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# 125 Megabaud Fiber Optic Transceiver JIS FO7 Connection

## Technical Data

### Features

- Data Transmission at Signal Rates of 1 to 125 MBd over Distances up to 100 Meters
- Compatible with Duplex JIS FO7 and Simplex JIS FO5 Connectors
- Specified for Use with Plastic Optical Fiber (POF), and with Large Core Silica Fiber (HCS®)
- Transmitter and Receiver Application Circuit Schematics Available
- Conductive Plastic Housing Provides Electrical Shield

### Applications

- Intra-System Links: Board-to-Board, Rack-to-Rack
- High Voltage Isolation
- Telecommunications Switching Systems
- Computer-to-Peripheral Data Links, PC Bus Extension
- Industrial Control Networks
- Proprietary LANs
- Digitized Video
- Medical Instruments
- Immune to Lightning and Voltage Transients

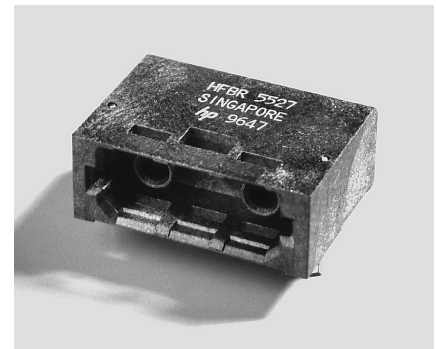
### Description

The 125 MBd transceiver is a cost-effective fiber-optic solution for transmission of 125 MBd data up to 100 meters with HCS® fiber. The data link consists of a 650 nm visible, red LED transmitter and a PIN/preamp receiver. These can be used with low-cost plastic or hard clad silica fiber. One millimeter diameter plastic fiber provides the lowest cost solution for distances under 25 meters. The lower attenuation of HCS® fiber allows data transmission over longer distance. These components can be used for high speed data links without the problems common with copper wire solutions.

The transmitter is a high power 650 nm LED. Both transmitter and receiver are molded in one housing which is compatible with the FO7 connector. This connector is designed to efficiently couple the power into POF or HCS® fiber.

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### HFBR-5527



With the recommended drive circuit, the LED operates at speeds from 1-125 MBd. The analog high bandwidth receiver contains a PIN photodiode and internal transimpedance amplifier. With the recommended application circuit for 125 MBd operation, the performance of the complete data link is specified for 0-25 meters with plastic fiber. A wide variety of other digitizing circuits can be combined with the HFBR-5527 Series to optimize performance and cost at higher or lower data rates.

**HFBR-5527**  
**125 MBd Data Link**

Data link operating conditions and performance are specified for the transmitter and receiver in

the recommended applications circuits shown in Figure 1. This circuit has been optimized for 125 MBd operation. The Applications Engineering Department in the Hewlett-

Packard Optical Communication Division is available to assist in optimizing link performance for higher or lower speed operation.

**Recommended Operating Conditions for the Circuits in Figures 1 and 2.**

Parameter	Symbol	Min.	Max.	Unit	Note
Ambient Temperature	T <sub>A</sub>	0	70	°C	
Supply Voltage	V <sub>CC</sub>	+4.75	+5.25	V	
Data Input Voltage - Low	V <sub>IL</sub>	V <sub>CC</sub> - 1.89	V <sub>CC</sub> - 1.62	V	
Data Input Voltage - High	V <sub>IH</sub>	V <sub>CC</sub> - 1.06	V <sub>CC</sub> - 0.70	V	
Data Output Load	R <sub>L</sub>	45	55	Ω	1
Signaling Rate	f <sub>S</sub>	1	125	MBd	
Duty Cycle	D.C.	40	60	%	2

**Link Performance:** 1-125 MBd, BER ≤ 10<sup>-9</sup>, under recommended operating conditions with recommended transmit and receive application circuits.

Parameter	Symbol	Min. <sup>[3]</sup>	Typ. <sup>[4]</sup>	Max.	Unit	Condition	Note
Optical Power Budget, 1 m POF	OPB <sub>POF</sub>	11	16		dB		5, 6, 7
Optical Power Margin, 20 m Standard POF	OPM <sub>POF,20</sub>	3	6		dB		5, 6, 7
Link Distance with Standard 1 mm POF	1	20	27		m		
Optical Power Margin, 25 m Low Loss POF	OPM <sub>POF,25</sub>	3	6		dB		5, 6, 7
Link Distance with Extra Low Loss 1 mm POF	1	25	32		m		
Optical Power Budget, 1 m HCS	OPB <sub>HCS</sub>		12		dB		5, 6, 7
Optical Power Margin, 100 m HCS	OPM <sub>HCS,100</sub>		6		dB		5, 6, 7
Link Distance with HCS cable	1		125		m		

