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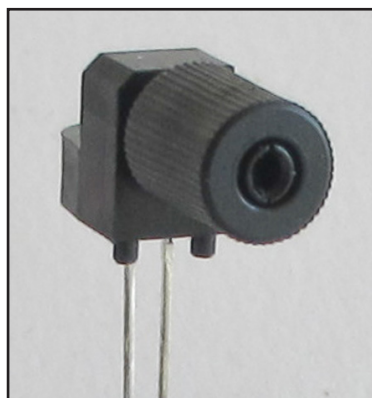
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## DESCRIPTION

The IF-D91B is a high-speed photodiode detector housed in a “connector-less” style plastic fiber optic package. Optical response of the IF-D91B extends from 450 to 1100 nm, making it compatible with a wide range of visible and nearinfrared LED and laser diode sources. This includes 650 nm visible red LEDs used for optimum transmission in PMMA plastic optic fiber. The detector package features an internal micro-lens and a precision-molded PBT housing to ensure efficient optical coupling with standard 1000  $\mu$ m core plastic fiber cable.

## APPLICATION HIGHLIGHTS

The fast response times of the IF-D91B make it suitable for high-speed digital data links. When used with an appropriate LED or laser diode source the IF-D91B is capable of 100 Mbps data rates. The IF-D91B also can be used in analog video links with bandwidths up to 70 MHz. The integrated design of the IF-D91B provides simple, cost-effective implementation in a variety of analog and digital applications.

## APPLICATIONS

- High-Speed Digital Data Links
- Local Area Networks
- Motor Controller Triggering
- Video Links
- Medical Instruments
- Automotive Electronics
- Robotics Communications
- EMC/EMI Signal Isolation
- Fiber Optic Modems

## FEATURES

- ◆ Fast Rise and Fall Times
- ◆ Mates with Standard 1000  $\mu$ m Core, 2.2 mm Jacketed Plastic Fiber Optic Cable
- ◆ No Optical Design Required
- ◆ Inexpensive Plastic Connector Housing
- ◆ Internal Micro-Lens for Efficient Optical Coupling
- ◆ Connector-Less Fiber Termination
- ◆ Light-Tight Housing provides Interference Free Transmission
- ◆ RoHS Compliant

## MAXIMUM RATINGS

( $T_A = 25^\circ\text{C}$ )

Operating Temperature Range  
( $T_{OP}$ ).....-30°to 80°C

Storage Temperature Range  
( $T_{STG}$ ).....-40°to 80°C

Junction Temperature ( $T_J$ ).....80°C

Soldering Temperature  
(2mm from case bottom)  
( $T_S$ )  $t \leq 5$  s.....260°C

Power Dissipation  
( $P_{TOT}$ )  $T_A = 25^\circ\text{C}$ .....100 mW

De-rate Above 25°C.....1.8 mW/°C

## CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ )

Parameter	Symbol	Min.	Typ.	Max.	Unit
Wavelength for Maximum Photosensitivity	$\lambda_{PEAK}$	-	920	-	nm
Spectral Bandwidth ( $R=10\%$ of $R_{MAX}$ )	$\Delta\lambda$	450	-	1050	nm
Rise and Fall Times (10% to 90% and 90% to 10%) ( $R_L=50 \Omega$ , $V_R=20V$ , $\lambda=850$ nm)	$t_r, t_f$	-	5	-	ns
Total Capacitance ( $P_{IN}=0$ , $f=1.0\text{MHz}$ ) $V_R=20$ V $V_R=0$ V	$C$ $C_o$	-	3 11	-	pF
Responsivity min. @ 870 nm @ 650 nm	$R$	- -	0.6 0.4	- -	$\mu\text{A}/\mu\text{W}$
Reverse Dark Current ( $V_R=30$ volts, $P_{IN}=0$ )	$I_D$	-	1	60	nA
Reverse Breakdown Voltage ( $I_R=100\mu\text{A}$ )	$V_{(BR)R}$	40	-	-	V
Forward Voltage	$V_f$	-	0.7	1.2	V

**CAUTION:** The IF D91B is ESD sensitive. To minimize risk of damage observe appropriate precautions during handling and processing.



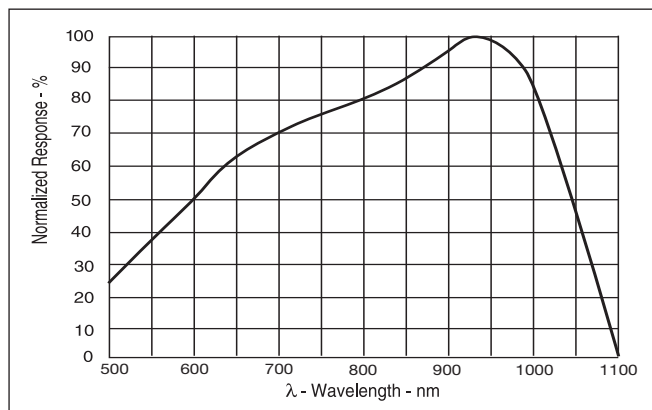


FIGURE 1. Typical detector response versus wavelength.

