

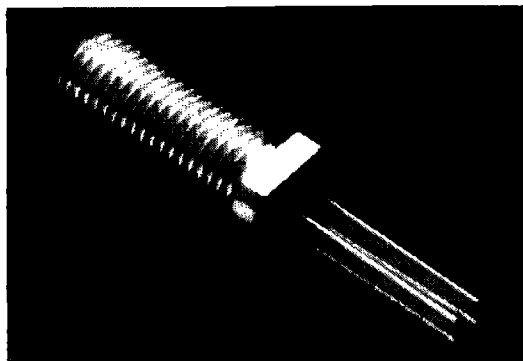


40 MBd MINIATURE FIBER OPTIC RECEIVER

HFBR-2204

Features

- DATA RATES UP TO 40 MBd
- HIGH OPTICAL COUPLING EFFICIENCY
- RUGGED, MINIATURE METAL PACKAGE
- COMPATIBLE WITH SMA STYLE CONNECTORS
- VERSATILE ANALOG RECEIVER OUTPUT
- 25 MHz ANALOG BANDWIDTH



Applications

- DATA ACQUISITION AND PROCESS CONTROL
- SECURE DATA COMMUNICATION
- EMC REGULATED SYSTEMS (FCC/VDE)
- EXPLOSION PROOF SYSTEMS
- WEIGHT SENSITIVE SYSTEMS (e.g., AVIONICS, MOBILE STATIONS)
- VIDEO TRANSMISSION

The signal from this simple analog receiver can be optimized for a variety of transmission requirements. For example, the circuits in Application Bulletin 73 add low-cost external components to achieve logic compatible signal levels optimized for various data formats and data rates.

Each of these fiber optic components uses the same rugged, lensed, miniature package. This package assures a consistent, efficient optical coupling between the active devices and the optical fiber.

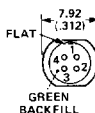
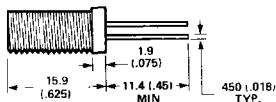
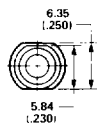
Description

The HFBR-2204 Receiver is capable of data rates up to 40 MBd at distances greater than 1 km when used with cable and HFBR-1202/4 Transmitters. The HFBR-2204 Receiver contains a discrete PIN photodiode and preamplifier IC.

The HFBR-2204 Receiver is compatible with SMA style connectors, types A and B (see Figure 11 and HP's 100/140 μ m SMA connected cable assemblies. HP's 100/140 μ m fiber optic cable can be ordered with or without connectors.

Mechanical Dimensions

HFBR-2204 RECEIVER



PIN	FUNCTION
1	CASE
2	SIGNAL
3	COMMON
4	Vcc

DIMENSIONS IN MILLIMETRES (INCHES)
UNLESS OTHERWISE SPECIFIED, THE TOLERANCES ARE:
.X - .51 mm (.02 IN)
.XX - .13 mm (.005 IN)

Electrical Description

The HFBR-2204 Fiber Optic Receiver contains a PIN photodiode and low noise transimpedance pre-amplifier hybrid circuit with an inverting output (see note 10). The HFBR-2204 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-2204 Receiver is much larger than from a simple PIN photodiode, it is less susceptible to EMI, especially at high signal rates.

The frequency response is typically dc to 25 MHz. Although the HFBR-2204 is an analog receiver, it is easily made compatible with digital systems (see Application Bulletin 73). Separate case and signal ground leads are provided for maximum design flexibility.

It is essential that a bypass capacitor (0.01 μ F to 0.1 μ F ceramic) be connected from Pin 4 (V_{CC}) to Pin 3 (circuit common) of the receiver. Total lead length between both ends of the capacitor and the pins should be less than 20 mm.