**Notes:**

- If the output of U4C in Figure 1, page 4 is transmitted via coaxial cable, terminate with a 50 Ω resistor to V<sub>CC</sub> - 2 V.
- Run length limited code with maximum run length of 10 μs.
- Minimum link performance is projected based on the worst case specifications of the transmitter, receiver, and POF cable, and the typical performance of other components (e.g., logic gates, transistors, resistors, capacitors, quantizer, HCS cable).
- Typical performance is at 25°C, 125 MBd, and is measured with typical values of all circuit components.
- Standard cable is HFBR-RXXYYY plastic optical fiber, with a maximum attenuation of 0.24 dB/m at 650 nm and NA = 0.5. Extra low loss cable is HFBR-EXXYYY plastic optical fiber, with a maximum attenuation of 0.19 dB/m at 650 nm and NA = 0.5. HCS cable is HFBR-H/VXXYYY glass optical fiber, with a maximum attenuation of 10 dB/km at 650 nm and NA = 0.37.
- Optical Power Budget is the difference between the transmitter output power and the receiver sensitivity, measured after 1 meter of fiber. The minimum OPB is based on the limits of optical component performance over temperature, process, and recommended power supply variation.
- The Optical Power Margin is the available OPB after including the effects of attenuation and modal dispersion for the minimum link distance: OPM = OPB - (attenuation power loss + modal dispersion power penalty). The minimum OPM is the margin available for long term LED LOP degradation and additional fixed passive losses (such as in-line connectors) in addition to the minimum specified distance.

### Plastic Optical Fiber (1 mm POF) Transmitter Application Circuit:

Performance of the transmitter in the recommended application circuit (Figure 1) for POF; 1-125 MBd, 25°C.

Parameter	Symbol	Typical	Unit	Condition	Note
Average Optical Power 1 mm POF	$P_{avg}$	-9.7	dBm	50% Duty Cycle	Note 1, Fig. 3
Average Modulated Power 1 mm POF	$P_{mod}$	-11.3	dBm		Note 2, Fig. 3
Optical Rise Time (10% to 90%)	$t_r$	2.1	ns	5 MHz	
Optical Fall Time (90% to 10%)	$t_f$	2.8	ns	5 MHz	
High Level LED Current (On)	$I_{F,H}$	30	mA		Note 3
Low Level LED Current (Off)	$I_{F,L}$	3	mA		Note 3
Optical Overshoot - 1 mm POF		45	%		
Transmitter Application Circuit Current Consumption - 1 mm POF	$I_{CC}$	115	mA		Figure 1

**Hard Clad Silica Fiber (200 μm HCS) Transmitter Application Circuit:** Performance of the transmitter in the recommended application circuit (Figure 1) for HCS; 1-125 MBd, 25°C.

Parameter	Symbol	Typical	Unit	Condition	Note
Average Optical Power 200 μm HCS	$P_{avg}$	-14.6	dBm	50% Duty Cycle	Note 1, Fig. 3
Average Modulated Power 200 μm HCS	$P_{mod}$	-16.2	dBm		Note 2, Fig. 3
Optical Rise Time (10% to 90%)	$t_r$	3.1	ns	5 MHz	
Optical Fall Time (90% to 10%)	$t_f$	3.4	ns	5 MHz	
High Level LED Current (On)	$I_{F,H}$	60	mA		Note 3
Low Level LED Current (Off)	$I_{F,L}$	6	mA		Note 3
Optical Overshoot - 200 μm HCS		30	%		
Transmitter Application Circuit Current Consumption - 200 μm HCS	$I_{CC}$	130	mA		Figure 1

#### Notes:

1. Average optical power is measured with an average power meter at 50% duty cycle, after 1 meter of fiber.
2. To allow the LED to switch at high speeds, the recommended drive circuit modulates LED light output between two non-zero power levels. The modulated (useful) power is the difference between the high and low level of light output power (transmitted) or input power (received), which can be measured with an average power meter as a function of duty cycle (see Figure 3). Average Modulated Power is defined as one half the slope of the average power versus duty cycle:

$$\text{Average Modulated Power} = \frac{[P_{avg} @ 80\% \text{ duty cycle} - P_{avg} @ 20\% \text{ duty cycle}]}{(2) [0.80 - 0.20]}$$

3. High and low level LED currents refer to the current through the LED. The low level LED "off" current, sometimes referred to as "hold-on" current, is prebias supplied to the LED during the off state to facilitate fast switching speeds.

## Plastic and Hard Clad Silica Optical Fiber Receiver Application Circuit:

Performance<sup>[4]</sup> of the receiver in the recommended application circuit (Figure 1); 1-125 MBd, 25°C unless otherwise stated.

