Agilent Technologies
Innovating the HP Way

# Low Cost, Miniature Fiber Optic Components with ST®, SMA, SC and FC Ports

## Technical Data

**HFBR-0400 Series**

## Features

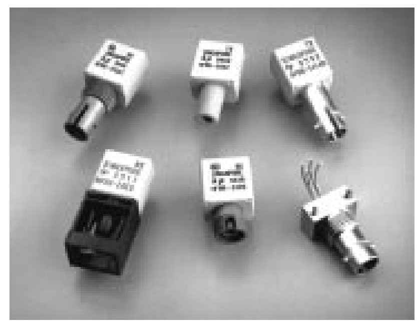
- **Meets IEEE 802.3 Ethernet and 802.5 Token Ring Standards**
- **Low Cost Transmitters and Receivers**
- **Choice of ST®, SMA, SC or FC Ports**
- **820 nm Wavelength Technology**
- **Signal Rates up to 175 Megabaud**
- **Link Distances up to 4 km**
- **Specified with 50/125 µm, 62.5/125 µm, 100/140 µm, and 200 µm HCS® Fiber**
- **Repeatable ST Connections within 0.2 dB Typical**
- **Unique Optical Port Design for Efficient Coupling**
- **Auto-Insertable and Wave Solderable**
- **No Board Mounting Hard-ware Required**
- **Wide Operating Temperature Range -40°C to 85°C**
- **AlGaAs Emitters 100% Burn-In Ensures High Reliability**
- **Conductive Port Option with the SMA and ST Threaded Port Styles**

## Applications

- **Local Area Networks**
- **Computer to Peripheral Links**
- **Computer Monitor Links**
- **Digital Cross Connect Links**
- **Central Office Switch/PBX Links**
- **Video Links**
- **Modems and Multiplexers**
- **Suitable for Tempest Systems**
- **Industrial Control Links**

## Description

The HFBR-0400 Series of components is designed to provide cost effective, high performance fiber optic communication links for information systems and industrial applications with link distances of up to 4 kilometers. With the HFBR-24X6, the 125 MHz analog receiver, data rates of up to 175 megabaud are attainable.



Transmitters and receivers are directly compatible with popular “industry-standard” connectors: ST, SMA, SC and FC. They are completely specified with multiple fiber sizes; including 50/125 µm, 62.5/125 µm, 100/140 µm, and 200 µm.

Complete evaluation kits are available for ST and SMA product offerings; including transmitter, receiver, connectored cable, and technical literature. In addition, ST and SMA connectored cables are available for evaluation.

## HFBR-0400 Series Part Number Guide

HFBR X4XXaa

1 = Transmitter
2 = Receiver

4 = 820 nm Transmitter and Receiver Products

0 = SMA, Housed
1 = ST, Housed
2 = FC, Housed
E = SC, Housed
3 = SMA Port, 90 deg. Bent Leads
4 = ST Port, 90 deg. Bent Leads
5 = SMA Port, Straight Leads
6 = ST Port, Straight Leads

Option T (Threaded Port Option)
Option C (Conductive Port Receiver Option)
Option M (Metal Port Option)
Option K (Kinked Lead Option)
TA = Square pinout/straight lead
TB = Square pinout/bent leads
HA = Diamond pinout/straight leads
HB = Diamond pinout/bent leads

2 = Tx, Standard Power
4 = Tx, High Power
2 = Rx, 5 MBd, TTL Output
6 = Rx, 125 MHz, Analog Output

## LINK SELECTION GUIDE

| Data Rate (MBd) | Distance (m) | Transmitter | Receiver | Fiber Size (μm) | Evaluation Kit |
|---|---|---|---|---|---|
| 5 | 1500 | HFBR-14X2 | HFBR-24X2 | 200 HCS | N/A |
| 5 | 2000 | HFBR-14X4 | HFBR-24X2 | 62.5/125 | HFBR-04X0 |
| 20 | 2700 | HFBR-14X4 | HFBR-24X6 | 62.5/125 | HFBR-0414, HFBR-0463 |
| 32 | 2200 | HFBR-14X4 | HFBR-24X6 | 62.5/125 | HFBR-0414 |
| 55 | 1400 | HFBR-14X4 | HFBR-24X6 | 62.5/125 | HFBR-0414 |
| 125 | 700 | HFBR-14X4 | HFBR-24X6 | 62.5/125 | HFBR-0416 |
| 155 | 600 | HFBR-14X4 | HFBR-24X6 | 62.5/125 | HFBR-0416 |
| 175 | 500 | HFBR-14X4 | HFBR-24X6 | 62.5/125 | HFBR-0416 |

For additional information on specific links see the following individual link descriptions. Distances measured over temperature range from 0 to 70°C.

## Applications Support Guide

This section gives the designer information necessary to use the HFBR-0400 series components to make a functional fiber-optic transceiver. Agilent offers a wide selection of evaluation kits for hands-on experience with fiber-optic products as well as a wide range of application notes complete with circuit diagrams and board layouts. Furthermore, Agilent's application support group is always ready to assist with any design consideration.

## Application Literature

| Title | Description |
|---|---|
| HFBR-0400 Series Reliability Data | Transmitter & Receiver Reliability Data |
| Application Bulletin 73 | Low Cost Fiber Optic Transmitter & Receiver Interface Circuits |
| Application Bulletin 78 | Low Cost Fiber Optic Links for Digital Applications up to 155 MBd |
| Application Note 1038 | Complete Fiber Solutions for IEEE 802.3 FOIRL, 10Base-FB and 10 Base-FL |
| Application Note 1065 | Complete Solutions for IEEE 802.5J Fiber-Optic Token Ring |
| Application Note 1073 | HFBR-0319 Test Fixture for 1X9 Fiber Optic Transceivers |
| Application Note 1086 | Optical Fiber Interconnections in Telecommunication Products |

# HFBR-0400 Series Evaluation Kits

### HFBR-0410 ST Evaluation Kit

Contains the following :

- One HFBR-1412 transmitter
- One HFBR-2412 five megabaud TTL receiver
- Three meters of ST connectored 62.5/125 (µm fiber optic cable with low cost plastic ferrules.
- Related literature

### HFBR-0414 ST Evaluation Kit

Includes additional components to interface to the transmitter and receiver as well as the PCB to reduce design time.

Contains the following:

- One HFBR-1414T transmitter
- One HFBR-2416T receiver
- Three meters of ST connectored 62.5/125 µm fiber optic cable
- Printed circuit board
- ML-4622 CP Data Quantizer
- 74ACTllOOON LED Driver
- LT1016CN8 Comparator
- 4.7 µH Inductor
- Related literature

### HFBR-0400 SMA Evaluation Kit

Contains the following :

- One HFBR-1402 transmitter
- One HFBR-2402 five megabaud TTL receiver
- Two meters of SMA connectored 1000 µm plastic optical fiber
- Related literature

### HFBR-0416 Evaluation Kit

Contains the following:

- One fully assembled 1x9 transceiver board for 155 MBd evaluation including:
  -HFBR-1414 transmitter
  -HFBR-2416 receiver
  -circuitry
- Related literature

### HFBR-0463 Ethernet MAU Evaluation Kit

Contains the following:

- One fully assembled Media Attachment Unit (MAU) board which includes:
  -HFBR-1414 transmitter
  -HFBR-2416 receiver
  -HFBR-4663 IC
- Related literature

Note: Cable not included. Order HFBR-BXS010 seperately (2 pieces)

# Package and Handling Information

### Package Information

All HFBR-0400 Series transmitters and receivers are housed in a low-cost, dual-inline package that is made of high strength, heat resistant, chemically resistant, and UL 94V-O flame retardant ULTEM® (plastic (UL File #E121562). The transmitters are easily identified by the light grey color connector port. The receivers are easily identified by the dark grey color connector port. (Black color for conductive port.) The package is designed for auto-insertion and wave soldering so it is ideal for high volume production applications.

### Handling and Design Information

Each part comes with a protective port cap or plug covering the optics. These caps/plugs will vary by port style. When soldering, it is advisable to leave the protective cap on the unit to keep the optics clean. Good system performance requires clean port optics and cable ferrules to avoid obstructing the optical path. Clean compressed air often is sufficient to remove particles of dirt; methanol on a cotton swab also works well.

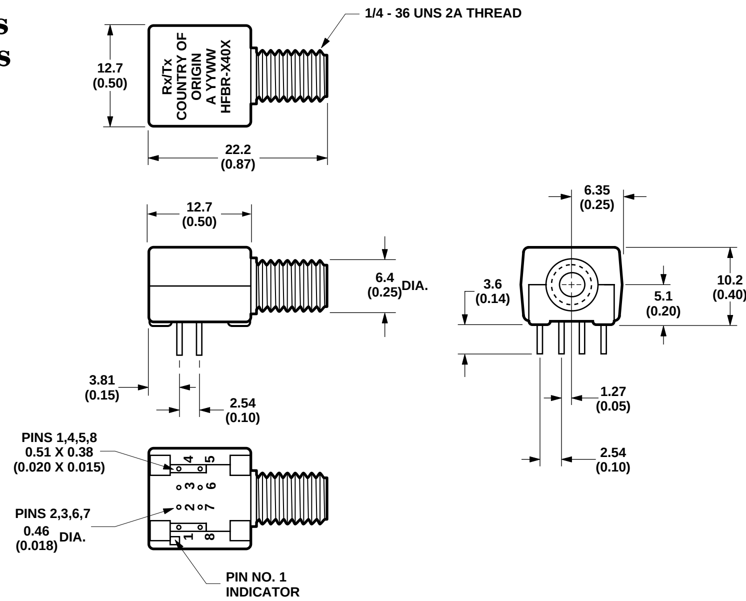
### Recommended Chemicals for Cleaning/Degreasing HFBR-0400 Products

Alcohols: methyl, isopropyl, isobutyl. Aliphatics: hexane, heptane, Other: soap solution, naphtha.

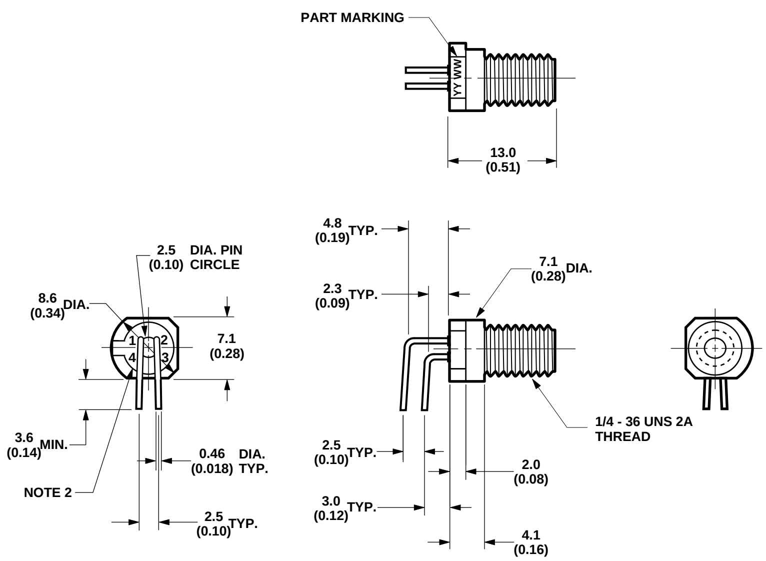
Do not use partially halogenated hydrocarbons such as 1,1.1 trichloroethane, ketones such as MEK, acetone, chloroform, ethyl acetate, methylene dichloride, phenol, methylene chloride, or N-methylpyrolldone. Also, Agilent does not recommend the use of cleaners that use halogenated hydrocarbons because of their potential environmental harm.

# Mechanical Dimensions
# HFBR-0400 SMA Series

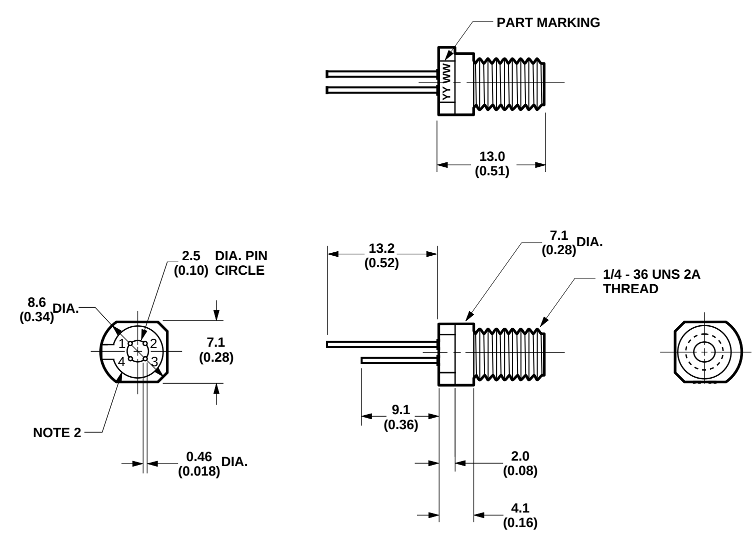
## HFBR-X40X




## HFBR-X43X



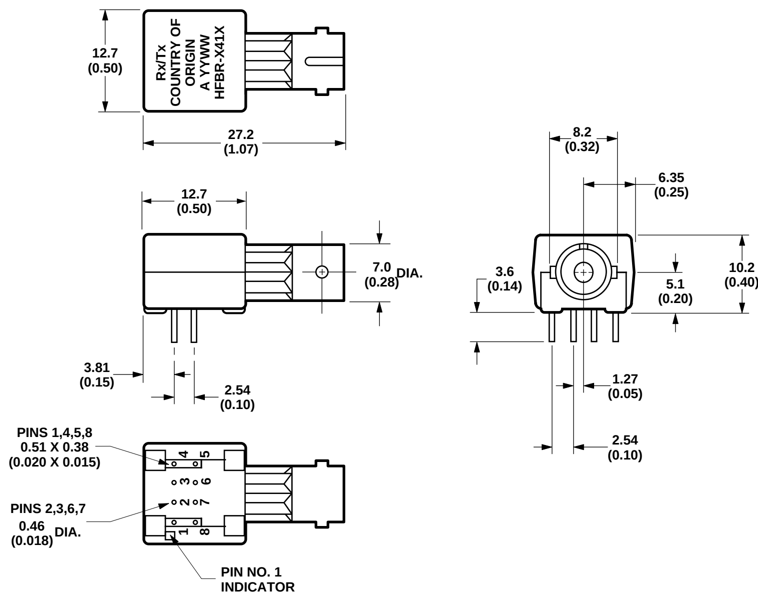

## HFBR-X45X



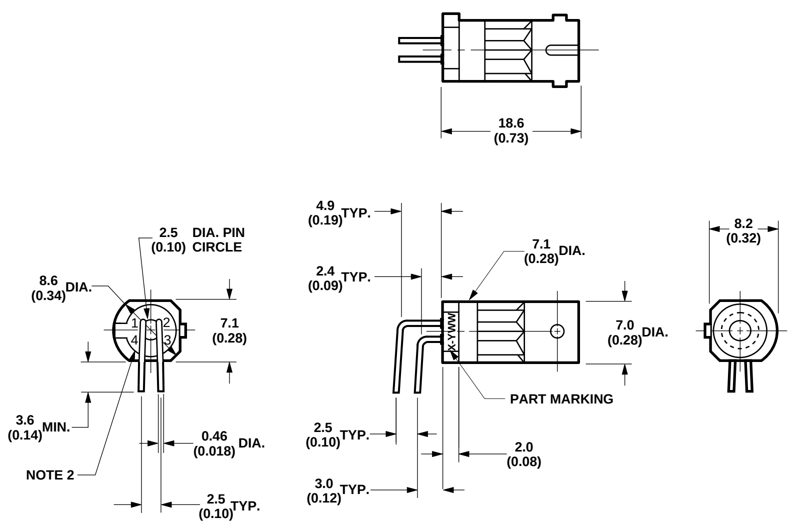

NOTE: ALL DIMENSIONS IN MILLIMETRES AND (INCHES).