Mechanical Description

The HFBR-2204 Fiber Optic Receiver is housed in a miniature package intended for use with HP's 100/140 μ m SMA connected cable assemblies. This package has important performance advantages:

1. Precision mechanical design and assembly procedures assure the user of consistent high efficiency optical coupling.
2. The lens is suspended to avoid contact with the active devices, thereby assuring improved reliability.

3. The versatile miniature package is easy to mount. This low profile package is designed for direct mounting on printed circuit boards or through panels without additional heat sinking.

A complete mounting hardware package is available for horizontal PCB applications, including a snap-on metal shield for harsh EMI/ESD environments.

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 or Freon on a cotton swab also works well.

Note:

When installing connected cable on the optical port, do not use excessive force to tighten the nut. Finger tightening is sufficient to ensure connecting integrity, while use of a wrench may cause damage to the connector or the optics.

System Design Considerations

For additional information, see Application Bulletin 73.

OPTICAL POWER BUDGETING

The HFBR-2204 Fiber Optic Receivers when used with the HFBR-1202 Fiber Optic Transmitter can be operated at a signalling rate of more than 40 MBd over a distance greater than 1000 metres (assuming 8 dB/km cable attenuation). For shorter transmission distances, power consumption can be reduced by decreasing Transmitter drive current. At a lower data rate, the transmission distance may be increased by applying bandwidth-filtering at the output of the HFBR-

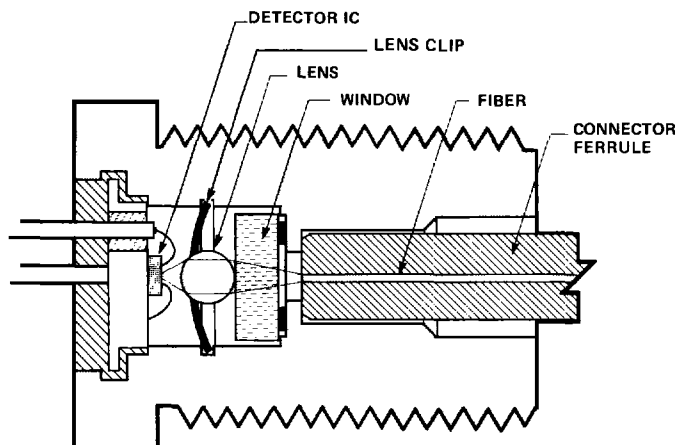


Figure 1. Cross Sectional View

2204 Receiver; since noise is reduced as the square root of the bandwidth, the sensitivity of the circuit is proportionately improved provided these two conditions are met:

- input-referred noise of the follow on circuit is well below the filtered noise of the Receiver
- logic comparator threshold is reduced in the same proportion as the noise reduction

As an example, consider a link with a maximum data rate of 10 MBd (e.g., 5 Mb/s Manchester); this requires a 3 dB bandwidth of only 5 MHz. For this example, the input-referred rms noise voltage of the follow-on circuit is 0.03 mV. The equivalent optical noise power of the complete receiver (P_{NO}) is given by:

$$P_{NO} = [(V_{NO})^2 (B/B_0) + (V_{NI})^2]^{0.5} / R_P$$

V_{NO} = rms output noise voltage of the HFBR-2203/04 with no bandwidth filtering

V_{NI} = input-referred rms noise voltage of the follow-on circuit

B = filtered 3 dB bandwidth

B_0 = Unfiltered 3dB bandwidth of the HFBR-2203/04 (25 MHz)

R_P = optical-to-electrical responsivity (mV/ μ W) of the HFBR-2240

Note that noise adds in an rms fashion, and that the square of the rms noise voltage of the HFBR-2204 is reduced by the bandwidth ratio, B/B_0 .