Parameter	Symbol	Typical	Unit	Condition	Note
Data Output Voltage - Low	$V_{OL}$	$V_{CC} - 1.7$	V	$R_L = 50 \Omega$	Note 5
Data Output Voltage - High	$V_{OH}$	$V_{CC} - 0.9$	V	$R_L = 50 \Omega$	Note 5
Receiver Sensitivity to Average Modulated Optical Power 1 mm POF	$P_{min}$	-27.5	dBm	50% eye opening	Note 2
Receiver Sensitivity to Average Modulated Optical Power 200 $\mu$ m HCS	$P_{min}$	-28.5	dBm	50% eye opening	Note 2
Receiver Overdrive Level of Average Modulated Optical Power 1 mm POF	$P_{max}$	-7.5	dBm	50% eye opening	Note 2
Receiver Overdrive Level of Average Modulated Optical Power 200 $\mu$ m HCS	$P_{max}$	-10.5	dBm	50% eye opening	Note 2
Receiver Application Circuit Current Consumption	$I_{CC}$	85	mA	$R_L = \infty$	Figure 1

### Notes:

- Performance in response to a signal from the transmitter driven with the recommended circuit at 1-125 MBd over 1 meter of plastic optical fiber or 1 meter of HCS<sup>®</sup> fiber with F07 plugs.
- Terminated through a 50  $\Omega$  resistor to  $V_{CC} - 2$  V.
- If there is no input optical power to the receiver, electrical noise can result in false triggering of the receiver. In typical applications, data encoding and error detection prevent random triggering from being interpreted as valid data.

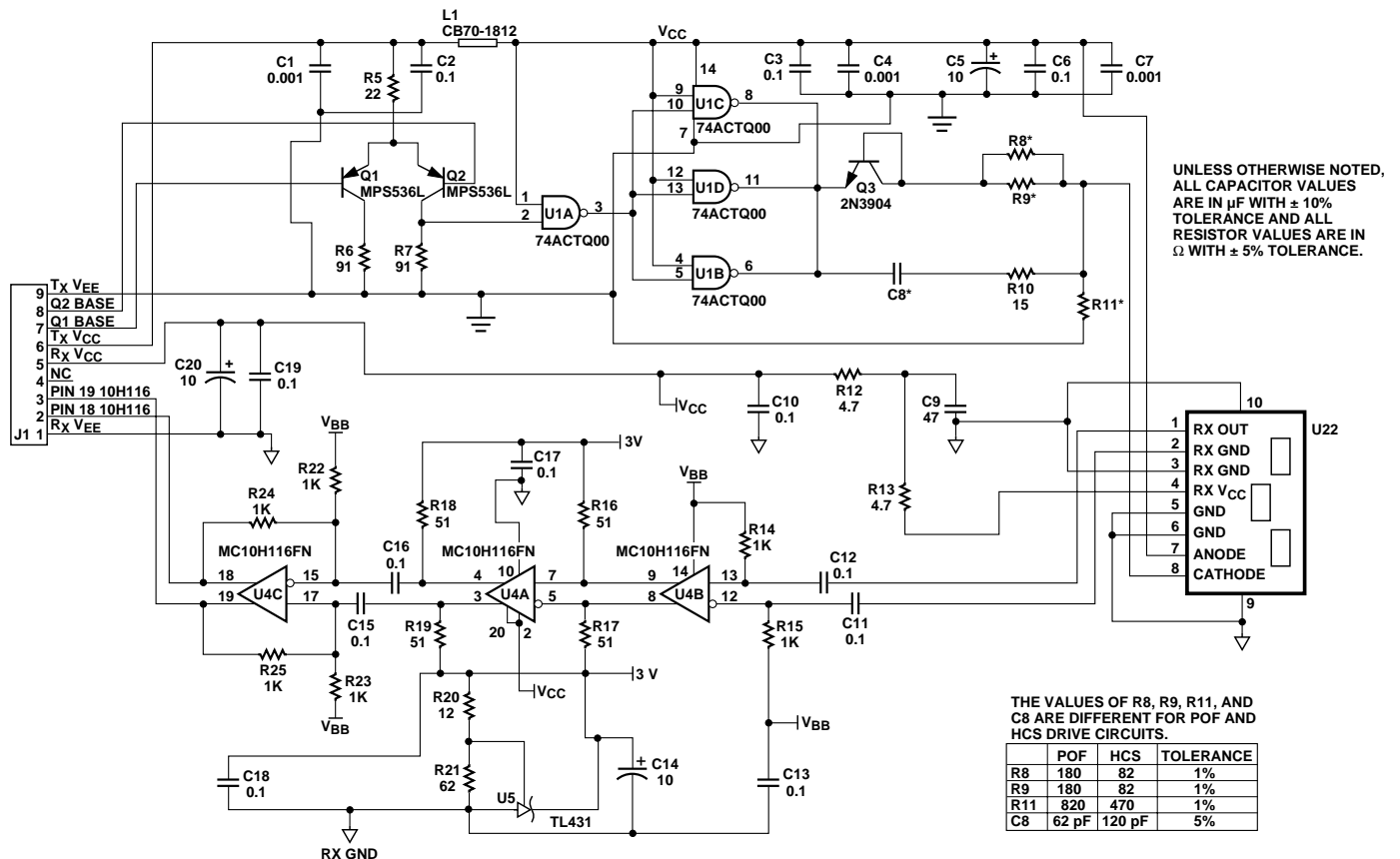


Figure 1. Transmitter and Receiver Application Circuit with +5 V ECL Inputs and Outputs.