# Mechanical Dimensions
# HFBR-0400 ST Series

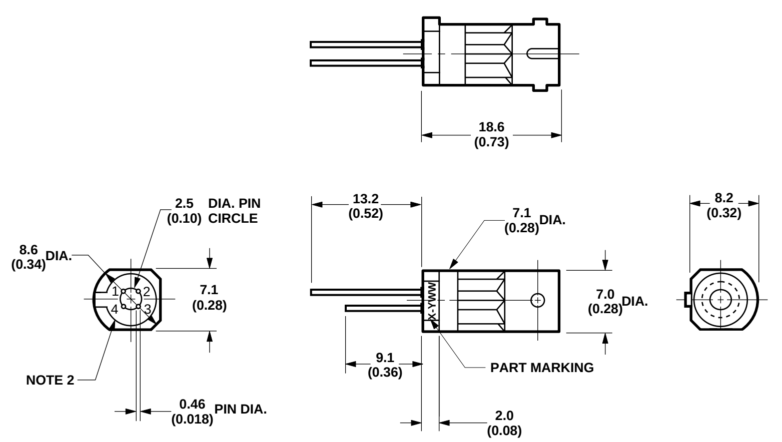
## HFBR-X41X




## HFBR-X44X



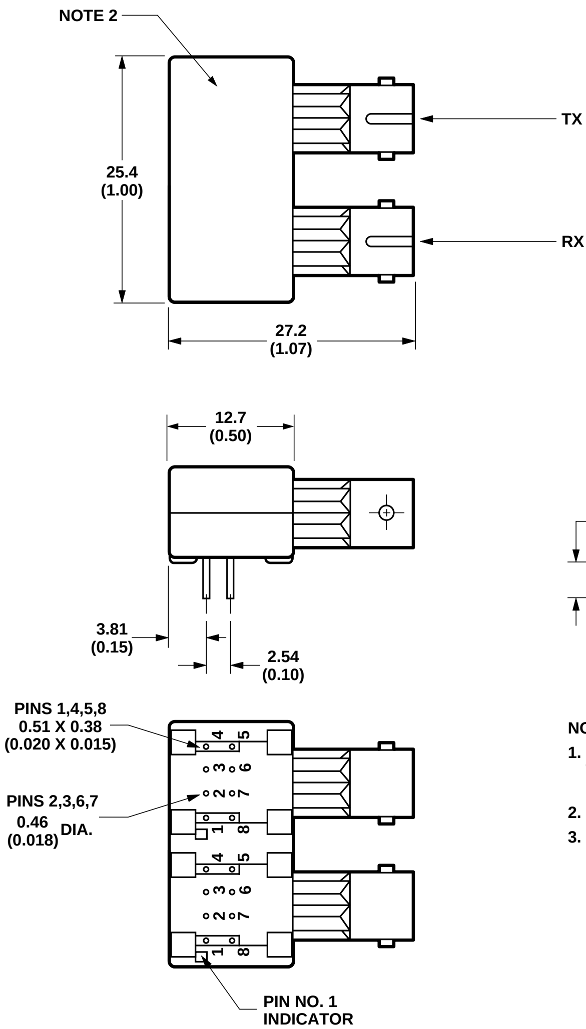

## HFBR-X46X

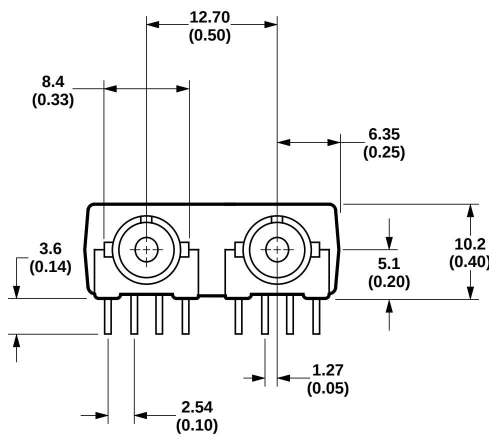



NOTE: ALL DIMENSIONS IN MILLIMETRES AND (INCHES).

# Mechanical Dimensions
# HFBR-0400 ST Series, continued

## HFBR-X41X Duplex



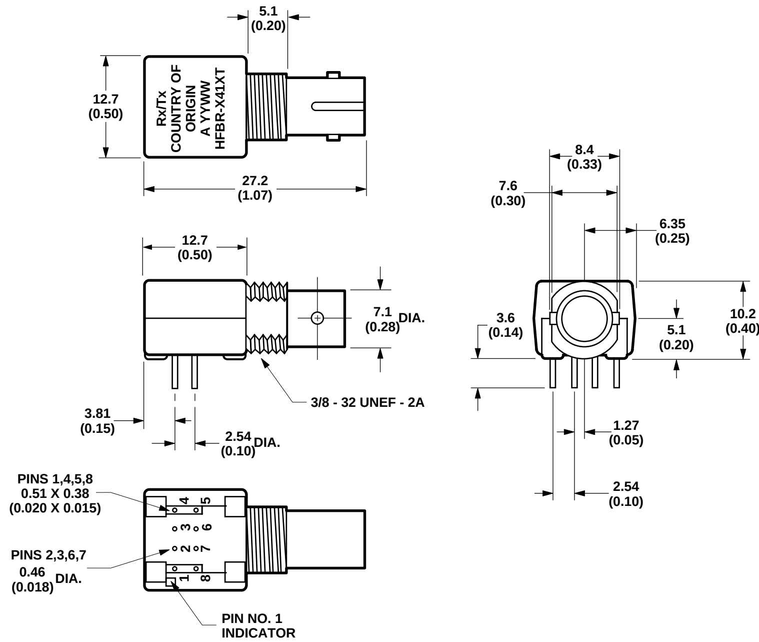




NOTES:

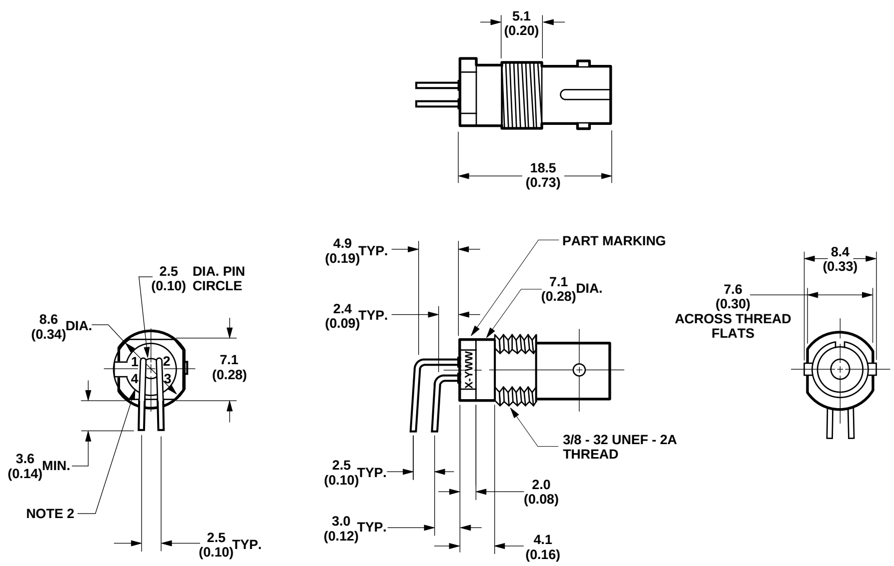
1. DIMENSIONS: MILLIMETERS (INCHES)
   TOLERANCE: .X ± 0.51 mm (.XX ± 0.02 IN.)
   .XX ± 0.13 mm (.XXX ± 0.005 IN.)
2. REFER TP PRODUCT(S) FOR MARKING.
3. 8 LEADS PRESENT MUST BE INSERTABLE INTO 0.040 DIA. HOLES ON 0.100 ROW & CENTER TO CENTER SPACES (USE FIXTURE 10176A FOR PRODUCTION, 10176B FOR QOA, OR EQUIVALENT).

# Mechanical Dimensions HFBR-0400T Threaded ST Series

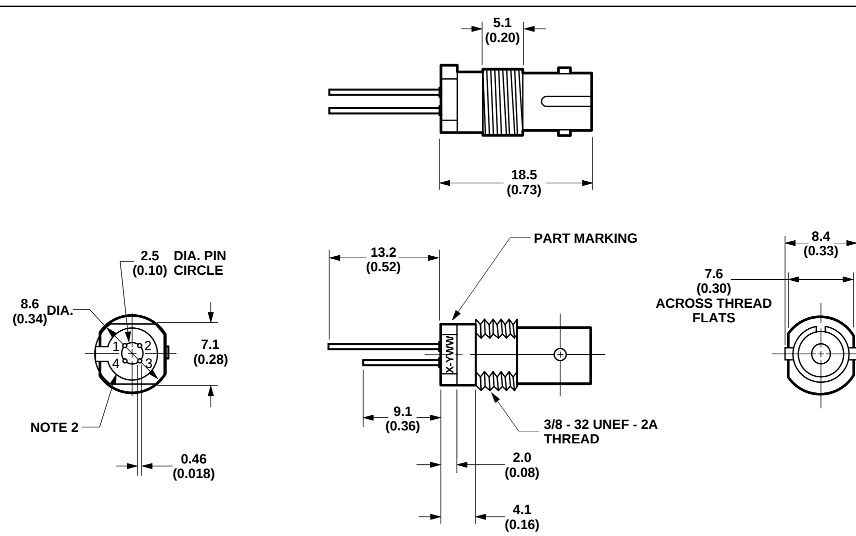
## HFBR-X41XT




## HFBR-X44XT



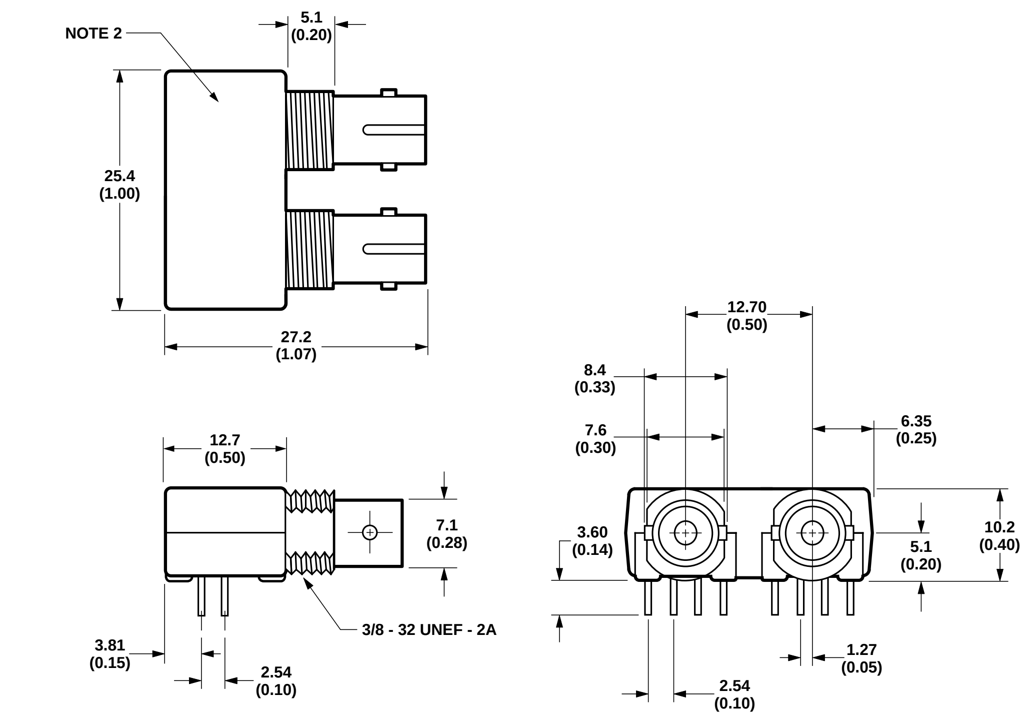

## HFBR-X46XT

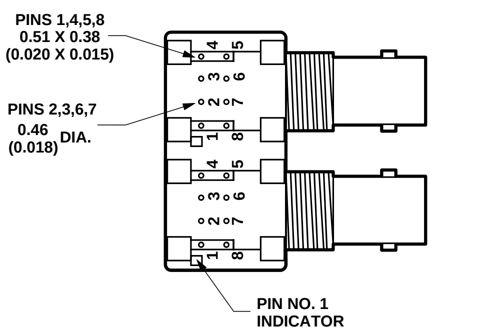



NOTE: ALL DIMENSIONS IN MILLIMETRES AND (INCHES).

# Mechanical Dimensions
# HFBR-0400T Threaded ST Series, continued

### HFBR-X41XT Duplex

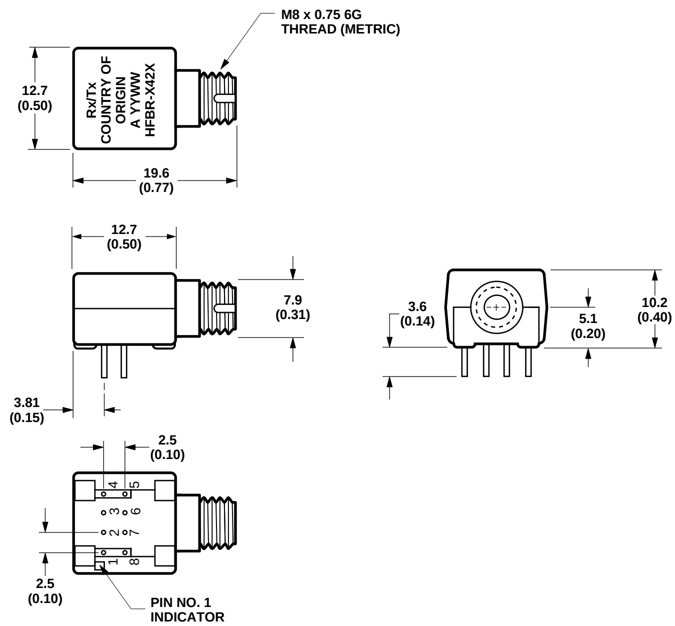



NOTES:

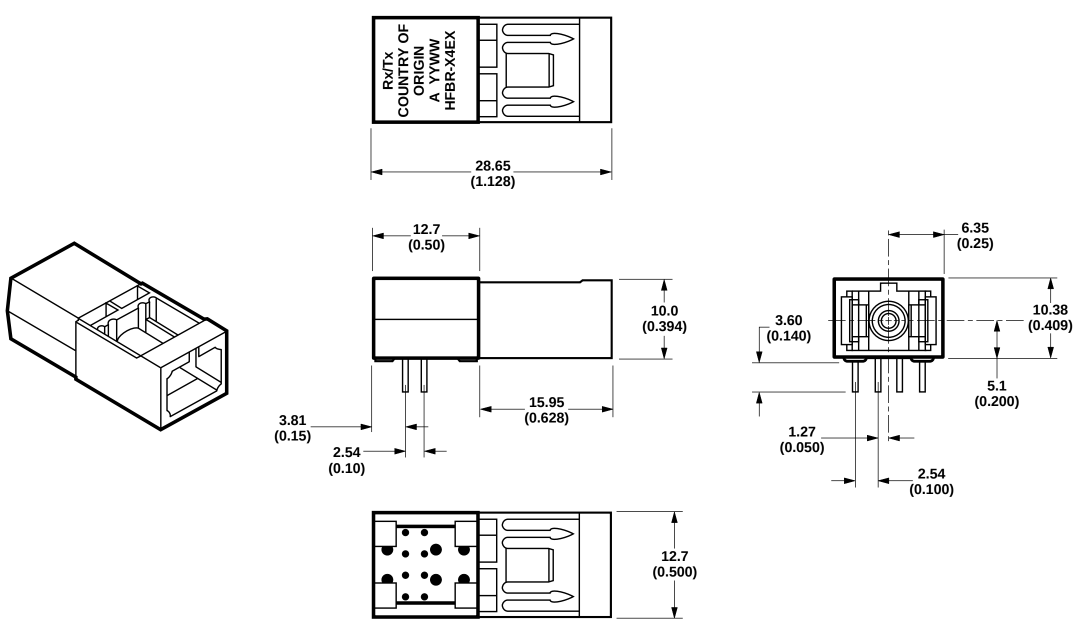
1. DIMENSIONS: MILLIMETERS (INCHES)
   TOLERANCE: .X ± 0.51 mm (.XX ± 0.02 IN.)
   .XX ± 0.13 mm (.XXX ± 0.005 IN.)
2. REFER TP PRODUCT(S) FOR MARKING.
3. 14XXT PRODUCT TO HAVE LIGHT GRAY PORT.
   24XXT PRODUCT TO HAVE DARK GRAY PORT.
   24XXTC PRODUCT TO HAVE BLACK CONDUCTIVE PORT.
4. 8 LEADS PRESENT MUST BE INSERTABLE INTO 0.040 DIA. HOLES ON 0.100 ROW & CENTER TO CENTER SPACES (USE FIXTURE 10176A FOR PRODUCTION, 10176B FOR QOA, OR EQUIVALENT).