From the receiver data (Electrical/Optical Characteristics) taking worst-case values, and applying NO bandwidth filtering ($B/B_0 = 1$):

$$P_{NO} = \frac{[(0.43)^2 + (0.03)^2]^{0.5} \text{ mV}}{4.6 \text{ mV}/\mu\text{W}} = 0.094 \mu\text{W} \text{ or } -40.3 \text{ dBm}$$

To ensure a bit error rate less than 10^{-9} requires the signal power to be 12 times larger (+11 dB) than the rms noise as referred to the Receiver input. The minimum Receiver input power is then:

$$P_{RMIN} = P_{NO} + 11 \text{ dB} = -29.3 \text{ dBm}$$

With the application of a 5 MHz low-pass filter, the bandwidth ratio becomes:

$$B/B_0 = 5 \text{ MHz}/25 \text{ MHz} = 0.2$$

Note that 25 MHz should be used for the total noise bandwidth of the HFBR-2204. Inserting this value of the bandwidth ratio in the expressions for P_{NO} and P_{RMIN} above yields the results:

$$P_{NO} = 0.042 \mu\text{W} \text{ or } -43.8 \text{ dBm} \text{ and } P_{RMIN} = -32.8 \text{ dBm}$$

Given the HFBR-1202 Transmitter optical power $P_T = -18 \text{ dBm}$ at $I_F = 40 \text{ mA}$, and allowing a 3 dB margin, a

minimum optical power budget of 11.8 dB is obtained:

$$[-18 \text{ dBm} -3 \text{ dB} -(-32.8 \text{ dBm})] = 11.8 \text{ dB}$$

Using 8 dB/km optical fiber, this translates into a minimum link length of 1475 metres (typical link power budget for this configuration is approximately 17.2 dB or 3130 metres with 5.5 dB/km fiber).

BANDWIDTH

The bandwidth of the HFBR-2204 is typically 25 MHz. Over the entire temperature range of -40°C to $+85^\circ\text{C}$, the rise and fall times vary in an approximately linear fashion with temperature. Under worst case conditions, t_r and t_f may reach a maximum of 26 ns, which translates to a 3 dB bandwidth of:

$$f_{3dB} \approx \frac{350}{t_r} = \frac{350}{26 \text{ ns}} = 13.5 \text{ MHz}$$

The receiver response is essentially that of a single-pole system, rolling off at 6 dB/octave. In order for the receiver to operate up to 40 MBd even though its worst case 3 dB bandwidth is 13.5 MHz, the received optical power must be increased by 3 dB to compensate for the restricted receiver transmission bandwidth.

PRINTED CIRCUIT BOARD LAYOUT

When operating at data rates above 10 MBd, standard PC board precautions should be taken. Lead lengths greater than 20 mm should be avoided whenever possible and a ground plane should be used. Although transmission line techniques are not required, wire wrap and plug boards are not recommended.

OPERATION WITH HEWLETT-PACKARD TRANSMITTERS

Hewlett-Packard offers two transmitters compatible with the HFBR-2204 Link performance with each transmitter is shown below for 25°C operation with HP's 100/140 μm glass fiber cable. See product data sheets for further information.

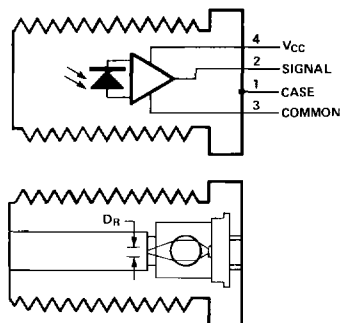
	HFBR-1202 -17 dBm Coupled Optical Power	HFBR-1204 -9.8 dBm Coupled Optical Power
HFBR-2204 -27 dBm Sensitivity	1200 m 40 MBd	2100 m 40 MBd
HFBR-2204 -32 dBm Sensitivity	1800 M 10 MBd	2800 M 10 MBd

HFBR-2204 RECEIVER

Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit	Reference
Storage Temperature	T_S	-55	85	°C	
Operating Temperature	T_A	-40	85	°C	Note 9
Lead Soldering Cycle	Temp.		260	°C	Note 1
	Time		10	sec	
Case Voltage	V_{CASE}		25	V	
Signal Pin Voltage	V_{SIGNAL}	-0.5	1	V	
Supply Voltage	V_{CC}	-0.5	7.0	V	