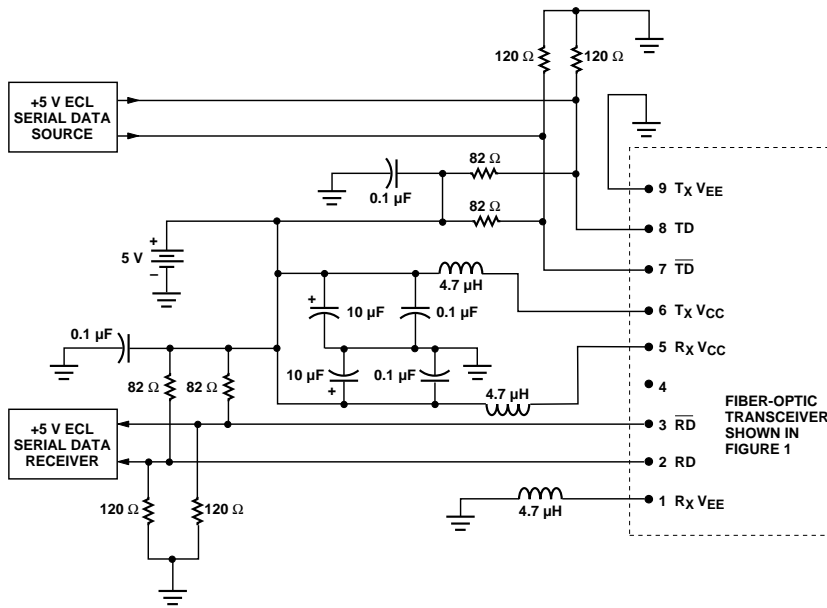


Figure 2. Recommended Power Supply Filter and +5 V ECL Signal Terminations for the Transmitter and Receiver Application Circuit of Figure 1.

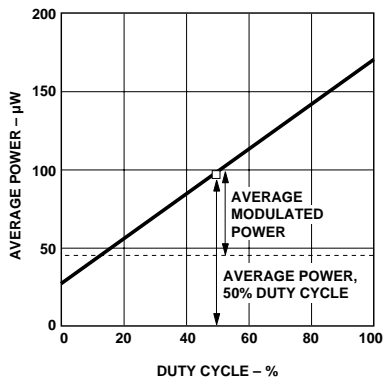


Figure 3. Average Modulated Power.

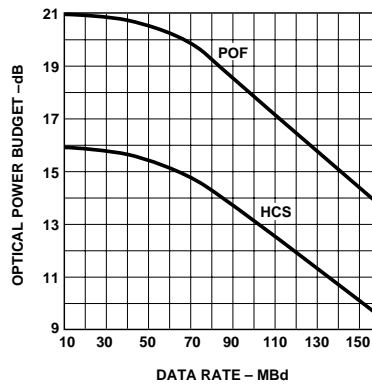


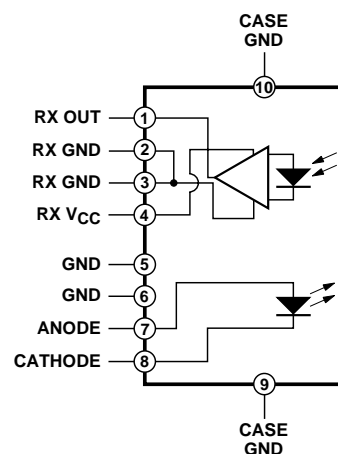
Figure 4. Typical Optical Power Budget vs. Data Rate.

# 125 Megabaud Fiber Optic Link Transmitter/Receiver

## Description

The HFBR-5527 incorporates a 650 nm LED, a PIN photodiode, and transimpedance preamplifier. The 650 nm LED is suitable for use with current peaking to decrease optical response time and can be used with the PIN preamplifier to build an optical transceiver that can be operated at signaling rates from 1 to 125 MBd over POF or HCS® fiber. The

receivers convert a received optical signal to an analog output voltage. Follow-on circuitry can optimize link performance for a variety of distance and data rate requirements. Electrical bandwidth greater than 65 MHz allows design of high speed data links with plastic or hard clad silica optical fiber.



## Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit	Reference
Storage Temperature	$T_S$	-40	+85	°C	
Operating Temperature	$T_O$	-40	+70	°C	
Lead Soldering Temperature			260	°C	Note 1
Cycle Time			10	s	
Transmitter High Level Forward Input Current	$I_{F,H}$		120	mA	50% Duty Cycle ≥ 1 MHz
Transmitter Average Forward Input Current	$I_{F,AV}$		60	mA	
Transmitter Reverse Input Voltage	$V_R$		3	V	
Receiver Signal Pin Voltage	$V_O$	-0.5	$V_{CC}$	V	
Receiver Supply Voltage	$V_{CC}$	-0.5	6.0	V	
Receiver Output Current	$I_O$		25	mA	

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

**WARNING:** WHEN VIEWED UNDER SOME CONDITIONS, THE OPTICAL PORT MAY EXPOSE THE EYE BEYOND THE MAXIMUM PERMISSIBLE EXPOSURE RECOMMENDED IN ANSI Z136.2, 1993. UNDER MOST VIEWING CONDITIONS THERE IS NO EYE HAZARD.

## HFBR-5527 Transmitter

**Electrical/Optical Characteristics** 0 to 70°C, unless otherwise stated.

Parameter	Symbol	Min.	Typ. <sup>[2]</sup>	Max.	Unit	Condition	Note
Transmitter Output Optical Power, 1 mm POF	$P_T$	-9.5 -10.4	-7.0	-4.8 -4.3	dBm	$I_{F,dc} = 30 \text{ mA}$ , 25°C 0-70°C	Note 3
Transmitter Output Optical Power, 200 $\mu\text{m}$ HCS <sup>®</sup>	$P_T$		-13.0	-10.5 -10.0	dBm	$I_{F,dc} = 60 \text{ mA}$ , 25°C 0-70°C	Note 3
Output Optical Power Temperature Coefficient	$\frac{\Delta P_T}{\Delta T}$		-0.02		dB/°C		
Peak Emission Wavelength	$\lambda_{PK}$	640	650	660	nm		
Peak Wavelength Temperature Coefficient	$\frac{\Delta \lambda}{\Delta T}$		0.12		nm/°C		
Spectral Width	FWHM		21		nm	Full Width, Half Maximum	
Forward Voltage	$V_F$	1.8	2.0	2.4	V	$I_F = 60 \text{ mA}$	
Forward Voltage Temperature Coefficient	$\frac{\Delta V_F}{\Delta T}$		-1.8		mV/°C		
Transmitter Numerical Aperture	NA		0.5				
Thermal Resistance, Junction to Case	$\theta_{jc}$		140		°C/W		Note 4
Reverse Input Breakdown Voltage	$V_{BR}$	3.0	13		V	$I_{F,dc} = -10 \mu\text{A}$	
Diode Capacitance	$C_O$		60		pF	$V_F = 0 \text{ V}$ , $f = 1 \text{ MHz}$	
Unpeaked Optical Rise Time, 10% - 90%	$t_r$		12		ns	$I_F = 60 \text{ mA}$ $f = 100 \text{ kHz}$	Figure 5 Note 5
Unpeaked Optical Fall Time, 90% - 10%	$t_f$		9		ns	$I_F = 60 \text{ mA}$ $f = 100 \text{ kHz}$	Figure 5 Note 5

### Notes:

- 1.6 mm below seating plane.
- Typical data is at 25°C.
- Optical Power measured at the end of 0.5 meter of 1 mm diameter plastic or 200  $\mu\text{m}$  diameter hard clad silica optical fiber with a large area detector.
- Typical value measured from junction to PC board solder joint.
- Optical rise and fall times can be reduced with the appropriate driver circuit.
- Pins 9 and 10 are primarily for mounting and retaining purposes, but are electrically connected with conductive housing; pins 5 and 6 are electrically unconnected. It is recommended that pins 5, 6, 9, and 10 all be connected to Rx ground to reduce coupling of electrical noise.
- Refer to the Versatile Link Family Fiber Optic Cable and Connectors Technical Data Sheet for cable connector options for 1 mm plastic optical fiber and 200  $\mu\text{m}$  HCS fiber.
- The LED current peaking necessary for high frequency circuit design contributes to electromagnetic interference (EMI). Care must be taken in circuit board layout to minimize emissions for compliance with governmental EMI emissions regulations.

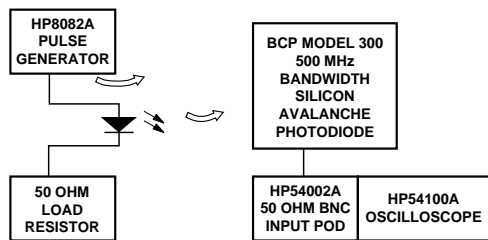


Figure 5. Test Circuit for Measuring Unpeaked Rise and Fall Times.