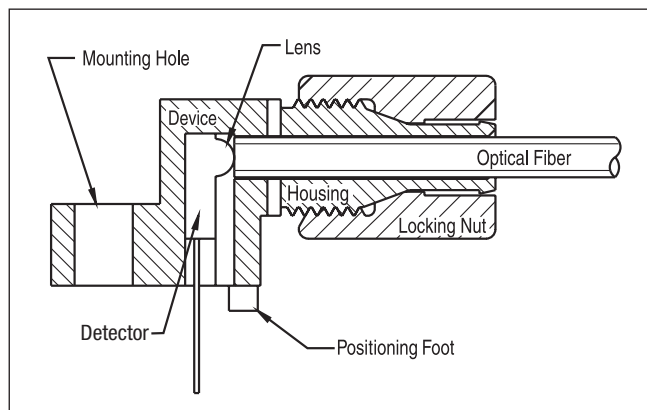


FIGURE 3. Cross-section of fiber optic device.

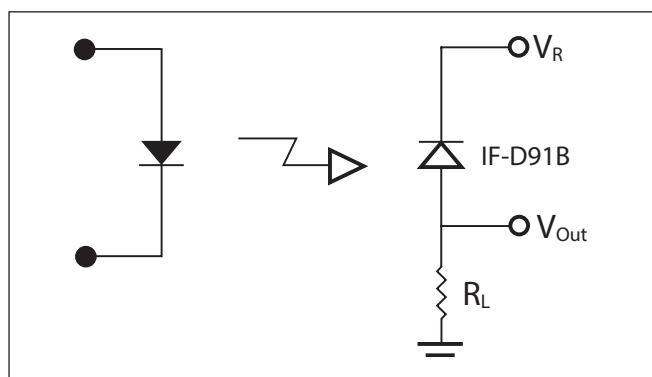


FIGURE 2. Circuit diagram for measuring rise and fall times.

## FIBER TERMINATION INSTRUCTIONS

1. Cut off the ends of the optical fiber with a single-edge razor blade or sharp knife. Try to obtain a precise 90-degree angle (square).
2. Insert the fiber through the locking nut and into the connector until the core tip seats against the internal micro-lens.
3. Screw the connector locking nut down to a snug fit, locking the fiber in place.