## Mechanical Dimensions
## HFBR-0400 FC Series



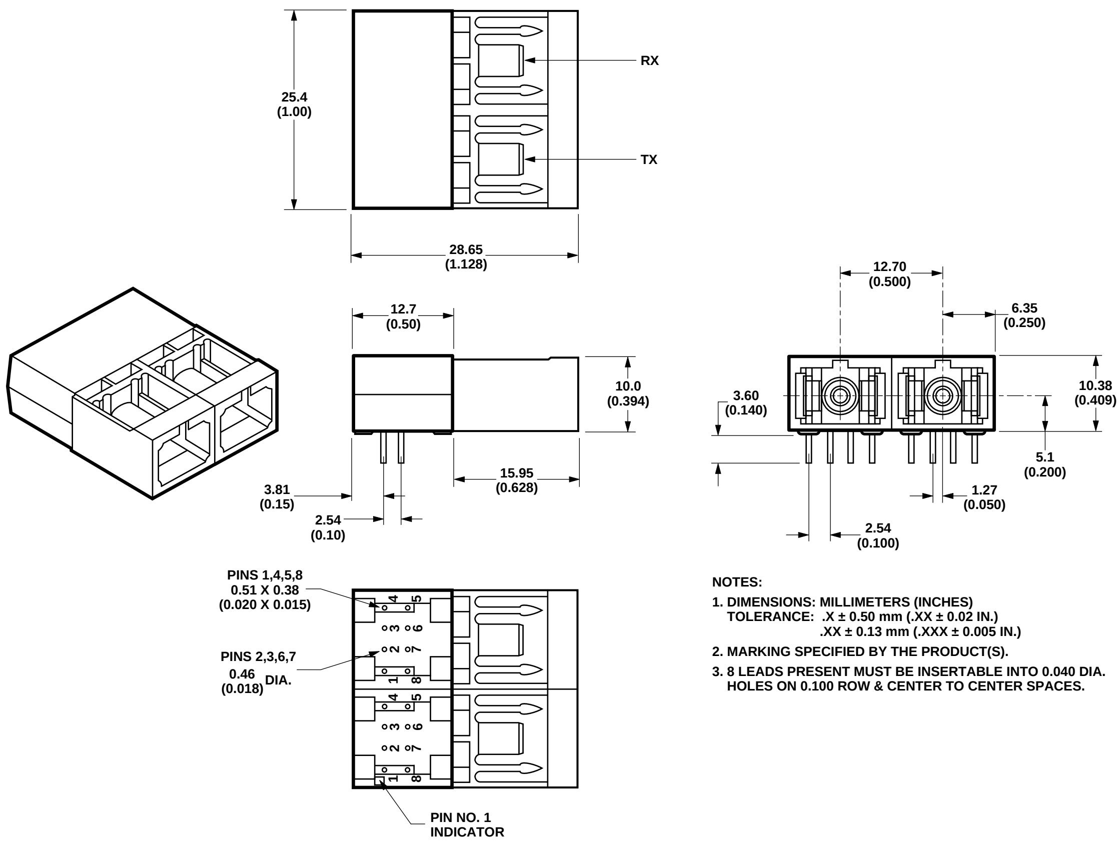

## Mechanical Dimensions
## HFBR-0400 SC Series

### HFBR-X4EX



# Mechanical Dimensions
# HFBR-0400 SC Series, continued

## HFBR-X4EX Duplex




NOTES:

1. DIMENSIONS: MILLIMETERS (INCHES)
   TOLERANCE: .X ± 0.50 mm (.XX ± 0.02 IN.)
   .XX ± 0.13 mm (.XXX ± 0.005 IN.)
2. MARKING SPECIFIED BY THE PRODUCT(S).
3. 8 LEADS PRESENT MUST BE INSERTABLE INTO 0.040 DIA. HOLES ON 0.100 ROW & CENTER TO CENTER SPACES.

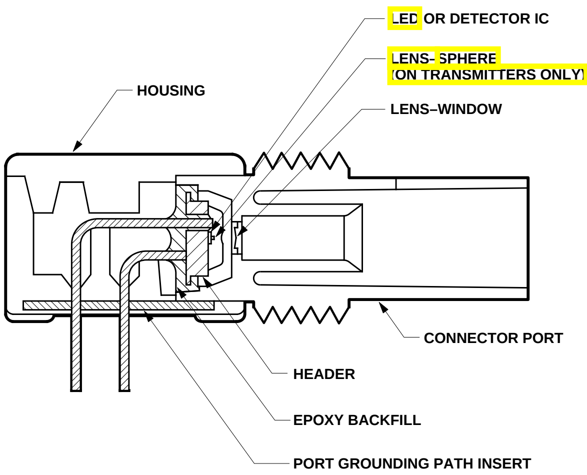
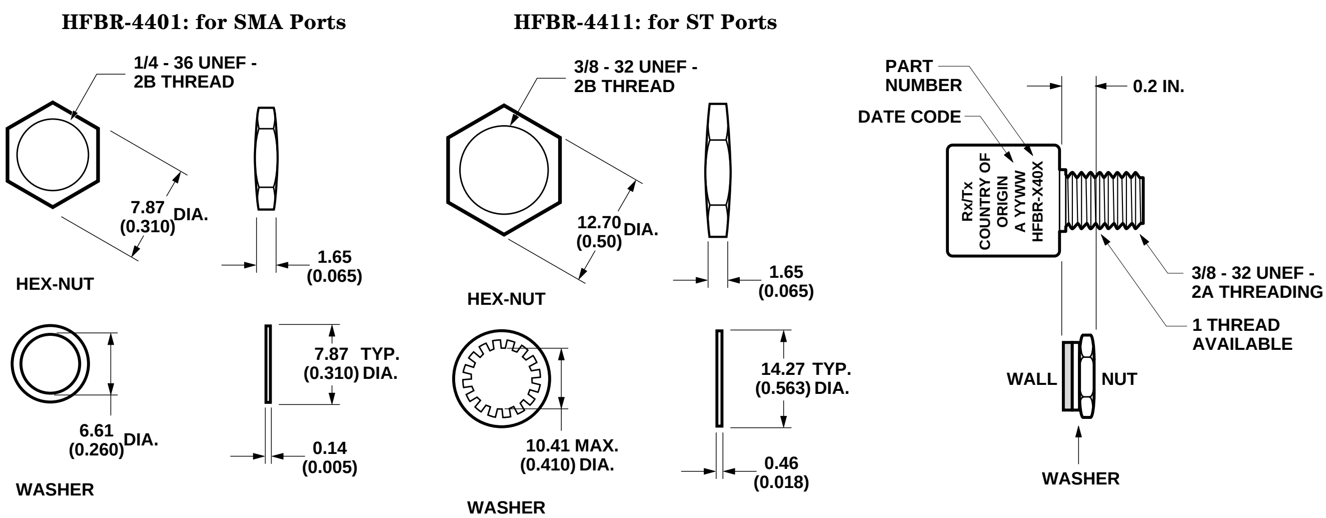



**Figure 1. HFBR-0400 ST Series Cross-Sectional View.**

## Panel Mount Hardware




**(Each HFBR-4401 and HFBR-4411 kit consists of 100 nuts and 100 washers.)**

## Port Cap Hardware

HFBR-4402: 500 SMA Port Caps
HFBR-4120: 500 ST Port Plugs (120 psi)
HFBR-4412: 500 FC Port Caps
HFBR-4417: 500 SC Port Plugs

## Options

In addition to the various port styles available for the HFBR-0400 series products, there are also several extra options that can be ordered. To order an option, simply place the corresponding option number at the end of the part number. For instance, a metal-port option SMA receiver would be HFBR-2406M. You can add any number of options in series at the end of a part number. Please contact your local sales office for further information or browse Agilent's fiber optics home page at http://www.agilent.com/go/fiber

**Option T (Threaded Port Option)**

- Allows ST style port components to be panel mounted.
- Compatible with all current makes of ST multimode connectors
- Mechanical dimensions are compliant with MIL-STD-83522/13
- Maximum wall thickness when using nuts and washers from the HFBR-4411 hardware kit is 2.8 mm (0.11 inch)
- Available on all ST ports

**Option C (Conductive Port Receiver Option)**

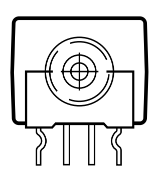
- Designed to withstand electrostatic discharge (ESD) of 25kV to the port
- Significantly reduces effect of electromagnetic interference (EMI) on receiver sensitivity
- Allows designer to separate the signal and conductive port grounds
- Recommended for use in noisy environments
- Available on SMA and threaded ST port style receivers only

**Option M (Metal Port Option)**

- Nickel plated aluminum connector receptacle
- Designed to withstand electrostatic discharge (ESD) of 15kV to the port
- Significantly reduces effect of electromagnetic interference (EMI) on receiver sensitivity
- Allows designer to separate the signal and metal port grounds
- Recommended for use in very noisy environments
- Available on SMA, FC, ST, and threaded ST ports

**Option K (Kinked Lead Option)**

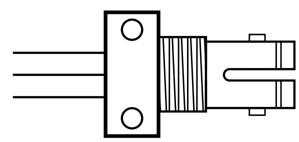
- Grounded outside 4 leads are "kinked"
- Allows components to stay anchored in the PCB during wave solder and aqueous wash processes



**Options TA, TB, HA, HB (Active Device Mount Options)**

*(These options are unrelated to the threaded port option T.)*

- All metal, panel mountable package with a 3 or 4 pin receptacle end
- Available for HFBR-14X4, 24X2 and 24X6 components
- Choose from diamond or square pinout, straight or bent leads ADM Picture

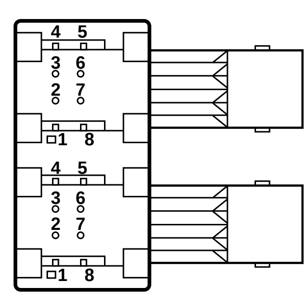


- TA = Square pinout/straight leads
  TB = Square pinout/bent leads
  HA = Diamond pinout/straight leads
  HB = Diamond pinout/bent leads

**Duplex Option**

In addition to the standard options, some HFBR-0400 series products come in a duplex configuration with the transmitter on the left and the receiver on the right. This option was designed for ergonomic and efficient manufacturing. The following part numbers are available in the duplex option:

HFBR-5414 (Duplex ST)
HFBR-5414T (Duplex Threaded ST)
HFBR-54E4 (Duplex SC)



# Typical Link Data

## HFBR-0400 Series

### Description

The following technical data is taken from 4 popular links using the HFBR-0400 series: the 5 MBd link, Ethernet 20 MBd link, Token Ring 32 MBd link, and the 155 MBd link. The data given corresponds to transceiver solutions combining the HFBR-0400 series components and various recommended transceiver design circuits using off-the-shelf electrical components. This data is meant to be regarded as an example of typical link performance for a given design and does not call out any link limitations. Please refer to the appropriate application note given for each link to obtain more information.

### 5 MBd Link (HFBR-14XX/24X2)

Link Performance -40°C to +85°C unless otherwise specified

| Parameter | Symbol | Min. | Typ. | Max. | Units | Conditions | Reference |
|---|---|---|---|---|---|---|---|
| Optical Power Budget with 50/125 µm fiber | $OPB_{50}$ | 4.2 | 9.6 | | dB | HFBR-14X4/24X2 NA = 0.2 | Note 1 |
| Optical Power Budget with 62.5/125 µm fiber | $OPB_{62.5}$ | 8.0 | 15 | | dB | HFBR-14X4/24X2 NA = 0.27 | Note 1 |
| Optical Power Budget with 100/140 µm fiber | $OPB_{100}$ | 8.0 | 15 | | dB | HFBR-14X2/24X2 NA = 0.30 | Note 1 |
| Optical Power Budget with 200 µm fiber | $OPB_{200}$ | 12 | 20 | | dB | HFBR-14X2/24X2 NA = 0.37 | Note 1 |
| Date Rate Synchronous | | dc | | 5 | MBd | | Note 2 |
| Asynchronous | | dc | | 2.5 | MBd | | Note 3, Fig. 7 |
| Propagation Delay LOW to HIGH | $t_{PLH}$ | | 72 | | ns | $T_A$ = 25°C, $P_R$ = -21 dBm Peak | Figs. 6, 7, 8 |
| Propagation Delay HIGH to LOW | $t_{PHL}$ | | 46 | | ns | | |
| System Pulse Width Distortion | $t_{PLH}$-$t_{PHL}$ | | 26 | | ns | Fiber cable length = 1 m | |
| Bit Error Rate | BER | | | $10^{-9}$ | | Data Rate <5 Bd $P_R$ > -24 dBm Peak | |

**Notes:**

1. OPB at $T_A$ = -40 to 85°C, $V_{CC}$ = 5.0 V dc, $I_{F,ON}$ = 60 mA. $P_R$ = -24 dBm peak.
2. Synchronous data rate limit is based on these assumptions: a) 50% duty factor modulation, e.g., Manchester I or BiPhase Manchester II; b) continuous data; c) PLL Phase Lock Loop demodulation; d) TTL threshold.
3. Asynchronous data rate limit is based on these assumptions: a) NRZ data; b) arbitrary timing-no duty factor restriction; c) TTL threshold.

## 5 MBd Logic Link Design

If resistor $R_1$ in Figure 2 is 70.4 Ω, a forward current $I_F$ of 48 mA is applied to the HFBR-14X4 LED transmitter. With $I_F$ = 48 mA the HFBR-14X4/24X2 logic link is guaranteed to work with 62.5/125 µm fiber optic cable over the entire range of 0 to 1750 meters at a data rate of dc to 5 MBd, with arbitrary data format and pulse width distortion typically less than 25%. By setting $R_1$ = 115 Ω, the transmitter can be driven with $I_F$ = 30 mA, if it is desired to economize on power or achieve lower pulse distortion.

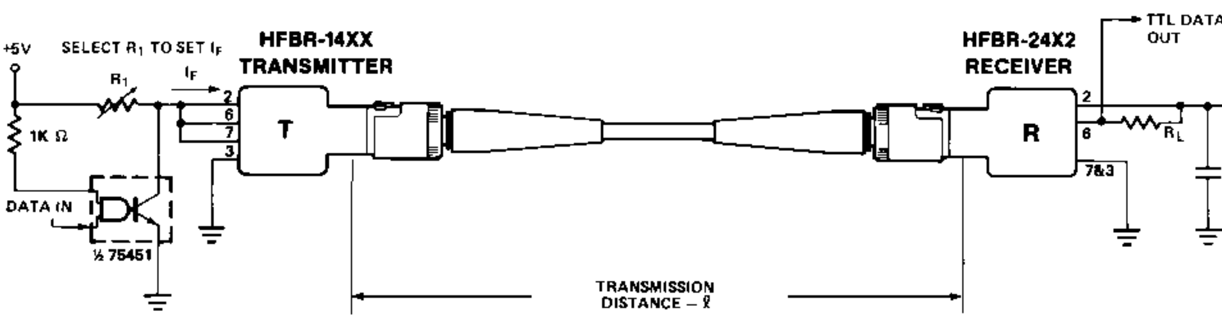
The following example will illustrate the technique for selecting the appropriate value of $I_F$ and $R_1$.

Maximum distance required = 400 meters. From Figure 3 the drive current should be 15 mA. From the transmitter data $V_F$ = 1.5 V (max.) at $I_F$ = 15 mA as shown in Figure 9.

$$R_1 = \frac{V_{CC} - V_F}{I_F} = \frac{5\text{ V} - 1.5\text{ V}}{15\text{ mA}}$$

$$R_1 = 233\ \Omega$$

The curves in Figures 3, 4, and 5 are constructed assuming no in-line splice or any additional system loss. Should the link consists of any in-line splices, these curves can still be used to calculate link limits provided they are shifted by the additional system loss expressed in dB. For example, Figure 3 indicates that with 48 mA of transmitter drive current, a 1.75 km link distance is achievable with 62.5/125 µm fiber which has a maximum attenuation of 4 dB/km. With 2 dB of additional system loss, a 1.25 km link distance is still achievable.




NOTE:
IT IS ESSENTIAL THAT A BYPASS CAPACITOR (0.01 µF TO 0.1 µF CERAMIC) BE CONNECTED FROM PIN 2 TO PIN 7 OF THE RECEIVER. TOTAL LEAD LENGTH BETWEEN BOTH ENDS OF THE CAPACITOR AND THE PINS SHOULD NOT EXCEED 20 mm.