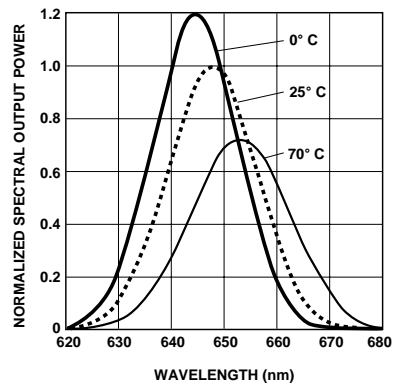


Figure 6. Typical Spectra Normalized to the 25°C Peak.

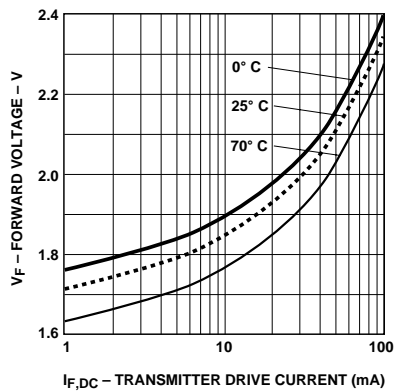


Figure 7. Typical Forward Voltage vs. Drive Current.

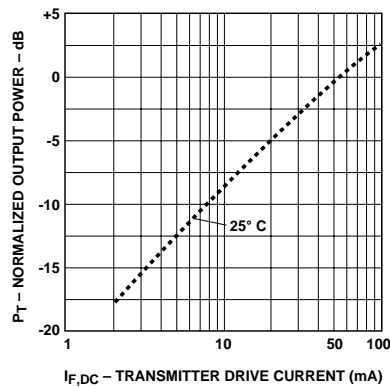


Figure 8. Typical Normalized Output Optical Power vs. Drive Current with the Drive Circuit in Figure 1 Recommended Application Circuit.



## HFBR-5527 Receiver

**Electrical/Optical Characteristics** 0 to 70°C; 5.25 V ≥ V<sub>CC</sub> ≥ 4.75 V; power supply must be filtered (see Figure 1, Note 2).

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Condition	Note
AC Responsivity 1 mm POF	R <sub>P,POF</sub>	1.7	3.9	6.5	mV/μW	650 nm	Note 4
AC Responsivity 200 μm HCS	R <sub>P,HCS</sub>	4.5	7.9	11.5	mV/μW		
RMS Output Noise	V <sub>NO</sub>		0.46	0.69	mV <sub>RMS</sub>		Note 5
Equivalent Optical Noise Input Power, RMS - 1 mm POF	P <sub>N,RMS</sub>		-39	-36	dBm		Note 5
Equivalent Optical Noise Input Power, RMS - 200 μm HCS	P <sub>N,RMS</sub>		-42	-40	dBm		Note 5
Peak Input Optical Power - 1 mm POF	P <sub>R</sub>			-5.8 -6.4	dBm dBm	5 ns PWD 2 ns PWD	Note 6
Peak Input Optical Power - 200 μm HCS	P <sub>R</sub>			-8.8 -9.4	dBm dBm	5 ns PWD 2 ns PWD	Note 6
Output Impedance	Z <sub>O</sub>		30		Ω	50 MHz	Note 4
DC Output Voltage	V <sub>O</sub>	0.8	1.8	2.6	V	P <sub>R</sub> = 0 μW	
Supply Current	I <sub>CC</sub>		9	15	mA		
Electrical Bandwidth	BW <sub>E</sub>	65	125		MHz	-3 dB electrical	
Bandwidth * Rise Time			0.41		Hz * s		
Electrical Rise Time, 10-90%	t <sub>r</sub>		3.3	6.3	ns	P <sub>R</sub> = -10 dBm peak	
Electrical Fall Time, 90-10%	t <sub>f</sub>		3.3	6.3	ns	P <sub>R</sub> = -10 dBm peak	
Pulse Width Distortion	PWD		0.4	1.0	ns	P <sub>R</sub> = -10 dBm peak	Note 7
Overshoot			4		%	P <sub>R</sub> = -10 dBm peak	Note 8