HFBR-2204 RECEIVER



Electrical/Optical Characteristics

-40°C to +85°C; $4.75 \leq V_{CC} \leq 5.25$; $R_{LOAD} = 511\Omega$ unless otherwise specified

Parameter	Symbol	Min.	Typ ^[4]	Max.	Unit	Conditions	Reference
Responsivity	R_P	5.1	7	10.9	mV/ μ W	$T_A = 25^\circ\text{C}$ at 820 nm	Note 10 Figure 3
		4.6		12.3	mV/ μ W	$-40 \leq T_A \leq +85^\circ\text{C}$	
RMS Output Noise Voltage	V_{NO}		.30	.36	mV	$T_A = 25^\circ\text{C}$, $P_{IN} = 0\mu\text{W}$	Figures 4, 7
				.43	mV	$-40 \leq T_A \leq 85^\circ\text{C}$, $P_{IN} = 0\mu\text{W}$	
Peak Input Power	P_R			-12.6	dBm	$T_A = 25^\circ\text{C}$	Note 2
				55	μ W		
				-14	dBm	$-40 \leq T_A \leq 85^\circ\text{C}$	
				40	μ W		
Output Impedance	Z_O		20		Ω	Test Frequency = 20 MHz	
DC Output Voltage	V_{odc}		.7		V	$P_{IN} = 0\mu\text{W}$	
Power Supply Current	I_{CC}		3.4	6.0	mA	$R_{LOAD} = \infty$	
Equivalent N.A.	NA		.35				
Equivalent Diameter	D_R		250		μm		Note 3
Equivalent Optical Noise Input Power	P_N		-43.7	-40.3	dBm		
			.042	.094	μ W		

Dynamic Characteristics

-40°C to +85°C; $4.75 \leq V_{CC} \leq 5.25$; $R_{LOAD} = 511\Omega$, $C_{LOAD} = 13\text{pF}$ unless otherwise specified

Parameter	Symbol	Min.	Typ ^[7]	Max.	Units	Conditions	Reference
Rise/Fall Time, 10% to 90%	t_r, t_f		14	19.5	ns	$T_A = 25^\circ\text{C}$ $P_{IN} = 10\mu\text{W Peak}$	Note 5 Figures 8, 9
				26	ns	$-40 \leq T_A \leq 85^\circ\text{C}$	
Pulse Width Distortion	$t_{phl} - t_{plh}$			2	ns	$P_{IN} = 40\mu\text{W Peak}$	Figure 9
Overshoot			4		%	$T_A = 25^\circ\text{C}$	Note 6 Figures 8, 9
Bandwidth			25		MHz		
Power Supply Rejection Ratio (Referred to Output)	PSRR		50		dB	at 2 MHz	Note 7 Figures 5, 6

Notes:

- 2.0 mm from where leads enter case.
- If $P_{in} < 40\mu\text{W}$, then pulse width distortion may increase. At $P_{in} = 80\mu\text{W}$ and $T_A = 80^\circ\text{C}$, some units have exhibited as much as 100 ns pulse width distortion.

Notes (cont.):

3. DR 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.
4. Typical specifications are for operation at $T_A = 25^\circ\text{C}$ and $V_{CC} = 5.0\text{V}$
5. Input optical signal is assumed to have 10% — 90% rise and fall times of less than 6 ns.
6. Percent overshoot is defined as:

$$\frac{V_{PK} - V_{100\%}}{V_{100\%}} \times 100\%$$
 See Figure 16.
7. Output referred P.S.R.R. is defined as

$$20 \log \left(\frac{V_{\text{POWER SUPPLY RIPPLE}}}{V_{\text{OUT RIPPLE}}} \right)$$
8. It is essential that a bypass capacitor (0.01 μF to 0.1 μF ceramic) be connected from pin 4 (V_{CC}) to pin 3 (circuit common) of the receiver. Total lead length between both ends of the capacitor and the pins should be less than 20 mm.
9. HP's 100/140 μm fiber cable is specified at a narrower temperature range, -20°C to 85°C .
10. $V_{\text{OUT}} = V_{\text{ODC}} - (R_P \times P_{\text{IN}})$.