**Figure 2. Typical Circuit Configuration.**

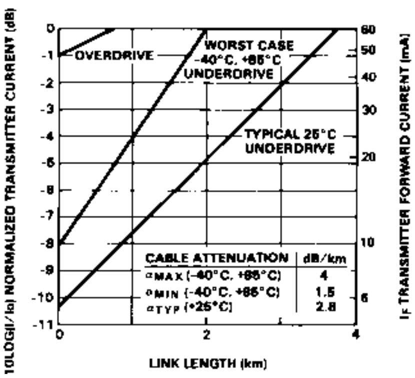



**Figure 3. HFBR-1414/HFBR-2412 Link Design Limits with 62.5/125 µm Cable.**

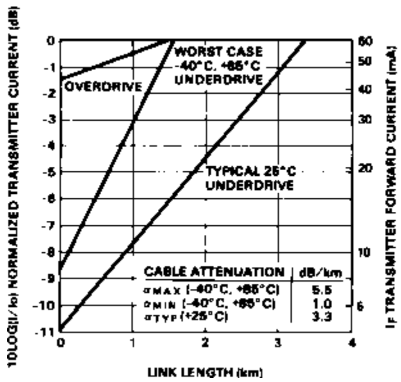



**Figure 4. HFBR-14X2/HFBR-24X2 Link Design Limits with 100/140 µm Cable.**

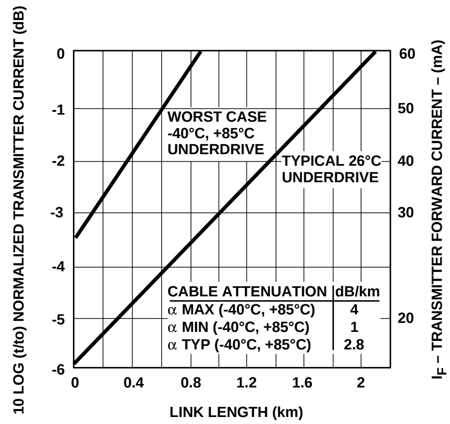



**Figure 5. HFBR-14X4/HFBR-24X2 Link Design Limits with 50/125 µm Cable.**

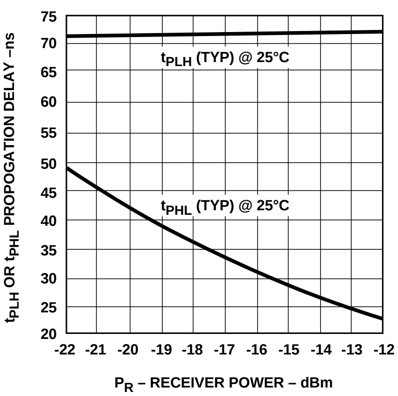



**Figure 6. Propagation Delay through System with One Meter of Cable.**

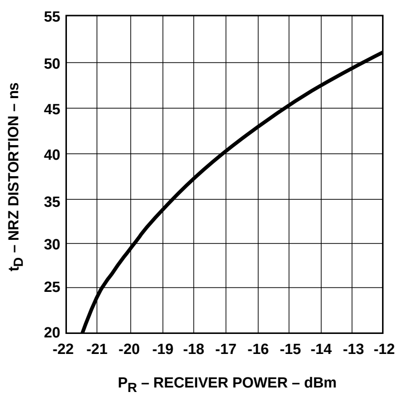



**Figure 7. Typical Distortion of Pseudo Random Data at 5 Mb/s.**

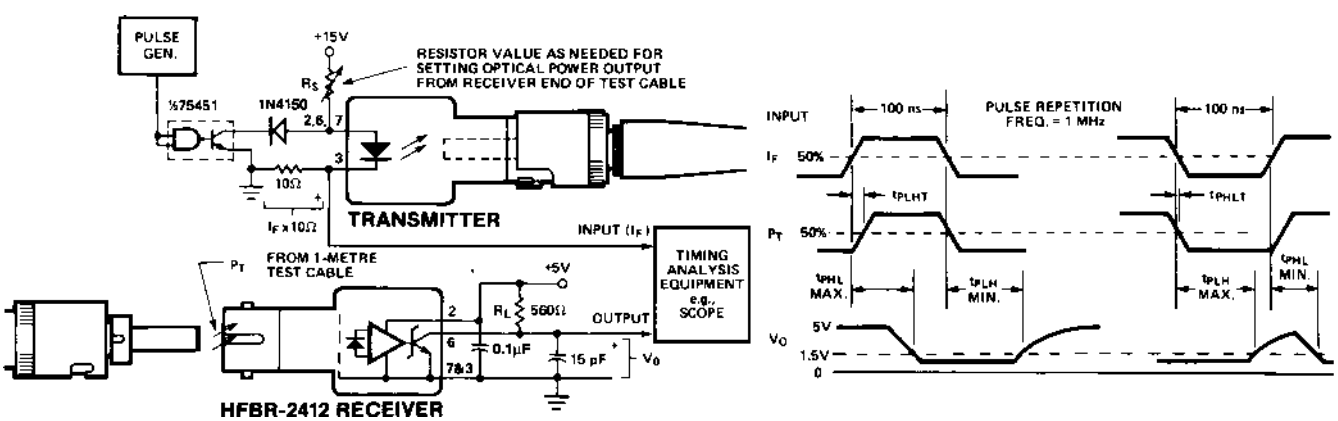



**Figure 8. System Propagation Delay Test Circuit and Waveform Timing Definitions.**

## Ethernet 20 MBd Link (HFBR-14X4/24X6)

(refer to Application Note 1038 for details)

### Typical Link Performance

| Parameter | Symbol | Typ.[1,2] | Units | Conditions |
|---|---|---|---|---|
| Receiver Sensitivity | | -34.4 | dBm average | 20 MBd D2D2 Hexadecimal Data 2 km 62.5/125 μm fiber |
| Link Jitter | | 7.56 | ns pk-pk | ECL Out Receiver |
| | | 7.03 | ns pk-pk | TTL Out Receiver |
| Transmitter Jitter | | 0.763 | ns pk-pk | 20 MBd D2D2 Hexadecimal Data |
| Optical Power | $P_T$ | -15.2 | dBm average | 20 MBd D2D2 Hexadecimal Data Peak $I_{F,ON}$ = 60 mA |
| LED rise time | $t_r$ | 1.30 | ns | 1 MHz Square Wave Input |
| LED fall time | $t_f$ | 3.08 | ns | |
| Mean difference | $\|t_r - t_f\|$ | 1.77 | ns | |
| Bit Error Rate | BER | $10^{-10}$ | | |
| Output Eye Opening | | 36.7 | ns | At AUI Receiver Output |
| Data Format 50% Duty Factor | | 20 | MBd | |

**Notes:**
1. Typical data at $T_A$ = 25°C, $V_{CC}$ = 5.0 V dc.
2. Typical performance of circuits shown in Figure 1 and Figure 3 of AN-1038 (see applications support section).

## Token Ring 32 MBd Link (HFBR-14X4/24X6)

(refer to Application Note 1065 for details)

### Typical Link Performance

| Parameter | Symbol | Typ.[1,2] | Units | Conditions |
|---|---|---|---|---|
| Receiver Sensitivity | | -34.1 | dBm average | 32 MBd D2D2 Hexadecimal Data 2 km 62.5/125 μm fiber |
| Link Jitter | | 6.91 | ns pk-pk | ECL Out Receiver |
| | | 5.52 | ns pk-pk | TTL Out Receiver |
| Transmitter Jitter | | 0.823 | ns pk-pk | 32 MBd D2D2 Hexadecimal Data |
| Optical Power Logic Level “0” | $P_{T\ ON}$ | -12.2 | dBm peak | Transmitter TTL in $I_{F\ ON}$ = 60 mA, $I_{F\ OFF}$ = 1 mA |
| Optical Power Logic Level “1” | $P_{T\ OFF}$ | -82.2 | | |
| LED Rise Time | $t_r$ | 1.3 | nsec | 1 MHz Square Wave Input |
| LED Fall Time | $t_f$ | 3.08 | nsec | |
| Mean Difference | $\|t_r - t_f\|$ | 1.77 | nsec | |
| Bit Error Rate | BER | $10^{-10}$ | | |
| Data Format 50% Duty Factor | | 32 | MBd | |

**Notes:**
1. Typical data at $T_A$ = 25°C, $V_{CC}$ = 5.0 V dc.
2. Typical performance of circuits shown in Figure 1 and Figure 3 of AN-1065 (see applications support section)

## 155 MBd Link (HFBR-14X4/24X6)

(refer to Application Bulletin 78 for details)

**Typical Link Performance**

| Parameter | Symbol | Typ.[1,2] | Units | Max. | Units | Conditions | Ref. |
|---|---|---|---|---|---|---|---|
| Optical Power Budget with 50/125 μm fiber | $OPB_{50}$ | 7.9 | 13.9 | | dB | NA = 0.2 | Note 2 |
| Optical Power Budget with 62.5/125 μm fiber | $OPB_{62}$ | 11.7 | 17.7 | | dB | NA = 0.27 | |
| Optical Power Budget with 100/140 μm fiber | $OPB_{100}$ | 11.7 | 17.7 | | dB | NA = 0.30 | |
| Optical Power Budget with 200 μm HCSfFiber | $OPB_{200}$ | 16.0 | 22.0 | | dB | NA = 0.35 | |
| Data Format 20% to 80% Duty Factor | | 1 | | 175 | MBd | | |
| System Pulse Width Distortion | $\|t_{PLH} - t_{PHL}\|$ | | 1 | | ns | PR = -7 dBm Peak<br>1 meter 62.5/125 μm fiber | |
| Bit Error Rate | BER | | $10^{-9}$ | | | Data Rate < 100 MBaud<br>PR >-31 dBm Peak | Note 2 |

**Notes:**

1. Typical data at $T_A = 25°C$, $V_{CC} = 5.0$ V dc, PECL serial interface.
2. Typical OPB was determined at a probability of error (BER) of $10^{-9}$. Lower probabilities of error can be achieved with short fibers that have less optical loss.

## HFBR-14X2/14X4 Low-Cost High-Speed Transmitters

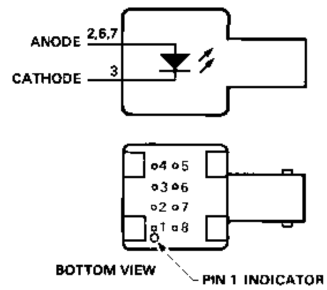
### Description

The HFBR-14XX fiber optic transmitter contains an 820 nm AlGaAs emitter capable of efficiently launching optical power into four different optical fiber sizes: 50/125 µm, 62.5/125 µm, 100/140 µm, and 200 µm HCS®. This allows the designer flexibility in choosing the fiber size. The HFBR-14XX is designed to operate with the Agilent HFBR-24XX fiber optic receivers.

The HFBR-14XX transmitter's high coupling efficiency allows the emitter to be driven at low current levels resulting in low power consumption and increased reliability of the transmitter. The HFBR-14X4 high power transmitter is optimized for small size fiber and typically can launch -15.8 dBm optical power at 60 mA into 50/125 µm fiber and -12 dBm into 62.5/125 µm fiber. The HFBR-14X2 standard transmitter typically can launch -12 dBm of optical power at 60 mA into 100/140 µm fiber cable. It is ideal for large size fiber such as 100/140 µm. The high launched optical power level is useful for systems where star couplers, taps, or inline connectors create large fixed losses.

Consistent coupling efficiency is assured by the double-lens optical system (Figure 1). Power coupled into any of the three fiber types varies less than 5 dB from part to part at a given drive current and temperature. Consistent coupling efficiency reduces receiver dynamic range requirements which allows for longer link lengths.

### Housed Product

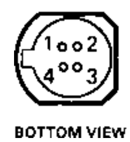



| PIN | FUNCTION |
|---|---|
| 1† | N.C. |
| 2 | ANODE |
| 3* | CATHODE |
| 4† | N.C. |
| 5† | N.C. |
| 6 | ANODE |
| 7* | ANODE |
| 8† | N.C. |

*PINS 2,6 AND 7 ARE ELECTRICALLY CONNECTED TO HEADER

†PINS 1, 4, 5, AND 8 ARE ELECTRICALLY CONNECTED

### Unhoused Product




| PIN | FUNCTION |
|---|---|
| 1 | ANODE |
| 2 | CATHODE |
| 3 | ANODE |
| 4 | ANODE |

## Absolute Maximum Ratings

| Parameter | | Symbol | Min. | Max. | Units | Reference |
|---|---|---|---|---|---|---|
| Storage Temperature | | $T_S$ | -55 | +85 | °C | |
| Operating Temperature | | $T_A$ | -40 | +85 | °C | |
| Lead Soldering Cycle | Temp. | | | +260 | °C | |
| | Time | | | 10 | sec | |
| Forward Input Current | Peak | $I_{FPK}$ | | 200 | mA | Note 1 |
| | dc | $I_{Fdc}$ | | 100 | mA | |
| Reverse Input Voltage | | $V_{BR}$ | | 1.8 | V | |

## Electrical/Optical Specifications -40°C to +85°C unless otherwise specified.

| Parameter | Symbol | Min. | Typ.[2] | Max. | Units | Conditions | Reference |
|---|---|---|---|---|---|---|---|
| Forward Voltage | $V_F$ | 1.48 | 1.70 | 2.09 | V | $I_F$ = 60 mA dc | Figure 9 |
| | | | 1.84 | | | $I_F$ = 100 mA dc | |
| Forward Voltage Temperature Coefficient | $\Delta V_F/\Delta T$ | | -0.22 | | mV/°C | $I_F$ = 60 mA dc | Figure 9 |
| | | | -0.18 | | | $I_F$ = 100 mA dc | |
| Reverse Input Voltage | $V_{BR}$ | 1.8 | 3.8 | | V | $I_F$ = 100 µA dc | |
| Peak Emission Wavelength | $\lambda_P$ | 792 | 820 | 865 | nm | | |
| Diode Capacitance | $C_T$ | | 55 | | pF | V = 0, f = 1 MHz | |
| Optical Power Temperature Coefficient | $\Delta P_T/\Delta T$ | | -0.006 | | dB/°C | I = 60 mA dc | |
| | | | -0.010 | | | I = 100 mA dc | |
| Thermal Resistance | $\theta_{JA}$ | | 260 | | °C/W | | Notes 3, 8 |
| 14X2 Numerical Aperture | NA | | 0.49 | | | | |
| 14X4 Numerical Aperture | NA | | 0.31 | | | | |
| 14X2 Optical Port Diameter | D | | 290 | | µm | | Note 4 |
| 14X4 Optical Port Diameter | D | | 150 | | µm | | Note 4 |

## HFBR-14X2 Output Power Measured Out of 1 Meter of Cable

| Parameter | Symbol | Min. | Typ.[2] | Max. | Unit | Conditions | | Reference |
|---|---|---|---|---|---|---|---|---|
| 50/125 µm Fiber Cable NA = 0.2 | $P_{T50}$ | -21.8 | -18.8 | -16.8 | dBm peak | $T_A$ = 25°C | $I_F$ = 60 mA dc | Notes 5, 6, 9 |
| | | -22.8 | | -15.8 | | | | |
| | | -20.3 | -16.8 | -14.4 | | $T_A$ = 25°C | $I_F$ = 100 mA dc | |
| | | -21.9 | | -13.8 | | | | |
| 62.5/125 µm Fiber Cable NA = 0.275 | $P_{T62}$ | -19.0 | -16.0 | -14.0 | dBm peak | $T_A$ = 25°C | $I_F$ = 60 mA dc | |
| | | -20.0 | | -13.0 | | | | |
| | | -17.5 | -14.0 | -11.6 | | $T_A$ = 25°C | $I_F$ = 100 mA dc | |
| | | -19.1 | | -11.0 | | | | |
| 100/140 µm Fiber Cable NA = 0.3 | $P_{T100}$ | -15.0 | -12.0 | -10.0 | dBm peak | $T_A$ = 25°C | $I_F$ = 60 mA dc | |
| | | 16.0 | | -9.0 | | | | |
| | | -13.5 | -10.0 | -7.6 | | $T_A$ = 25°C | $I_F$ = 100 mA dc | |
| | | -15.1 | | -7.0 | | | | |
| 200 µm HCS Fiber Cable NA = 0.37 | $P_{T200}$ | -10.7 | -7.1 | -4.7 | dBm peak | $T_A$ = 25°C | $I_F$ = 60 mA dc | |
| | | -11.7 | | -3.7 | | | | |
| | | -9.2 | -5.2 | -2.3 | | $T_A$ = 25°C | $I_F$ = 100 mA dc | |
| | | -10.8 | | -1.7 | | | | |

*CAUTION: The small junction sizes inherent to the design of these components increase the components' susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of these components to prevent damage and/or degradation which may be induced by ESD.*

### HFBR-14X4 Output Power Measured out of 1 Meter of Cable

| Parameter | Symbol | Min. | Typ.[2] | Max. | Unit | Conditions | | Reference |
|---|---|---|---|---|---|---|---|---|
| 50/125 μm Fiber Cable NA = 0.2 | PT50 | -18.8 | -15.8 | -13.8 | dBm peak | $T_A$ = 25°C | $I_F$ = 60 mA dc | Notes 5, 6, 9 |
| | | -19.8 | | -12.8 | | | | |
| | | -17.3 | -13.8 | -11.4 | | $T_A$ = 25°C | $I_F$ = 100 mA dc | |
| | | -18.9 | | -10.8 | | | | |
| 62.5/125 μm Fiber Cable NA = 0.275 | PT62 | -15.0 | -12.0 | -10.0 | dBm peak | $T_A$ = 25°C | $I_F$ = 60 mA dc | |
| | | -16.0 | | -9.0 | | | | |
| | | -13.5 | -10.0 | -7.6 | | $T_A$ = 25°C | $I_F$ = 100 mA dc | |
| | | -15.1 | | -7.0 | | | | |
| 100/140 μm Fiber Cable NA = 0.3 | PT100 | -9.5 | -6.5 | -4.5 | dBm peak | $T_A$ = 25°C | $I_F$ = 60 mA dc | |
| | | -10.5 | | -3.5 | | | | |
| | | -8.0 | -4.5 | -2.1 | | $T_A$ = 25°C | $I_F$ = 100 mA dc | |
| | | -9.6 | | -1.5 | | | | |
| 200 μm HCS Fiber Cable NA = 0.37 | PT200 | -5.2 | -3.7 | +0.8 | dBm peak | $T_A$ = 25°C | $I_F$ = 60 mA dc | |
| | | -6.2 | | +1.8 | | | | |
| | | -3.7 | -1.7 | +3.2 | | $T_A$ = 25°C | $I_F$ = 100 mA dc | |
| | | -5.3 | | +3.8 | | | | |

### 14X2/14X4 Dynamic Characteristics

| Parameter | Symbol | Min. | Typ.[2] | Max. | Units | Conditions | Reference |
|---|---|---|---|---|---|---|---|
| Rise Time, Fall Time (10% to 90%) | $t_r$, $t_f$ | | 4.0 | 6.5 | nsec No Pre-bias | $I_F$ = 60 mA Figure 12 | Note 7, |
| Rise Time, Fall Time (10% to 90%) | $t_r$, $t_f$ | | 3.0 | | nsec | $I_F$ = 10 to 100 mA | Note 7, Figure 11 |
| Pulse Width Distortion | PWD | | 0.5 | | nsec | | Figure 11 |

**Notes:**
1. For $I_{FPK}$ > 100 mA, the time duration should not exceed 2 ns.
2. Typical data at $T_A$ = 25°C.
3. Thermal resistance is measured with the transmitter coupled to a connector assembly and mounted on a printed circuit board.
4. D is measured at the plane of the fiber face and defines a diameter where the optical power density is within 10 dB of the maximum.
5. $P_T$ is measured with a large area detector at the end of 1 meter of mode stripped cable, with an ST® precision ceramic ferrule (MIL-STD-83522/13) for HFBR-1412/1414, and with an SMA 905 precision ceramic ferrule for HFBR-1402/1404.
6. When changing μW to dBm, the optical power is referenced to 1 mW (1000 μW). Optical Power P (dBm) = 10 log P (μW)/1000 μW.
7. Pre-bias is recommended if signal rate >10 MBd, see recommended drive circuit in Figure 11.
8. Pins 2, 6 and 7 are welded to the anode header connection to minimize the thermal resistance from junction to ambient. To further reduce the thermal resistance, the anode trace should be made as large as is consistent with good RF circuit design.
9. Fiber NA is measured at the end of 2 meters of mode stripped fiber, using the far-field pattern. NA is defined as the sine of the half angle,determined at 5% of the peak intensity point. When using other manufacturer's fiber cable, results will vary due to differing NA values and specification methods.