### Notes:

- 1.6 mm below seating plane.
- The signal output is an emitter follower, which does not reject noise in the power supply. The power supply must be filtered as in Figure 9.
- Typical data are at 25°C and V<sub>CC</sub> = +5 Vdc.
- Pin 1 should be ac coupled to a load ≥ 510 Ω with load capacitance less than 5 pF.
- Measured with a 3 pole Bessel filter with a 75 MHz, -3 dB bandwidth. No modulation applied to Tx.
- The maximum Peak Input Optical Power is the level at which the Pulse Width Distortion is guaranteed to be less than the PWD listed under Test Condition. P<sub>R,Max</sub> is given for PWD = 5 ns for designing links at ≤ 50 MBd operation, and also for PWD = 2 ns for designing links up to 125 MBd (for both POF and HCS input conditions).
- 10 ns pulse width, 50% duty cycle, at the 50% amplitude point of the waveform.
- Percent overshoot is defined at:

$$\frac{(V_{PK} - V_{100\%})}{V_{100\%}} \times 100\%$$

- Pins 9 and 10 are primarily for mounting and retaining purposes, but are electrically connected with the conductive housing. Pins 5 and 6 are electrically unconnected. It is recommended that pins 5 and 6 be connected to Rx ground to reduce coupling of electrical noise. Refer to Figure 1. The connections between pins 1 and 2 of the HFBR-5527 and pins 13 and 12 of the MC10H116 should be adjacent and nearly the same length to maximize the common mode rejection of the MC10H116 to eliminate cross talk between the transmitter and receiver.
- If there is no input optical power to the receiver (no transmitted signal) electrical noise can result in false triggering of the receiver. In typical applications, data encoding and error detection prevent random triggering from being interpreted as valid data.

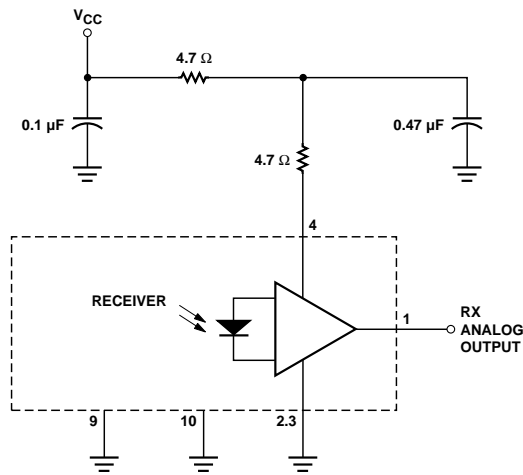


Figure 9. Recommended Power Supply Filter Circuit.

The HFBR-5527 is typically used to construct 125 MBd digital fiber-optic receivers which use the same +5 volt power supply that powers the host system's microprocessors, CMOS logic, or TTL logic. To build a digital receiver, the analog HFBR-5527 component must be connected to a post amplifier and a comparator. This post amplifier plus comparator function is commonly known as a quantizer. The 0 V common and +5 V power supply connections for the HFBR-5527 and quantizer must be isolated from the host system's power and ground planes by a low pass filter. This recommended low pass

filter assures that the electrical noise normally present in the host system's digital logic power supply will not reduce the sensitivity of fiber-optic receivers implemented with the HFBR-5527. The quantizer and power supply filter circuits recommended for use with the HFBR-5527 are shown in Figure 7 of HP Application Note 1066. For optimum performance, the HFBR-5527 should be used with the same quantizer and power supply filters recommended for use with HP's HFBR-15X7 and HFBR-25X6 components. To maximize immunity to electrical

noise, pins 3, 9, and 10 of the HFBR-5527 should be connected to filtered receiver common. For best common mode noise rejection, the connections between pins 1 and 2 of the HFBR-5527 and the quantizer's differential input should be of equal length, and the components in both traces should be placed to achieve symmetry. The preceding recommendations minimize the cross talk between the fiber-optic transmitter and receiver. These recommendations also improve the fiber-optic receiver's immunity to environmental noise and the host system's electrical noise.

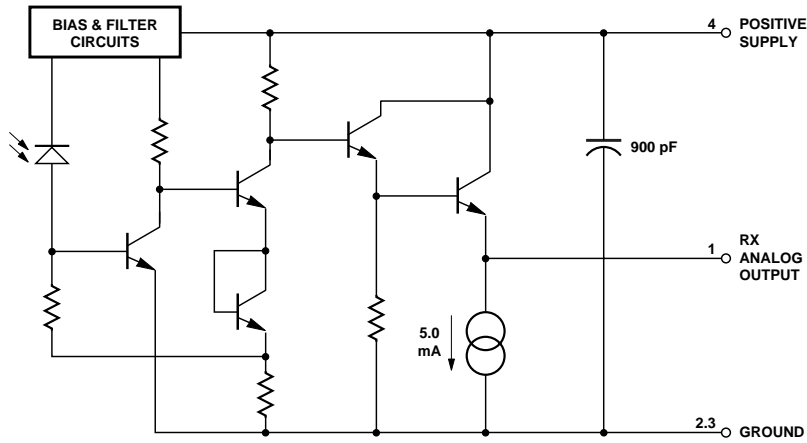


Figure 10. Simplified Receiver Schematic.