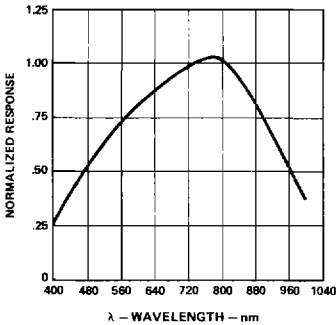


Figure 3. Receiver Spectral Response Normalized to 820 nm

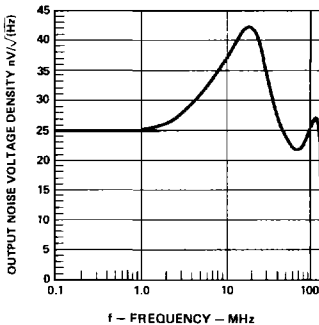


Figure 4. Receiver Noise Spectral Density

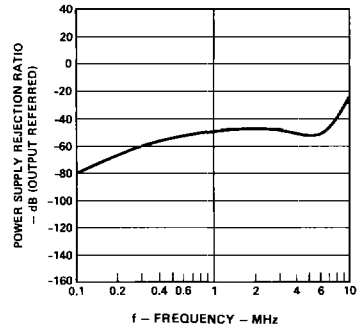


Figure 5. Receiver Power Supply Rej. vs. Freq.