**All HFBR-14XX LED transmitters are classified as IEC 825-1 Accessible Emission Limit (AEL) Class 1 based upon the current proposed draft scheduled to go in to effect on January 1, 1997. AEL Class 1 LED devices are considered eye safe. Contact your Agilent sales representative for more information.**

*CAUTION: The small junction sizes inherent to the design of these components increase the components' susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of these components to prevent damage and/or degradation which may be induced by ESD.*

## Recommended Drive Circuits

The circuit used to supply current to the LED transmitter can significantly influence the optical switching characteristics of the LED. The optical rise/fall times and propagation delays can be improved by using the appropriate circuit techniques. The LED drive circuit shown in Figure 11 uses frequency compensation to reduce the typical rise/fall times of the LED and a small pre-bias voltage to minimize propagation delay differences that cause pulse-width distortion. The circuit will typically produce rise/fall times of 3 ns, and a total jitter including pulse-width distortion of less than 1 ns. This circuit is recommended for applications requiring low edge jitter or high-speed data transmission at signal rates of up to 155 MBd. Component values for this circuit can be calculated for different LED drive currents using the equations shown below. For additional details about LED drive circuits, the reader is encouraged to read Agilent Application Bulletin 78 and Application Note 1038.

$$R_y = \frac{(V_{CC} - V_F) + 3.97\,(V_{CC} - V_F - 1.6\text{ V})}{I_{F\,ON}\,(A)}$$

$$R_{X1} = \frac{1}{2}\left(\frac{R_y}{3.97}\right)$$

$$R_{EQ2}(\Omega) = R_{X1} - 1$$

$$R_{X2} = R_{X3} = R_{X4} = 3(R_{EQ2})$$

$$C(pF) = \frac{2000(ps)}{R_{X1}(\Omega)}$$

*Example for $I_{F\,ON}$ = 100 mA: $V_F$ can be obtained from Figure 9* (= 1.84 *V*).

$$R_y = \frac{(5 - 1.84) + 3.97\,(5 - 1.84 - 1.6)}{0.100}$$

$$R_y = \frac{3.16 + 6.19}{0.100} = 93.5\ \Omega$$

$$R_{X1} = \frac{1}{2}\left(\frac{93.5}{3.97}\right) = 11.8\ \Omega$$

$$R_{EQ2} = 11.8 - 1 = 10.8\ \Omega$$

$$R_{X2} = R_{X3} = R_{X4} = 3(10.8) = 32.4\ \Omega$$

$$C = \frac{2000\text{ ps}}{11.8\ \Omega} = 169\text{ pF}$$

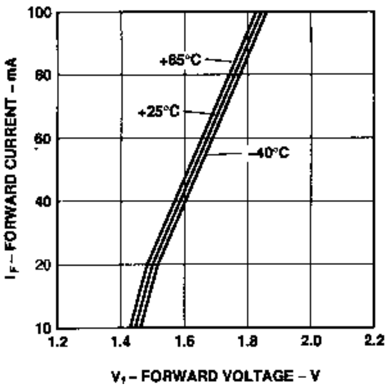



Figure 9. Forward Voltage and Current Characteristics.

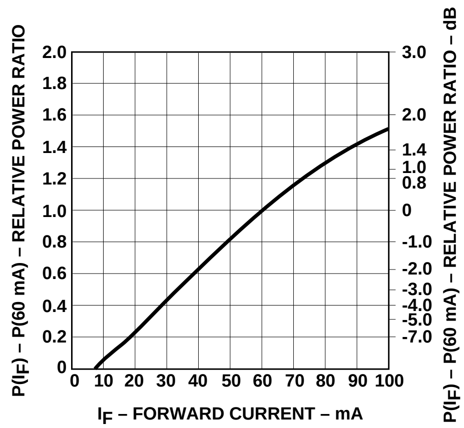



Figure 10. Normalized Transmitter Output vs. Forward Current.

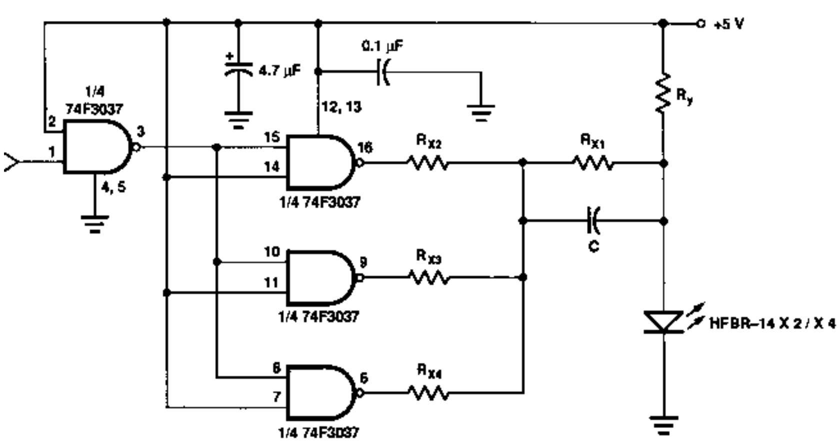



Figure 11. Recommended Drive Circuit.

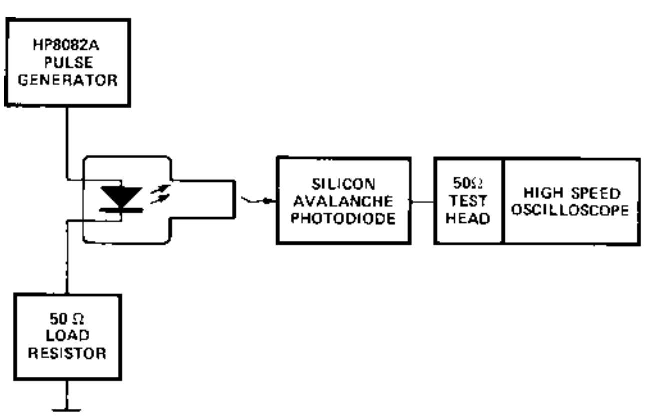



Figure 12. Test Circuit for Measuring $t_r$, $t_f$.

## HFBR-24X2 Low-Cost 5 MBd Receiver

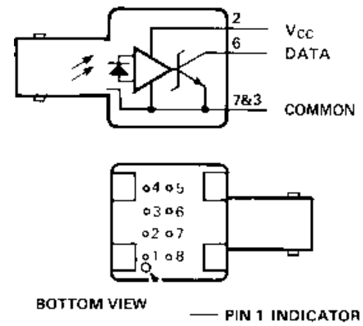
### Description

The HFBR-24X2 fiber optic receiver is designed to operate with the Hewlett-Packard HFBR-14XX fiber optic transmitter and 50/125 µm, 62.5/125 µm, 100/140 µm, and 200 µm HCS® fiber optic cable. Consistent coupling into the receiver is assured by the lensed optical system (Figure 1). Response does not vary with fiber size ≤ 0.100 µm.

The HFBR-24X2 receiver incorporates an integrated photo IC containing a photodetector and dc amplifier driving an open-collector Schottky output transistor. The HFBR-24X2 is designed for direct interfacing to popular logic families. The absence of an internal pull-up resistor allows the open-collector output to be used with logic families such as CMOS requiring voltage excursions much higher than $V_{CC}$.

Both the open-collector “Data” output Pin 6 and $V_{CC}$ Pin 2 are referenced to “Com” Pin 3, 7. The “Data” output allows busing, strobing and wired “OR” circuit configurations. The transmitter is designed to operate from a single +5 V supply. It is essential that a bypass capacitor (0.1 µF ceramic) be connected from Pin 2 ($V_{CC}$) to Pin 3 (circuit common) of the receiver.

**Housed Product**

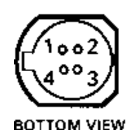



| PIN | FUNCTION |
|---|---|
| 1† | N.C. |
| 2 | $V_{CC}$ (5 V) |
| 3* | COMMON |
| 4† | N.C. |
| 5† | N.C. |
| 6 | DATA |
| 7* | COMMON |
| 8† | N.C. |

*PINS 3 AND 7 ARE ELECTRICALLY CONNECTED TO HEADER

†PINS 1, 4, 5, AND 8 ARE ELECTRICALLY CONNECTED

**Unhoused Product**




| PIN | FUNCTION |
|---|---|
| 1 | $V_{CC}$ (5 V) |
| 2 | COMMON |
| 3 | DATA |
| 4 | COMMON |

## Absolute Maximum Ratings

| Parameter | | Symbol | Min. | Max. | Units | Reference |
|---|---|---|---|---|---|---|
| Storage Temperature | | $T_S$ | -55 | +85 | °C | |
| Operating Temperature | | $T_A$ | -40 | +85 | °C | |
| Lead Soldering Cycle | Temp. | | | +260 | °C | Note 1 |
| | Time | | | 10 | sec | |
| Supply Voltage | | $V_{CC}$ | -0.5 | 7.0 | V | |
| Output Current | | $I_O$ | | 25 | mA | |
| Output Voltage | | $V_O$ | -0.5 | 18.0 | V | |
| Output Collector Power Dissipation | | $P_{O\ AV}$ | | 40 | mW | |
| Fan Out (TTL) | | N | | 5 | | Note 2 |

**Electrical/Optical Characteristics** -40°C to + 85°C unless otherwise specified

Fiber sizes with core diameter ≤ 100 μm and NA ≤ 0.35, 4.75 V ≤ $V_{CC}$ ≤ 5.25 V

| Parameter | Symbol | Min. | Typ.[3] | Max. | Units | Conditions | Reference |
|---|---|---|---|---|---|---|---|
| High Level Output Current | $I_{OH}$ | | 5 | 250 | μA | $V_O$ = 18<br>$P_R$ < -40 dBm | |
| Low Level Output Voltage | $V_{OL}$ | | 0.4 | 0.5 | V | $I_O$ = 8 mA<br>$P_R$ > -24 dBm | |
| High Level Supply Current | $I_{CCH}$ | | 3.5 | 6.3 | mA | $V_{CC}$ = 5.25 V<br>$P_R$ < -40 dBm | |
| Low Level Supply Current | $I_{CCL}$ | | 6.2 | 10 | mA | $V_{CC}$ = 5.25 V<br>$P_R$ > -24 dBm | |
| Equivalent N.A. | NA | | 0.50 | | | | |
| Optical Port Diameter | D | | 400 | | μm | | Note 4 |

## Dynamic Characteristics

-40°C to +85°C unless otherwise specified; 4.75 V ≤ $V_{CC}$ ≤ 5.25 V; BER ≤ $10^{-9}$

| Parameter | Symbol | Min. | Typ.[3] | Max. | Units | Conditions | Reference |
|---|---|---|---|---|---|---|---|
| Peak Optical Input Power Logic Level HIGH | $P_{RH}$ | | | -40 | dBm pk | $\lambda_P$ = 820 nm | Note 5 |
| | | | | 0.1 | μW pk | | |
| Peak Optical Input Power Logic Level LOW | $P_{RL}$ | -25.4 | | -9.2 | dBm pk | $T_A$ = +25°C,<br>$I_{OL}$ = 8 mA | Note 5 |
| | | 2.9 | | 120 | μW pk | | |
| | | -24.0 | | -10.0 | dBm pk | $I_{OL}$ = 8 mA | |
| | | 4.0 | | 100 | μW pk | | |
| Propagation Delay LOW to HIGH | $t_{PLHR}$ | | 65 | | ns | $T_A$ = 25°C,<br>$P_R$ = -21 dBm,<br>Data Rate =<br>5 MBd | Note 6 |
| Propagation Delay HIGH to LOW | $t_{PHLR}$ | | 49 | | ns | | |

**Notes:**

1. 2.0 mm from where leads enter case.
2. 8 mA load (5 x 1.6 mA), $R_L$ = 560 Ω.
3. Typical data at $T_A$ = 25°C, $V_{CC}$ = 5.0 Vdc.
4. D is the effective diameter of the detector image on the plane of the fiber face. The numerical value is the product of the actual detector diameter and the lens magnification.
5. Measured at the end of 100/140 μm fiber optic cable with large area detector.
6. Propagation delay through the system is the result of several sequentially-occurring phenomena. Consequently it is a combination of data-rate-limiting effects and of transmission-time effects. Because of this, the data-rate limit of the system must be described in terms of time differentials between delays imposed on falling and rising edges.
7. As the cable length is increased, the propagation delays increase at 5 ns per meter of length. Data rate, as limited by pulse width distortion, is not affected by increasing cable length if the optical power level at the receiver is maintained.

*CAUTION: The small junction sizes inherent to the design of these components increase the components' susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of these components to prevent damage and/or degradation which may be induced by ESD.*

## HFBR-24X6 Low-Cost 125 MHz Receiver

### Description

The HFBR-24X6 fiber optic receiver is designed to operate with the Agilent HFBR-14XX fiber optic transmitters and 50/125 µm, 62.5/125 µm, 100/140 µm and 200 µm HCS® fiber optic cable. Consistent coupling into the receiver is assured by the lensed optical system (Figure 1). Response does not vary with fiber size for core diameters of 100 µm or less.

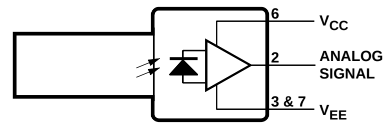
The receiver output is an analog signal which allows follow-on circuitry to be optimized for a variety of distance/data rate requirements. Low-cost external components can be used to convert the analog output to logic compatible signal levels for various data formats and data rates up to 175 MBd. This distance/data rate tradeoff results in increased optical power budget at lower data rates which can be used for additional distance or splices.

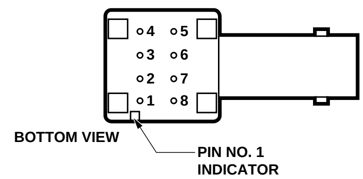
The HFBR-24X6 receiver contains a PIN photodiode and low noise transimpedance pre-amplifier integrated circuit. The HFBR-24X6 receives an optical signal and converts it to an analog voltage. The output is a buffered emitter-follower. Because the signal amplitude from the HFBR-24X6 receiver is much larger than from a simple PIN photodiode, it is less susceptible to EMI, especially at high signaling rates. For very noisy environments, the conductive or metal port option is recommended. A receiver dynamic range of 23 dB over temperature is achievable (assuming $10^{-9}$ BER).

The frequency response is typically dc to 125 MHz. Although the HFBR-24X6 is an analog receiver, it is compatible with digital systems. Please refer to Application Bulletin 78 for simple and inexpensive circuits that operate at 155 MBd or higher.

The recommended ac coupled receiver circuit is shown in Figure 12. It is essential that a 10 ohm resistor be connected between pin 6 and the power supply, and a 0.1 µF ceramic bypass capacitor be connected between the power supply and ground. In addition, pin 6 should be filtered to protect the receiver from noisy host systems. Refer to AN 1038, 1065, or AB 78 for details.