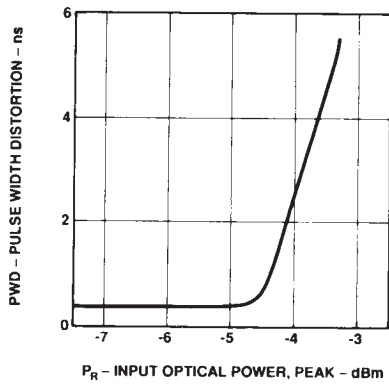


Figure 11. Typical Pulse Width Distortion vs. Peak Input Power.

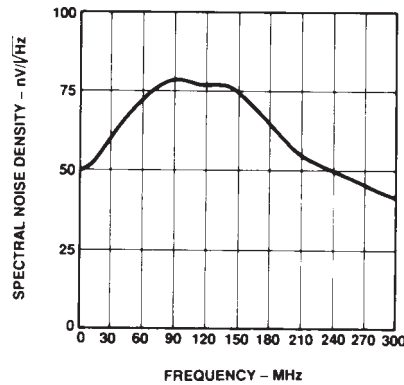


Figure 12. Typical Output Spectral Noise Density vs. Frequency.

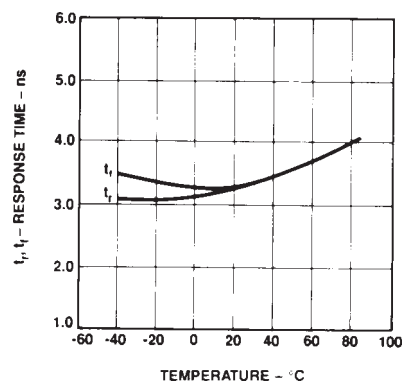
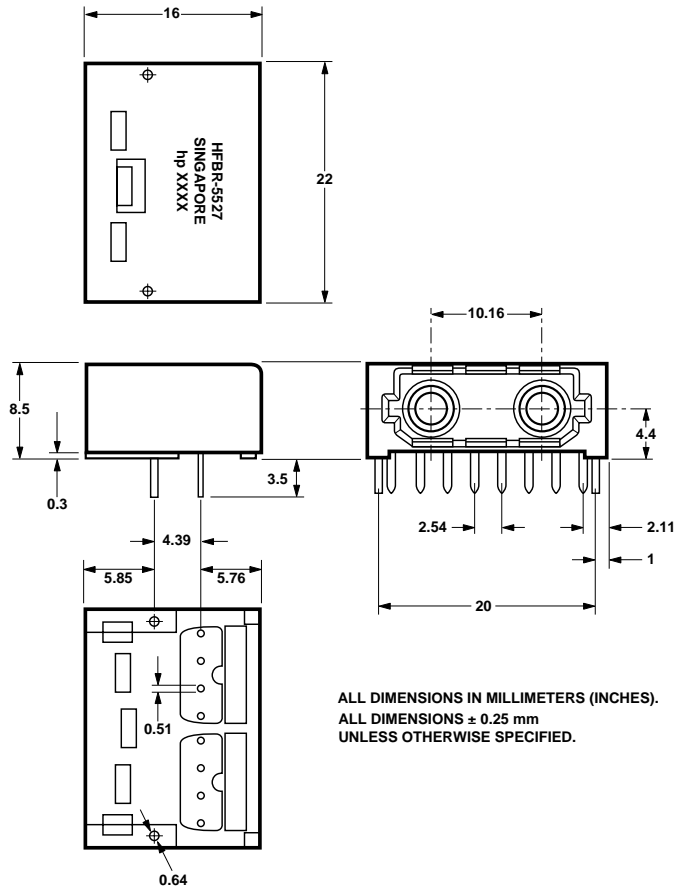


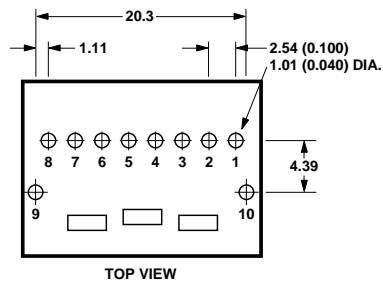
Figure 13. Typical Rise and Fall Time vs. Temperature.

# HFBR-5527

## Mechanical Dimensions



## Printed Circuit Board Layout Dimensions



### ELECTRICAL PIN FUNCTIONS

PIN NO.	FUNCTION
1	RX OUT
2	RX GND
3	RX GND
4	RX V <sub>CC</sub>
5	TX GND*
6	TX GND*
7	ANODE
8	CATHODE
9	CASE GND
10	CASE GND

\*NO INTERNAL CONNECTION

**CAUTION:**  
 THIS PACKAGE IS MADE  
 OF CONDUCTIVE PLASTIC.  
 PLEASE TAKE THIS INTO  
 ACCOUNT WHEN  
 INCORPORATING THIS  
 PACKAGE INTO INTRINSICALLY  
 SAFE APPLICATIONS.

**NOTE:**  
 DIMENSIONS IN MILLIMETERS  
 AND (INCHES).