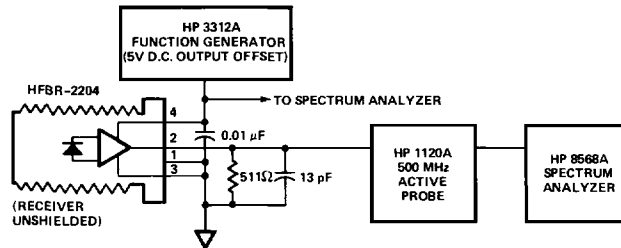


Figure 6. Power Supply Rejection Test Circuit

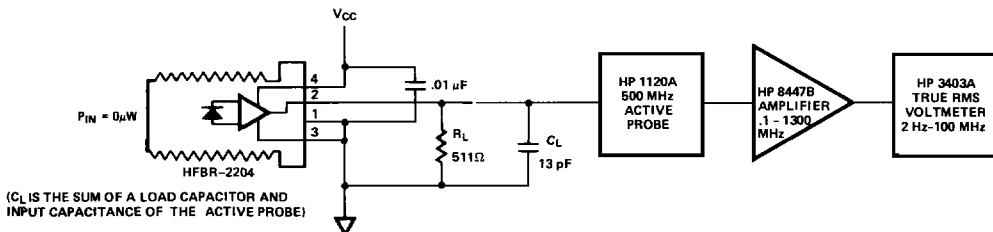


Figure 7. RMS Output Noise Voltage Test Circuit

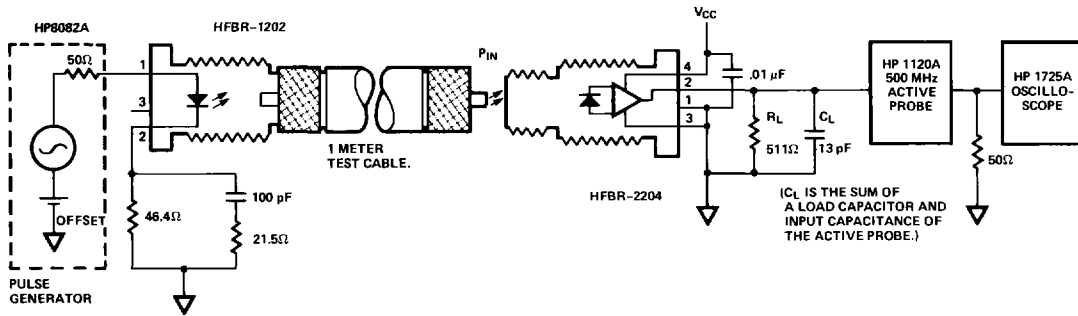


Figure 8. Rise and Fall Time Test Circuit

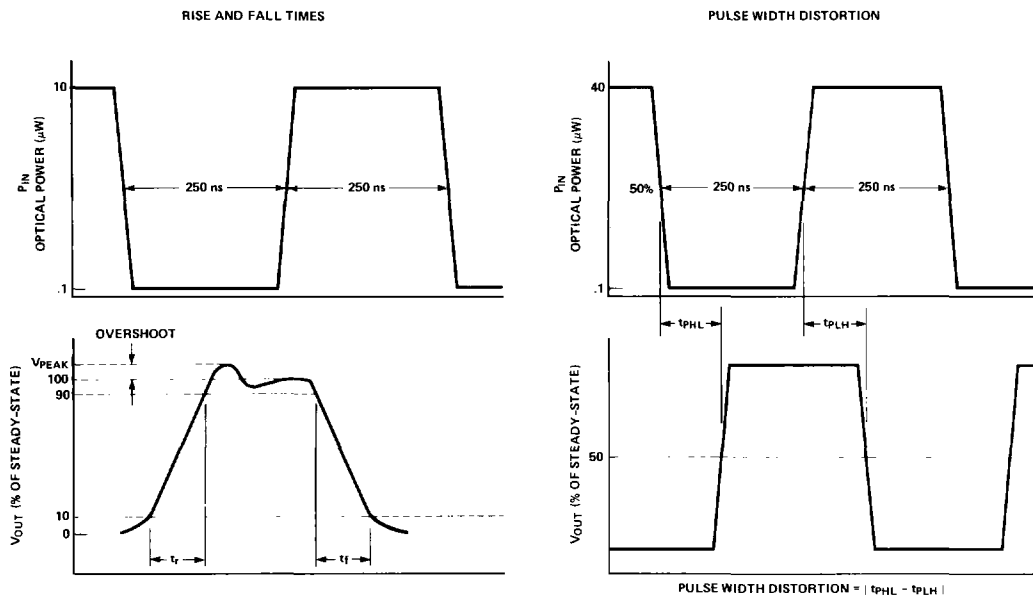
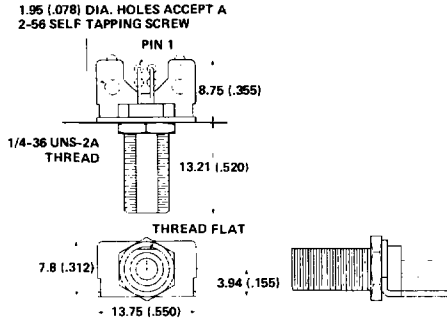


Figure 9. Waveform Timing Definitions

HFBR-2204 RECEIVER



RECEIVER PCB LAYOUT DIMENSIONS

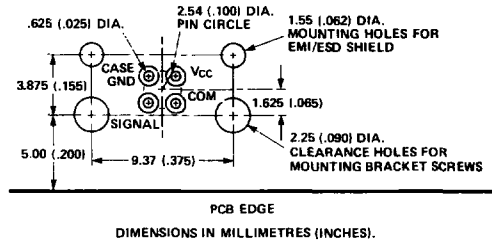


Figure 10. Mounting Dimensions

SMA STYLE CONNECTORS

TYPE A

(Used in HP's SMA Connected Cable Assemblies).