### Housed Product




| PIN | FUNCTION |
|---|---|
| 1† | N.C. |
| 2 | SIGNAL |
| 3* | $V_{EE}$ |
| 4† | N.C. |
| 5† | N.C. |
| 6 | $V_{CC}$ |
| 7* | $V_{EE}$ |
| 8† | N.C. |

* PINS 3 AND 7 ARE ELECTRICALLY CONNECTED TO THE HEADER.

† PINS 1, 4, 5, AND 8 ARE ISOLATED FROM THE INTERNAL CIRCUITRY, BUT ARE ELECTRICALLY CONNECTED TO EACH OTHER.

### Unhoused Product


| PIN | FUNCTION |
|---|---|
| 1 | SIGNAL |
| 2* | $V_{EE}$ |
| 3 | $V_{CC}$ |
| 4* | $V_{EE}$ |

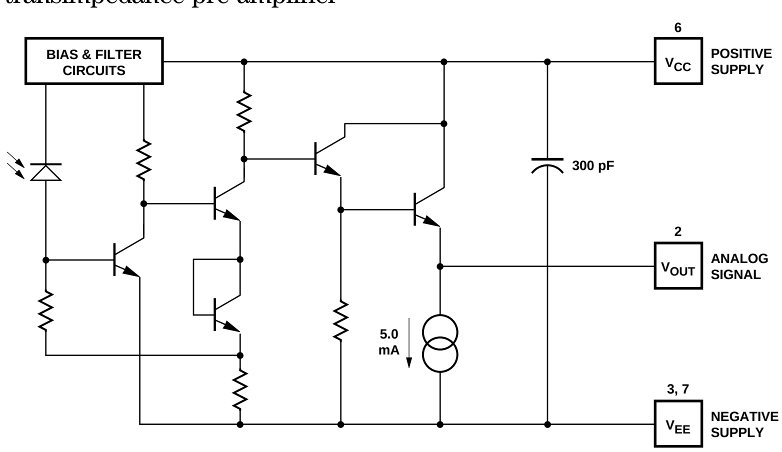



**Figure 11. Simplified Schematic Diagram.**

*CAUTION: The small junction sizes inherent to the design of these components increase the components' susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of these components to prevent damage and/or degradation which may be induced by ESD.*

## Absolute Maximum Ratings

| Parameter | | Symbol | Min. | Max. | Units | Reference |
|---|---|---|---|---|---|---|
| Storage Temperature | | $T_S$ | -55 | +85 | °C | |
| Operating Temperature | | $T_A$ | -40 | +85 | °C | |
| Lead Soldering Cycle | Temp. | | | +260 | °C | Note 1 |
| | Time | | | 10 | s | |
| Supply Voltage | | $V_{CC}$ | -0.5 | 6.0 | V | |
| Output Current | | $I_O$ | | 25 | mA | |
| Signal Pin Voltage | | $V_{SIG}$ | -0.5 | $V_{CC}$ | V | |

## Electrical/Optical Characteristics

-40°C to +85°C; 4.75 V ≤ Supply Voltage ≤ 5.25 V, $R_{LOAD}$ = 511 Ω, Fiber sizes with core diameter ≤ 100 µm, and N.A. ≤ -0.35 unless otherwise specified

| Parameter | Symbol | Min. | Typ.[2] | Max. | Units | Conditions | Reference |
|---|---|---|---|---|---|---|---|
| Responsivity | $R_P$ | 5.3 | 7 | 9.6 | mV/µW | $T_A$= 25°C @ 820 nm, 50 MHz | Note 3, 4 Figure 16 |
| | | 4.5 | | 11.5 | mV/µW | @ 820 nm, 50 MHz | |
| RMS Output Noise Voltage | $V_{NO}$ | | 0.40 | 0.59 | mV | Bandwidth Filtered @ 75 MHz $P_R$ = 0 µW | Note 5 |
| | | | | 0.70 | mV | Unfiltered Bandwidth $P_R$ = 0 µW | Figure 13 |
| Equivalent Input Optical Noise Power (RMS) | $P_N$ | | -43.0 | -41.4 | dBm | Bandwidth Filtered @ 75 MHz | |
| | | | 0.050 | 0.065 | µW | | |
| Optical Input Power (Overdrive) | $P_R$ | | | -7.6 | dBm pk | $T_A$ = 25°C | Figure 14 Note 6 |
| | | | | 175 | µW pk | | |
| | | | | -8.2 | dBm pk | | |
| | | | | 150 | µW pk | | |
| Output Impedance | $Z_o$ | | 30 | | Ω | Test Frequency = 50 MHz | |
| dc Output Voltage | $V_{o\,dc}$ | -4.2 | -3.1 | -2.4 | V | $P_R$ = 0 µW | |
| Power Supply Current | $I_{EE}$ | | 9 | 15 | mA | $R_{LOAD}$ = 510 Ω | |
| Equivalent N.A. | NA | | 0.35 | | | | |
| Equivalent Diameter | D | | 324 | | µm | | Note 7 |

*CAUTION: The small junction sizes inherent to the design of these components increase the components' susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of these components to prevent damage and/or degradation which may be induced by ESD.*

**Dynamic Characteristics** -40°C to +85°C; 4.75 V ≤ Supply Voltage ≤ 5.25 V; $R_{LOAD}$ = 511 Ω, $C_{LOAD}$ = 5 pF unless otherwise specified

| Parameter | Symbol | Min. | Typ.[2] | Max. | Units | Conditions | Reference |
|---|---|---|---|---|---|---|---|
| Rise/Fall Time 10% to 90% | $t_r$, $t_f$ | | 3.3 | 6.3 | ns | $P_R$ = 100 µW peak | Figure 15 |
| Pulse Width Distortion | PWD | | 0.4 | 2.5 | ns | $P_R$ = 150 µW peak | Note 8, Figure 14 |
| Overshoot | | | 2 | | % | $P_R$ = 5 µW peak, $t_r$ = 1.5 ns | Note 9 |
| Bandwidth (Electrical) | BW | | 125 | | MHz | -3 dB Electrical | |
| Bandwidth - Rise Time Product | | | 0.41 | | Hz • s | | Note 10 |

**Notes:**

1. 2.0 mm from where leads enter case.
2. Typical specifications are for operation at $T_A$ = 25°C and $V_{CC}$ = +5 V dc.
3. For 200 µm HCS fibers, typical responsivity will be 6 mV/µW. Other parameters will change as well.
4. Pin #2 should be ac coupled to a load ≥ 510 ohm. Load capacitance must be less than 5 pF.
5. Measured with a 3 pole Bessel filter with a 75 MHz, -3 dB bandwidth. Recommended receiver filters for various bandwidths are provided in Application Bulletin 78.
6. Overdrive is defined at PWD = 2.5 ns.
7. D is the effective diameter of the detector image on the plane of the fiber face. The numerical value is the product of the actual detector diameter and the lens magnification.
8. Measured with a 10 ns pulse width, 50% duty cycle, at the 50% amplitude point of the waveform.
9. Percent overshoot is defined as:
   $$\left(\frac{V_{PK} - V_{100\%}}{V_{100\%}}\right) \times 100\%$$
10. The conversion factor for the rise time to bandwidth is 0.41 since the HFBR-24X6 has a second order bandwidth limiting characteristic.

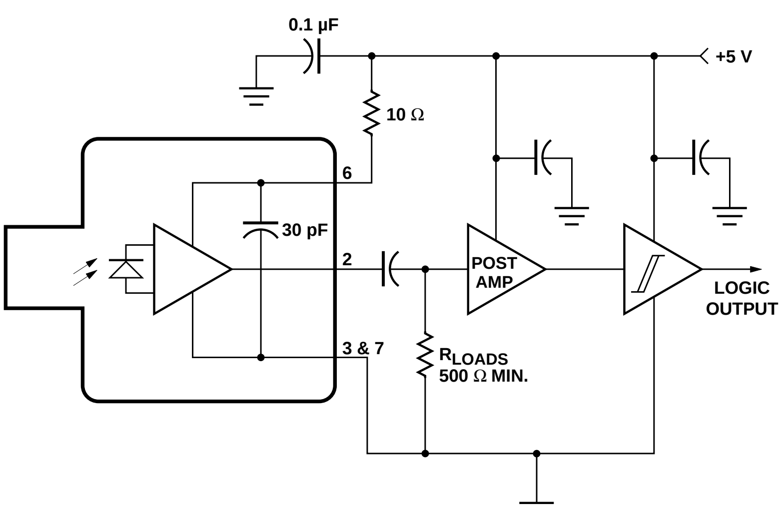



**Figure 12. Recommended ac Coupled Receiver Circuit. (See AB 78 and AN 1038 for more information.)**

*CAUTION: The small junction sizes inherent to the design of these components increase the components' susceptibility to damage from electrostatic discharge (ESD). It is advised that normal static precautions be taken in handling and assembly of these components to prevent damage and/or degradation which may be induced by ESD.*

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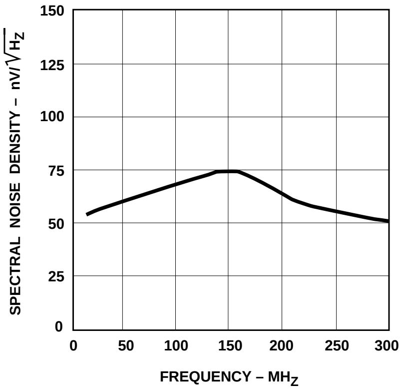


Figure 13. Typical Spectral Noise Distortion vs. Peak Input Power.

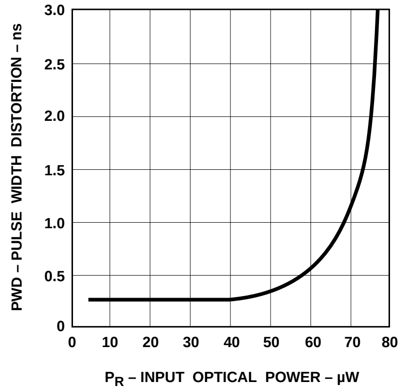


Figure 14. Typical Pulse Width Density vs. Frequency.

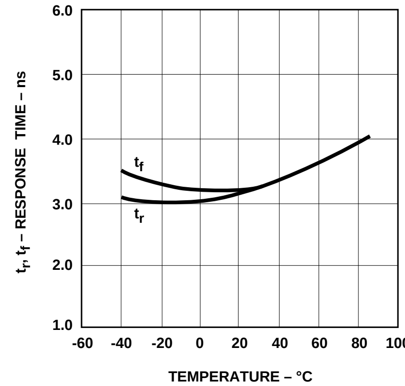


Figure 15. Typical Rise and Fall Times vs. Temperature.

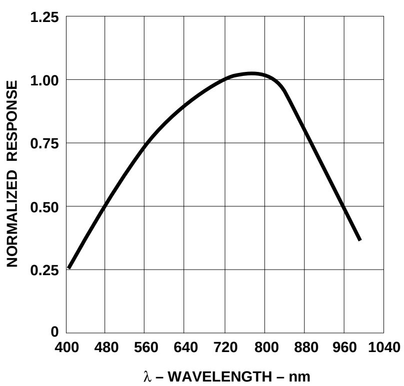


Figure 16. Receiver Spectral Response Normalized to 820 nm.

*www.semiconductor.agilent.com*

Data subject to change.



Obsoletes 5965-1655E (1/97)

5968-6320E (11/99)

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# Fiber Optic Transmitter and Receiver Data Links for 125 MBd

# Technical Data

**HFBR-1115T Transmitter**
**HFBR-2115T Receiver**

## Features

- **Full Compliance with the Optical Performance Requirements of the FDDI PMD Standard**
- **Full Compliance with the Optical Performance Requirements of the ATM 100 Mbps Physical Layer**
- **Full Compliance with the Optical Performance Requirements of the 100 Mbps Fast Ethernet Physical Layer**
- **Other Versions Available for:**
  **- ATM**
  **- Fibre Channel**
- **Compact 16-pin DIP Package with Plastic ST* Connector**
- **Wave Solder and Aqueous Wash Process Compatible Package**
- **Manufactured in an ISO 9001 Certified Facility**

## Applications

- **FDDI Concentrators, Bridges, Routers, and Network Interface Cards**
- **100 Mbps ATM Interfaces**
- **Fast Ethernet Interfaces**
- **General Purpose, Point-to-Point Data Communications**
- **Replaces DLT/R1040-ST1 Model Transmitters and Receivers**

## Description

The HFBR-1115/-2115 series of data links are high-performance, cost-efficient, transmitter and receiver modules for serial optical data communication applications specified at 100 Mbps for FDDI PMD or 100 Base-FX Fast Ethernet applications.

These modules are designed for 50 or 62.5 µm core multi-mode optical fiber and operate at a nominal wavelength of 1300 nm. They incorporate our high-performance, reliable, long-wavelength, optical devices and proven circuit technology to give long life and consistent performance.

## Transmitter

The transmitter utilizes a 1300 nm surface-emitting InGaAsP LED, packaged in an optical subassembly. The LED is dc-coupled to a custom IC which converts differential-input, PECL logic signals, ECL-referenced (shifted) to a +5 V power supply, into an analog LED drive current.

## Receiver

The receiver utilizes an InGaAs PIN photodiode coupled to a custom silicon transimpedance

preamplifier IC. The PIN-preamplifier combination is ac-coupled to a custom quantizer IC which provides the final pulse shaping for the logic output and the Signal Detect function. Both the Data and Signal Detect Outputs are differential. Also, both Data and Signal Detect Outputs are PECL compatible, ECL-referenced (shifted) to a +5 V power supply.

## Package

The overall package concept for the Data Links consists of the following basic elements: two optical subassemblies, two electrical subassemblies, and the outer housings as illustrated in Figure 1.

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

The package outline drawing and pinout are shown in Figures 2 and 3. The details of this package outline and pinout are compatible with other data-link modules from other vendors.

