a combination of Duty Cycle Distortion (DCD) and Data Dependent Jitter (DDJ).

27. Random Jitter contributed by the 800 nm transmitter is specified with an IDLE Line State, 125 MBd (62.5 MHz square-wave), input signal.
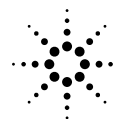
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