TYPE B

(Not Available from Hewlett-Packard)

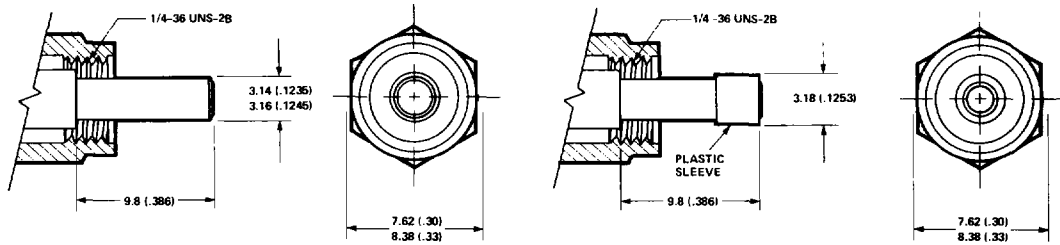


Figure 11. Fiber Optic Connector Styles

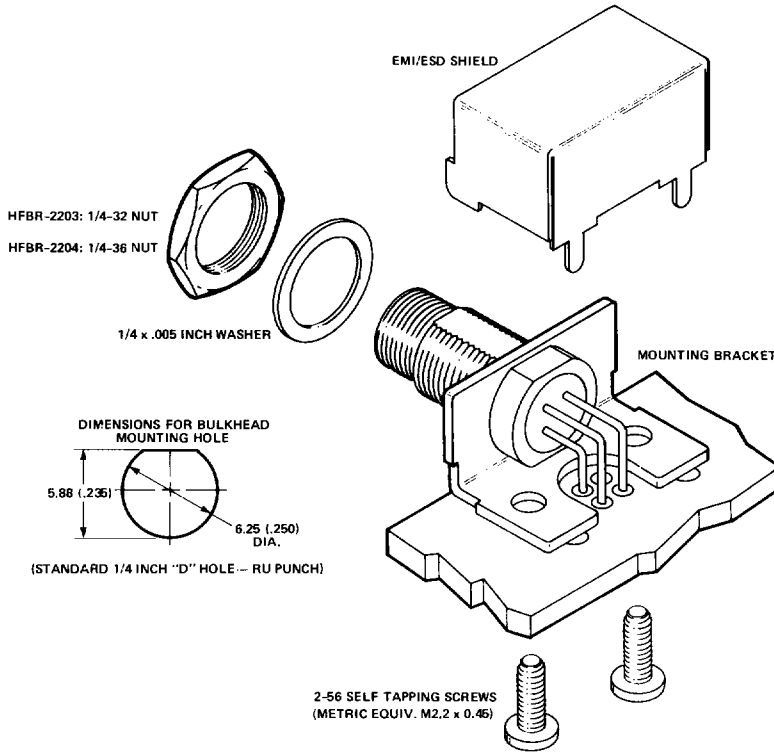
Horizontal PCB Mounting

Mounting at the edge of a printed circuit board with the lock nut overhanging the edge is recommended.

When bending the leads, avoid sharp bends right where the lead enters the backfill. Use needle nose pliers to support

the leads at the base of the package and bend the leads as desired.

When soldering, it is advisable to leave the protective cap on the unit to keep the optics clean.



- MOUNTING HARDWARE: HFBR-4202 (HFBR-2204)**
- 1 EMI/ESD SHIELD
 - 1 1/4-36 NUT
 - 1 1/4 x .005 INCH WASHER
 - 2 2-56 SELF TAPPING SCREWS
 - 1 MOUNTING BRACKET

Ordering Guide

Transmitter: HFBR-1202 (SMA Connector Compatible)
 HFBR-1204 (SMA Connector Compatible)

Receiver: HFBR-2204 (SMA Connector Compatible)

Mounting Hardware: HFBR-4202 (SMA Connector Compatible)

FIBER OPTICS