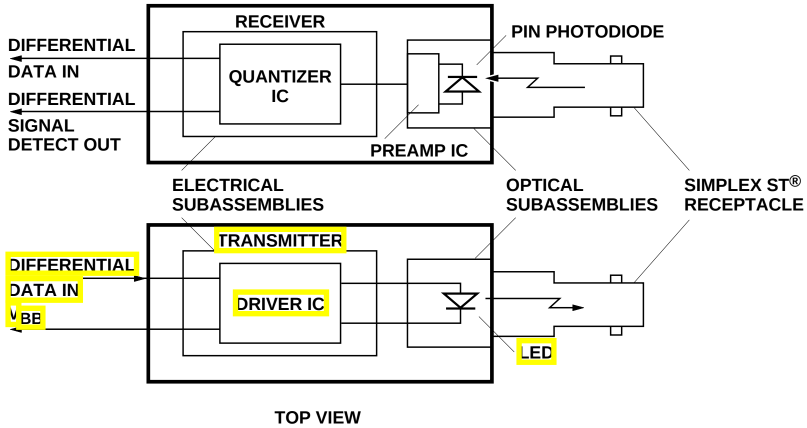



**Figure 1. Transmitter and Receiver Block Diagram.**

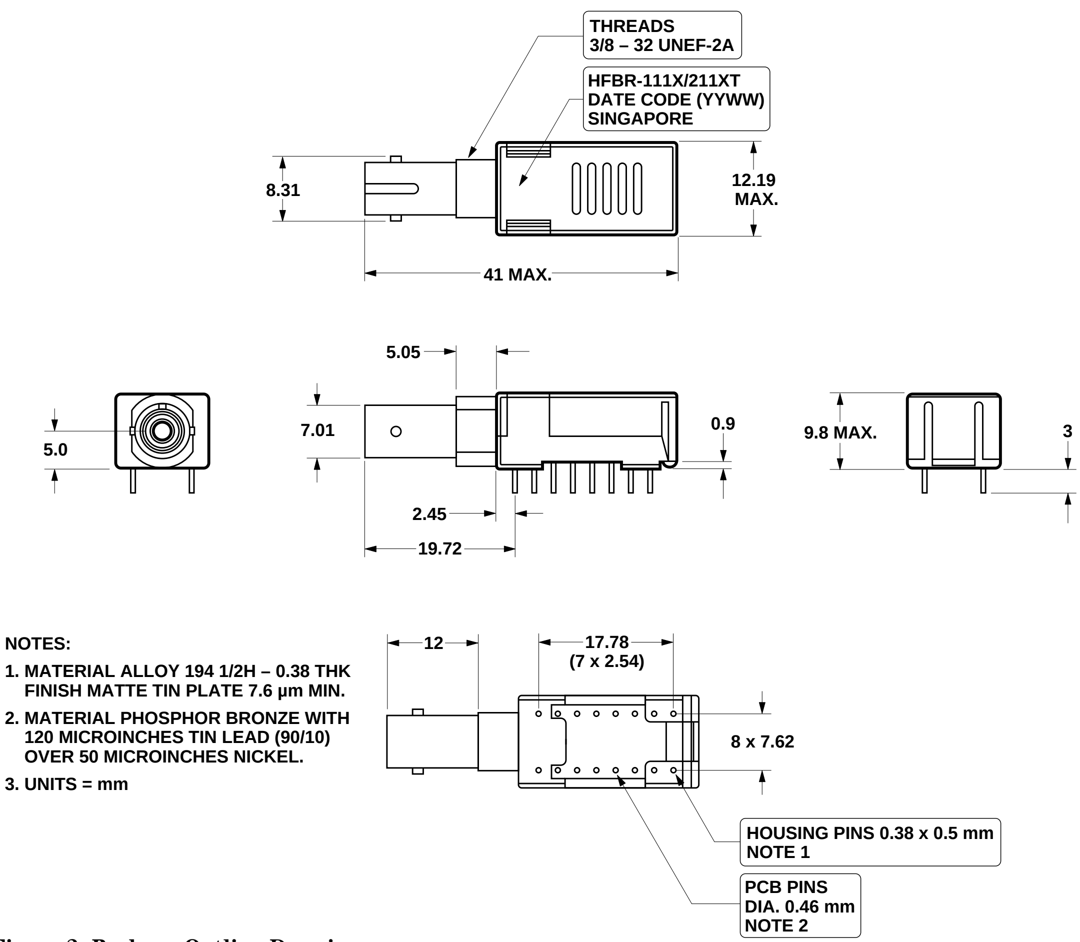



**Figure 2. Package Outline Drawing.**

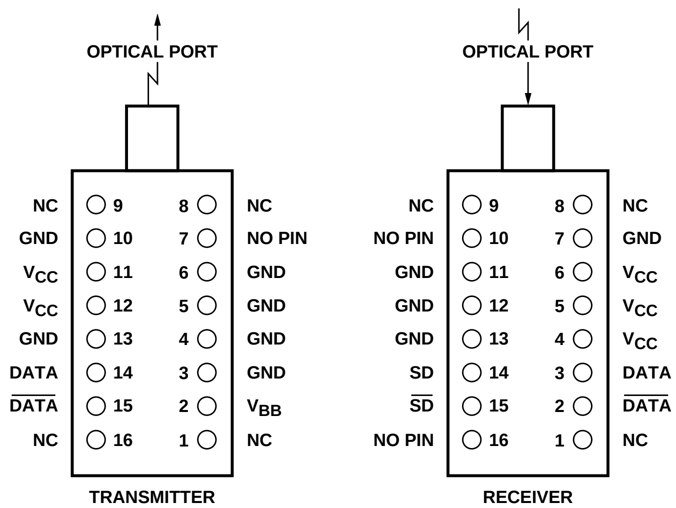



**Figure 3. Pinout Drawing.**

The optical subassemblies consist of a transmitter subassembly in which the LED resides and a receiver subassembly housing the PIN-preamplifier combination.

The electrical subassemblies consist of a multi-layer printed circuit board on which the IC chips and various sufrace-mounted, passive circuit elements are attached.

Each transmitter and receiver package includes an internal shield for the electrical subassembly to ensure low EMI emissions and high immunity to external EMI fields.

The outer housing, including the ST* port, is molded of filled, non-conductive plastic to provide mechanical strength and electrical isolation. For other port styles, please contact your Agilent Technologies Sales Representative.

Each data-link module is attached to a printed circuit board via the 16-pin DIP interface. Pins 8 and 9 provide mechanical strength for these plastic-port devices and will provide port-ground for forthcoming metal-port modules.

## Application Information

The Applications Engineering group of the Optical Communication Division is available to assist you with the technical understanding and design tradeoffs associated with these transmitter and receiver modules. You can contact them through your Agilent Technologies sales representative.

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

## Transmitter and Receiver Optical Power Budget versus Link Length

The 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 transmitter and receiver specified in this data sheet at the Beginning of Life (BOL). This curve represents the attenuation and chromatic plus modal dispersion losses associated with 62.5/125 µm and 50/125 µm fiber cables only. The area under the curve represents the remaining OPB at any link length, which is available for overcoming non-fiber cable related losses.

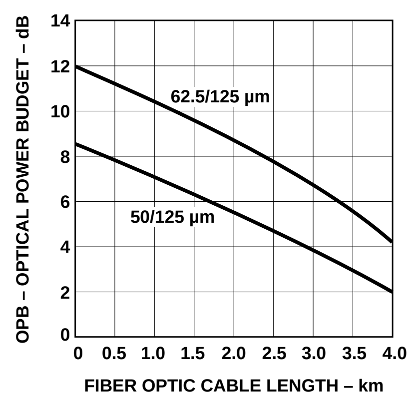



**Figure 4. Optical Power Budget at BOL vs. Fiber Optic Cable Length.**

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

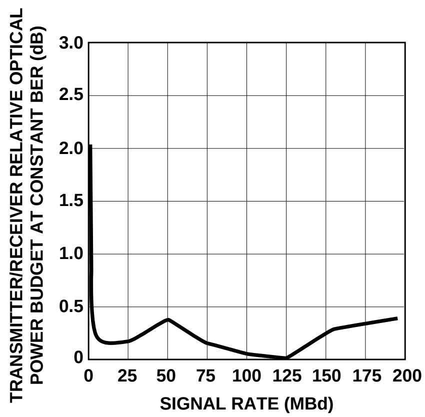
Figure 4 was generated with an Agilent fiber-optic link model containing the current industry conventions for fiber cable specifications and the FDDI PMD optical parameters. These parameters are reflected in the guaranteed performance of the transmitter and receiver specifications in this data sheet. 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.

## Transmitter and Receiver Signaling Rate Range and BER Performance

For purposes of definition, the symbol rate (Baud), also called signaling rate, is the reciprocal of the 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, ATM 100 Mbps, and Fast Ethernet applications, the performance of Hewlett-Packard's 1300 nm HFBR-1115/-2115 data link modules is guaranteed over the signaling rate of 10 MBd to 125 MBd to the full conditions listed in the individual product specification tables.

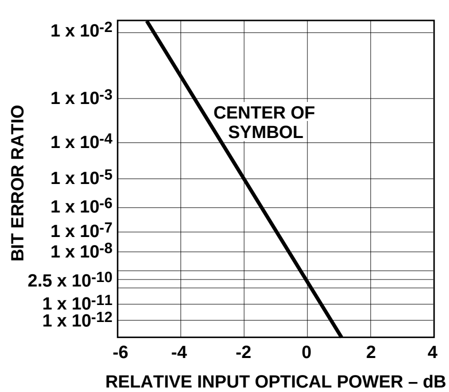
The data link modules can be used for other applications at signaling rates outside of the 10 MBd to 125 MBd range with some penalty in the link optical power budget primarily caused by a reduction of receiver sensitivity. Figure 5 gives an indication of the typical performance of these 1300 nm products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




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 Vdc
6. INPUT OPTICAL RISE/FALL TIMES = 1.0/2.1 ns.

**Figure 5. Transmitter/Receiver Relative Optical Power Budget at Constant BER vs. Signaling Rate.**

These data link modules can also be used for applications which require different bit-error-ratio (BER) performance. Figure 6 illustrates the typical trade-off between link BER and the receiver input optical power level.




CONDITIONS:
1. 125 MBd
2. PRBS $2^7$-1
3. $T_A$ = 25° C
4. $V_{CC}$ = 5 Vdc
5. INPUT OPTICAL RISE/FALL TIMES = 1.0/2.1 ns.

**Figure 6. Bit-Error-Ratio vs. Relative Receiver Input Optical Power.**

## Data Link Jitter Performance

The Agilent 1300 nm data link modules are designed to operate per the system jitter allocations stated in Table E1 of Annex E of the FDDI PMD standard.

The 1300 nm transmitter will tolerate the worst-case input electrical jitter allowed in the table without violating the worst-case output jitter requirements of Section 8.1 Active Output Interface of the FDDI PMD standard.

The 1300 nm receiver will tolerate the worst-case input optical jitter allowed in Section 8.2 Active Input Interface of the FDDI PMD standard without violating the worst-case output electrical jitter allowed in the Table E1 of the Annex E.

The jitter specifications stated in the following transmitter and receiver specification table are derived from the values in Table E1 of Annex E. They represent the worst-case jitter contribution that the transmitter and receiver are allowed to make to the overall system jitter without violating the Annex E allocation example. In practice, the typical jitter contribution of the Hewlett-Packard data link modules is well below the maximum amounts.

## Recommended Handling Precautions

It is advised that normal static precautions be taken in the handling and assembly of these data link modules to prevent damage which may be induced by electrostatic discharge (ESD). The HFBR-1115/-2115 series meets MIL-STD-883C Method 3015.4 Class 2.

Care should be taken to avoid shorting the receiver Data or Signal Detect Outputs directly to ground without proper current-limiting impedance.

## Solder and Wash Process Compatibility

The transmitter and receiver are delivered with protective process caps covering the individual ST* ports. These process caps protect the optical subassemblies during wave solder and aqueous wash processing and act as dust covers during shipping.

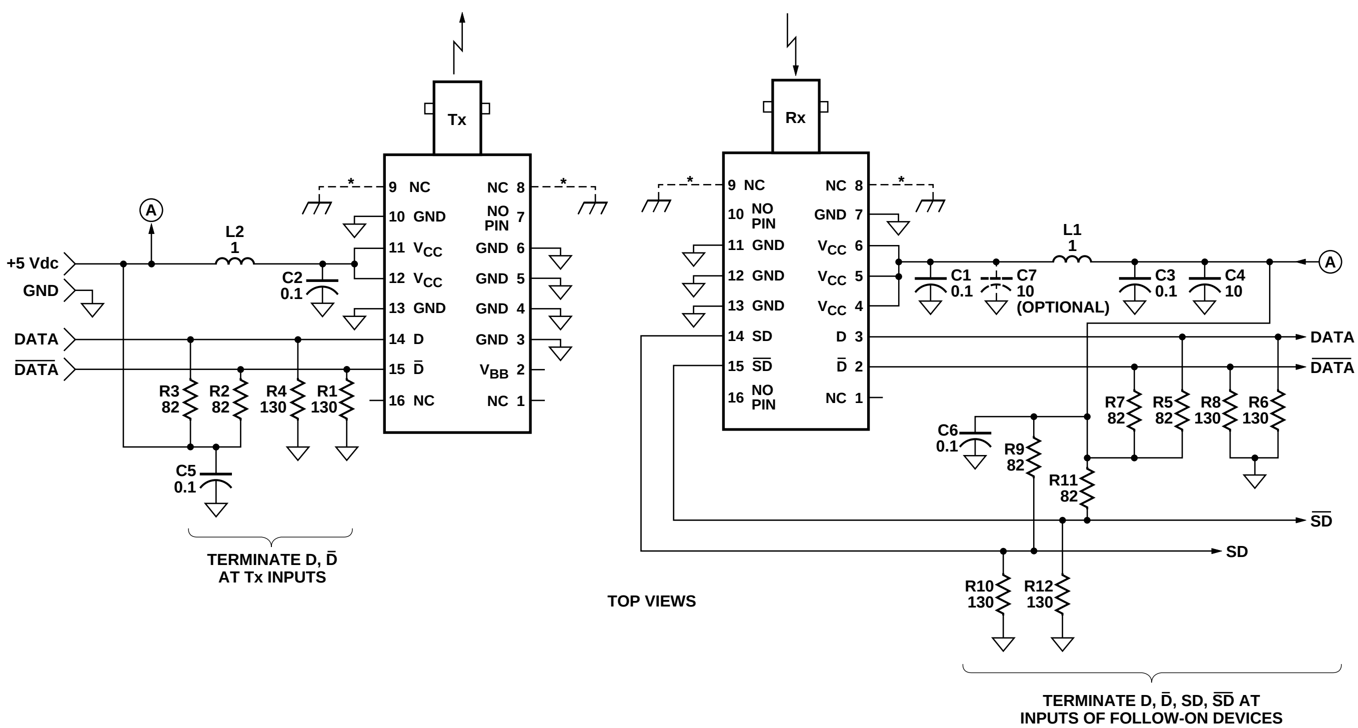
These data link modules are compatible with either industry standard wave- or hand-solder processes.

## Shipping Container

The data link modules are packaged in a shipping container designed to protect it from mechanical and ESD damage during shipment or storage.

## Board Layout–Interface Circuit and Layout Guidelines

It is important to take care in the layout of your circuit board to achieve optimum performance from these data link modules. Figure 7 provides a good example of a power supply filter circuit that works well with these parts. Also, suggested signal terminations for the Data, Data-bar, Signal Detect and Signal Detect-bar lines are shown. Use of a multilayer, ground-plane printed circuit board will provide good high-frequency




NOTES:

1. RESISTANCE IS IN OHMS. CAPACITANCE IS IN MICROFARADS. INDUCTANCE IS IN MICROHENRIES.
2. TERMINATE TRANSMITTER INPUT DATA AND DATA-BAR AT THE TRANSMITTER INPUT PINS. TERMINATE THE RECEIVER OUTPUT DATA, DATA-BAR, AND SIGNAL DETECT-BAR AT THE FOLLOW-ON DEVICE INPUT PINS. FOR LOWER POWER DISSIPATION IN THE SIGNAL DETECT TERMINATION CIRCUITRY WITH SMALL COMPROMISE TO THE SIGNAL QUALITY, EACH SIGNAL DETECT OUTPUT CAN BE LOADED WITH 510 OHMS TO GROUND INSTEAD OF THE TWO RESISTOR, SPLIT-LOAD PECL TERMINATION SHOWN IN THIS SCHEMATIC.
3. MAKE DIFFERENTIAL SIGNAL PATHS SHORT AND OF SAME LENGTH WITH EQUAL TERMINATION IMPEDANCE.
4. SIGNAL TRACES SHOULD BE 50 OHMS MICROSTRIP OR STRIPLINE TRANSMISSION LINES. USE MULTILAYER, GROUND-PLANE PRINTED CIRCUIT BOARD FOR BEST HIGH-FREQUENCY PERFORMANCE.
5. USE HIGH-FREQUENCY, MONOLITHIC CERAMIC BYPASS CAPACITORS AND LOW SERIES DC RESISTANCE INDUCTORS. RECOMMEND USE OF SURFACE-MOUNT COIL INDUCTORS AND CAPACITORS. IN LOW NOISE POWER SUPPLY SYSTEMS, FERRITE BEAD INDUCTORS CAN BE SUBSTITUTED FOR COIL INDUCTORS. LOCATE POWER SUPPLY FILTER COMPONENTS CLOSE TO THEIR RESPECTIVE POWER SUPPLY PINS. C7 IS AN OPTIONAL BYPASS CAPACITOR FOR IMPROVED, LOW-FREQUENCY NOISE POWER SUPPLY FILTER PERFORMANCE.
6. DEVICE GROUND PINS SHOULD BE DIRECTLY AND INDIVIDUALLY CONNECTED TO GROUND.
7. CAUTION: DO NOT DIRECTLY CONNECT THE FIBER-OPTIC MODULE PECL OUTPUTS (DATA, DATA-BAR, SIGNAL DETECT, SIGNAL DETECT-BAR, $V_{BB}$) TO GROUND WITHOUT PROPER CURRENT LIMITING IMPEDANCE.
8. (*) OPTIONAL METAL ST OPTICAL PORT TRANSMITTER AND RECEIVER MODULES WILL HAVE PINS 8 AND 9 ELECTRICALLY CONNECTED TO THE METAL PORT ONLY AND NOT CONNECTED TO THE INTERNAL SIGNAL GROUND.

**Figure 7. Recommended Interface Circuitry and Power Supply Filter Circuits.**

circuit performance with a low inductance ground return path. See additional recommendations noted in the interface schematic shown in Figure 7.

## Board Layout–Hole Pattern

The Agilent transmitter and receiver hole pattern is compatible with other data link modules from other vendors. The drawing shown in Figure 8 can be used as a guide in the mechanical layout of your circuit board.

## Regulatory Compliance

These data link modules are intended to enable commercial system designers to develop equipment that complies with the various international regulations governing certification of Information Technology Equipment. Additional information is available from your Agilent sales representative.

All HFBR-1115T LED transmitters are classified as IEC-825-1 Accessible Emission Limit (AEL) Class 1 based upon the current proposed draft scheduled to go into effect on January 1, 1997. AEL Class 1 LED devices are considered eye safe. See Application Note 1094, *LED Device Classifications with Respect to AEL Values as Defined in the IEC 825-1 Standard and the European EN60825-1 Directive*.

The material used for the housing in the HFBR-1115/-2115 series is Ultem 2100 (GE). Ultem 2100 is recognized for a UL flammability rating of 94V-0 (UL File Number E121562) and the CSA (Canadian Standards Association) equivalent (File Number LS88480).

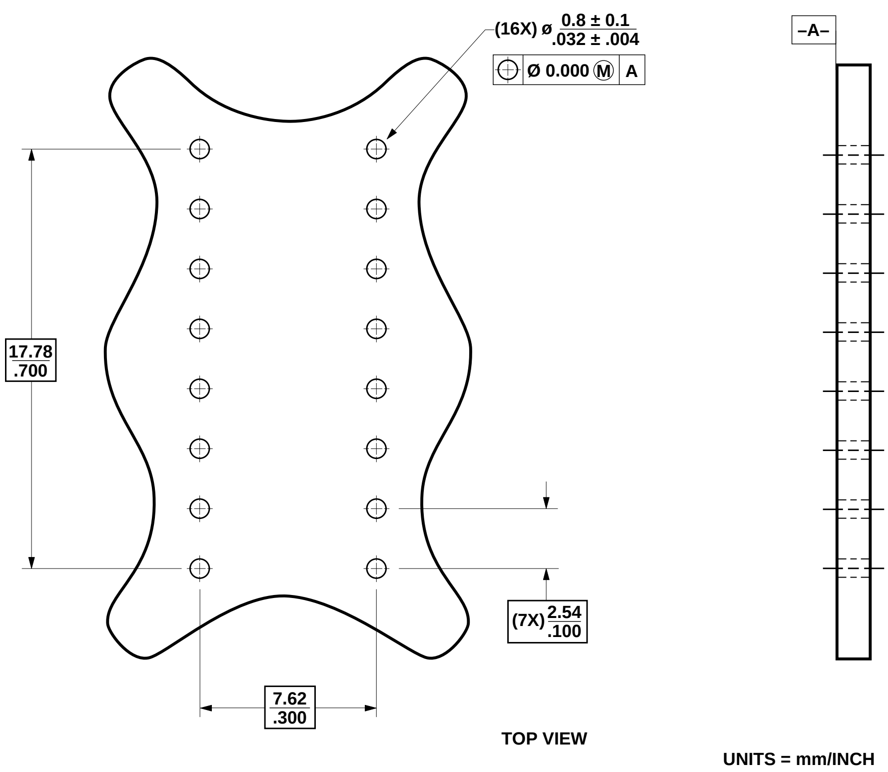
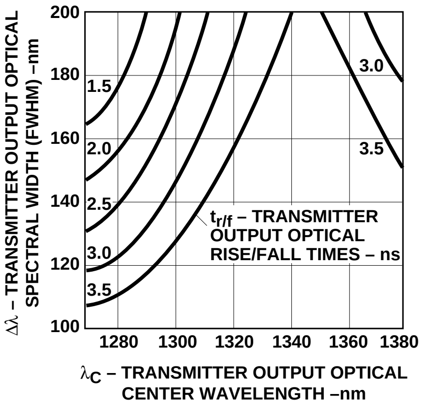
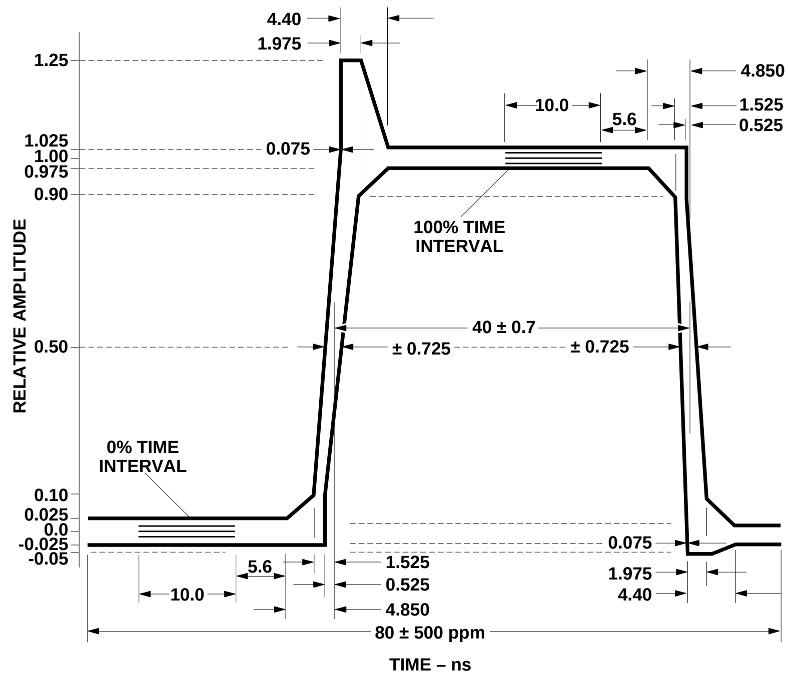



**Figure 8. Recommended Board Layout Hole Pattern.**



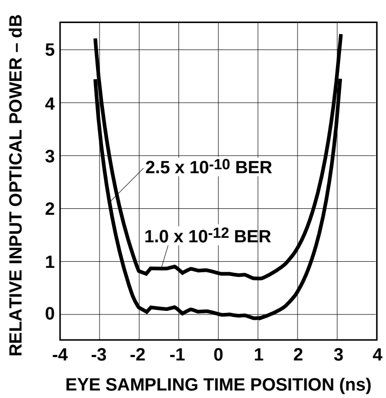

HFBR-1115T FDDI TRANSMITTER TEST RESULTS OF $\lambda_C$, $\Delta\lambda$ AND $t_{r/f}$ ARE CORRELATED AND COMPLY WITH THE ALLOWED SPECTRAL WIDTH AS A FUNCTION OF CENTER WAVELENGTH FOR VARIOUS RISE AND FALL TIMES.

**Figure 9. HFBR-1115T Transmitter Output Optical Spectral Width (FWHM) vs. Transmitter Output Optical Center Wavelength and Rise/Fall Times.**



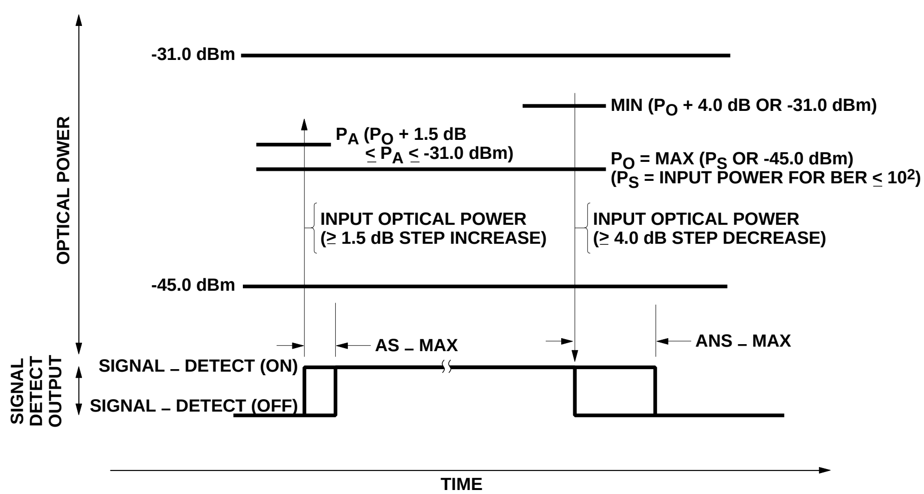

THE HFBR-1115T OUTPUT OPTICAL PULSE SHAPE FITS WITHIN THE BOUNDARIES OF THE PULSE ENVELOPE FOR RISE AND FALL TIME MEASUREMENTS.

**Figure 10. Output Optical Pulse Envelope.**




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 21 AND 22 APPLY.

**Figure 11. HFBR-2115T Receiver 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-1115T Transmitter Pin-Out Table

| Pin | Symbol | Functional Description | Reference |
|---|---|---|---|
| 1 | NC | No internal connect, used for mechanical strength only | |
| 2 | $V_{BB}$ | $V_{BB}$ Bias output | |
| 3 | GND | Ground | Note 3 |
| 4 | GND | Ground | Note 3 |
| 5 | GND | Ground | Note 3 |
| 6 | GND | Ground | Note 3 |
| 7 | OMIT | No pin | |
| 8 | NC | No internal connect, used for mechanical strength only | Note 5 |
| 9 | NC | No internal connect, used for mechanical strength only | Note 5 |
| 10 | GND | Ground | Note 3 |
| 11 | $V_{CC}$ | Common supply voltage | Note 1 |
| 12 | $V_{CC}$ | Common supply voltage | Note 1 |
| 13 | GND | Ground | Note 3 |
| 14 | DATA | Data input | Note 4 |
| 15 | $\overline{\text{DATA}}$ | Inverted Data input | Note 4 |
| 16 | NC | No internal connect, used for mechanical strength only | |

## HFBR-2115T Receiver Pin-Out Table

| Pin | Symbol | Functional Description | Reference |
|---|---|---|---|
| 1 | NC | No internal connect, used for mechanical strength only | |
| 2 | $\overline{\text{DATA}}$ | Inverted Data input | Note 4 |
| 3 | DATA | Data input | Note 4 |
| 4 | $V_{CC}$ | Common supply voltage | Note 1 |
| 5 | $V_{CC}$ | Common supply voltage | Note 1 |
| 6 | $V_{CC}$ | Common supply voltage | Note 1 |
| 7 | GND | Ground | Note 3 |
| 8 | NC | No internal connect, used for mechanical strength only | Note 5 |
| 9 | NC | No internal connect, used for mechanical strength only | Note 5 |
| 10 | OMIT | No pin | |
| 11 | GND | Ground | Note 3 |
| 12 | GND | Ground | Note 3 |
| 13 | GND | Ground | Note 3 |
| 14 | SD | Signal Detect | Note 2, 4 |
| 15 | $\overline{\text{SD}}$ | Inverted Signal Detect | Note 2, 4 |
| 16 | OMIT | No pin | |

**Notes:**
1. Voltages on $V_{CC}$ must be from the same power supply (they are connected together internally).
2. Signal Detect is a logic signal that indicates the presence or absence of an input optical signal. A logic-high, $V_{OH}$, on Signal Detect indicates presence of an input optical signal. A logic-low, $V_{OL}$, on Signal Detect indicates an absence of input optical signal.
3. All GNDs are connected together internally and to the internal shield.
4. DATA, $\overline{\text{DATA}}$, SD, $\overline{\text{SD}}$ are open-emitter output circuits.
5. On metal-port modules, these pins are redefined as "Port Connection."

## Specifications–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 | |

## Recommended Operating Conditions

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Reference |
|---|---|---|---|---|---|---|
| Ambient Operating Temperature | $T_A$ | 0 | | 70 | °C | |
| Supply Voltage | $V_{CC}$ | 4.5 | | 5.5 | 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 |
| Signaling Rate | $f_S$ | 10 | 125 | | MBd | Note 3<br>Figure 5 |

## HFBR-1115T Transmitter Electrical Characteristics

($T_A$ = 0°C to 70°C, $V_{CC}$ = 4.5 V to 5.5 V)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Reference |
|---|---|---|---|---|---|---|
| Supply Current | $I_{CC}$ | | 145 | 185 | mA | Note 4 |
| Power Dissipation | $P_{DISS}$ | | 0.76 | 1.1 | W | Note 7 |
| Threshold Voltage | $V_{BB}$ - $V_{CC}$ | -1.42 | -1.3 | -1.24 | V | Note 5 |
| Data Input Current–Low | $I_{IL}$ | -350 | 0 | | µA | |
| Data Input Current–High | $I_{IH}$ | | 14 | 350 | µA | |

## HFBR-2115T Receiver Electrical Characteristics

($T_A$ = 0°C to 70°C, $V_{CC}$ = 4.5 V to 5.5 V)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Reference |
|---|---|---|---|---|---|---|
| Supply Current | $I_{CC}$ | | 82 | 145 | mA | Note 6 |
| Power Dissipation | $P_{DISS}$ | | 0.3 | 0.5 | W | Note 7 |
| Data Output Voltage–Low | $V_{OL}$ - $V_{CC}$ | -1.840 | | -1.620 | V | Note 8 |
| Data Output Voltage–High | $V_{OH}$ - $V_{CC}$ | -1.045 | | -0.880 | V | Note 8 |
| Data Output Rise Time | $t_r$ | 0.35 | | 2.2 | ns | Note 9 |
| Data Output Fall Time | $t_f$ | 0.35 | | 2.2 | ns | Note 9 |
| Signal Detect Output Voltage–Low (De-asserted) | $V_{OL}$ - $V_{CC}$ | -1.840 | | -1.620 | V | Note 8 |
| Signal Detect Output Voltage–High (Asserted) | $V_{OH}$ - $V_{CC}$ | -1.045 | | -0.880 | V | Note 8 |
| Signal Detect Output Rise Time | $t_r$ | 0.35 | | 2.2 | ns | Note 9 |
| Signal Detect Output Fall Time | $t_f$ | 0.35 | | 2.2 | ns | Note 9 |

## HFBR-1115T Transmitter Optical Characteristics

($T_A$ = 0°C to 70°C, $V_{CC}$ = 4.5 V to 5.5 V)

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

## HFBR-2115T Receiver Optical and Electrical Characteristics

($T_A$ = 0°C to 70°C, $V_{CC}$ = 4.5 V to 5.5 V)

| Parameter | Symbol | Min. | Typ. | Max. | Unit | Reference |
|---|---|---|---|---|---|---|
| Input Optical Power<br>Minimum at Window Edge | $P_{IN\ Min.}$ (W) | | -33.5 | -31 | dBm<br>avg. | Note 21,<br>Figure 11 |
| Input Optical Power<br>Minimum at Eye Center | $P_{IN\ Min.}$ (C) | | -34.5 | -31.8 | dBm<br>avg. | Note 22,<br>Figure 8 |
| Input Optical Power Maximum | $P_{IN\ Max.}$ | -14 | -11.8 | | dBm<br>avg. | Note 21 |
| Operating Wavelength | $\lambda$ | 1270 | | 1380 | nm | |
| Duty Cycle Distortion<br>Contributed by the Receiver | DCD | | 0.02 | 0.4 | ns p-p | Note 10 |
| Data Dependent Jitter<br>Contributed by the Receiver | DDJ | | 0.35 | 1.0 | ns p-p | Note 11 |
| Random Jitter Contributed by the Receiver | RJ | | 1.0 | 2.14 | ns p-p | Note 12 |
| Signal Detect–Asserted | $P_A$ | $P_D$+1.5 dB | | -33 | dBm<br>avg. | Note 23, 24<br>Figure 9 |
| Signal Detect–De-asserted | $P_D$ | -45 | | | dBm<br>avg. | Note 25, 26<br>Figure 12 |
| Signal Detect–Hysteresis | $P_A$-$P_D$ | 1.5 | 2.4 | | dB | Figure 9 |
| Signal Detect Assert Time<br>(off to on) | AS_Max | 0 | 55 | 100 | µs | Note 23, 24<br>Figure 12 |
| Signal Detect De-assert Time<br>(on to off) | ANS_Max | 0 | 110 | 350 | µs | Note 25, 26<br>Figure 12 |

**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 specified signaling rate of 10 MBd to 125 MBd guarantees operation of the transmitter and receiver link to the full conditions listed in the FDDI Physical Layer Medium Dependent standard. Specifically, the link bit-error-ratio will be equal to or better than 2.5 x $10^{-10}$ for any valid FDDI pattern. The transmitter section of the link is capable of dc to 125 MBd. The receiver is internally ac-coupled which limits the lower signaling rate to 10 MBd. For purposes of definition, the symbol rate (Baud), also called signaling rate, fs, is the reciprocal of the symbol time. Data rate (bits/sec) is the symbol rate divided by the encoding factor used to encode the data (symbols/bit).
4. 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.
5. This value is measured with an output load $R_L$ = 10 kΩ.
6. 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.
7. The power dissipation value is the power dissipated in the transmitter and 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.
8. This value is measured with respect to $V_{CC}$ with the output terminated into 50 Ω connected to $V_{CC}$ - 2 V.
9. 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.
10. 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–Data Link Jitter Section for further information.
11. 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–Data Link Jitter Section for further information.
12. 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 the maximum of "$P_{IN\ Min.}$ (W)." See Application Information–Data Link Jitter Section for further information.
13. 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 Hewlett-Packard's 1300 nm LED products is < 1dB, 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.
14. 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.
15. 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.
16. This parameter complies with the FDDI PMD requirements for the tradeoffs between center wavelength, spectral width, and rise/fall times shown in Figure 9.
17. 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.
18. 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–Data Link Jitter Performance Section of this data sheet for further details.
19. Data Dependent Jitter contributed by the transmitter is specified with the FDDI test pattern described in FDDI PMD Annex A.5. See Application Information–Data Link Jitter Performance Section of this data sheet for further details.
20. 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–Data Link Jitter Performance Section of this data sheet for further details.
21. This specification is intended to indicate the performance of the receiver 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 x $10^{-10}$.
    - At the Beginning of Life (BOL).
    - Over the specified operating voltage and temperature 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.

22. All conditions of Note 21 apply except that the measurement is made at the center of the symbol with no window time-width.
23. This value is measured during the transition from low to high levels of input optical power.
24. The Signal Detect output shall be asserted, logic-high ($V_{OH}$), 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.
25. 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.
26. Signal Detect output shall be deasserted, logic-low ($V_{OL}$), 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 de-asserted), 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 de-asserted. The input data stream is the Quiet Line State. Also, Signal Detect will be de-asserted 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.

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