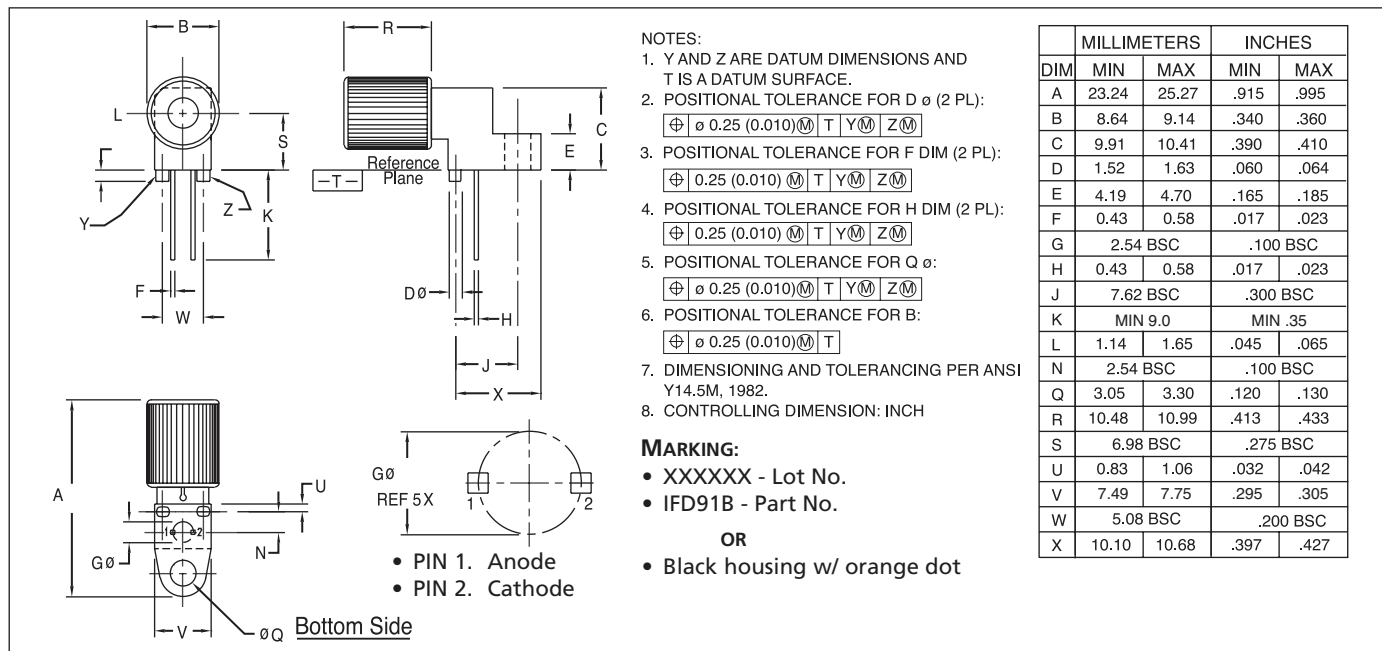


FIGURE 4. Case outline. Specifications are believed to be accurate but are subject to change. Industrial Fiber Optics assumes no responsibility for the consequences of using the information provided beyond replacement warranty for products not meeting stated specifications. Industrial Fiber Optics products are not authorized for use in life support applications without written approval from the President of Industrial Fiber Optics Corporation.

**CAUTION:**

- To avoid degraded device life due to package stress, do not bend or form leads outside the orientation shown on drawing.
- Ensure that solder flux does not migrate into the device and block the optical path, degrading the performance.
- If washing the device, liquid may become trapped in the part cavity. Ensure that all potentially corrosive materials are flushed out of the device.

## APPLICATION NOTES

To create a fiber optic link between an emitter and a detector an optical budget should be calculated. This is a determination of how much margin a system (emitter, fiber, junctions and detector) will have. Certain parameters may be set by the system, such as power available, cost, temperature etc. Other parameters may be adjusted to increase or decrease the margin.

### Example of an optical budget:

The link length is two meters. The fiber will be GH4001 and the ends will be razor cut. The signal is 5 V digital data and the rate is no higher than 100 K bits per second.

For this data rate any of the emitters could be used, so we will use the IF-E96E with the IF-D91B.

We could start the calculation at the detector or the emitter, do all of the calculations and then adjust the starting conditions as needed.

We will start with the emitter and set the drive current to the nominal 20 mA given on the data sheet. This will give us a nominal -4.9 dBm of power at the end of 1 meter of fiber. We have 2 meters of fiber so that the one additional meter gives us 0.17 dB of loss at the IF-E96E wavelength. <http://www.i-fiberoptics.com/pdf/attenuation.pdf> We also have two razor cut ends on the fiber. At 2 dB of loss per cut, this gives us an additional 4 dB of loss. So the power at the detector end of the 2 meter fiber will be  $-4.9 \text{ dBm} - 0.17 \text{ dB} - 4 \text{ dB} = -9.07 \text{ dBm}$  (124 uW).

At the IF-D91B detector the responsivity to the IF-E96E wavelength will be about 0.4 uA/uW. The IF-D91B will be biased with  $V_R = 5 \text{ V}$ . The current from the IF-D91B will be  $0.4 \text{ uA/uW} \times 124 \text{ uW} = 49.6 \text{ uA}$ . To get a 5 Volt signal from this we will need  $R_L$  to be  $5 \text{ V} \div 49.6 \text{ uA} = 100806 \text{ Ohm}$ . Round it off to 100 kOhm. To calculate the bandwidth we need to know the total capacitance (CT) connected to  $R_L$ . The capacitance of the IF-D91B is 3 pF. Any circuitry connected to  $V_{Out}$  will add to CT, as will any stray capacitance. If  $V_{Out}$  is connected to a CMOS logic gate then the added capacitance will be about 5 pF for a total CT of 8 pF. So the bandwidth will be

$$BW = \frac{1}{2 \times \pi \times 100 \text{ kOhm} \times 8 \text{ pf}} = 199 \text{ kHz}$$

This is a high enough bandwidth for this application.

However, there is one issue. As calculated, this optical budget has no margin. The nominal values were used and if anything changes to increase the signal loss the loop may not work. To guard against this we should add in some margin. How much is up to the individual designer. We will add in 6 dB for this example. The 6 dB can be taken out anywhere in the calculations. For this example we will take the 6 dB out of the power received by the detector.

Set the power at the detector end of the fiber to  $-9.07 \text{ dBm} - 6 \text{ dB} = -15.07 \text{ dBm}$  (31.1 uW). The detector current will be  $0.4 \text{ uA/uW} \times 31.1 \text{ uW} = 12.4 \text{ uA}$ .  $R_L = 5 \text{ V} \div 12.4 \text{ uA} = 403226 \text{ Ohm}$ . Round off to 402 kOhm.

$$BW = \frac{1}{2 \times \pi \times 402 \text{ kOhm} \times 8 \text{ pf}} = 49 \text{ kHz}$$

There will not be enough bandwidth if the input signal is at 100 kbps.

There are a number of ways to fix this.

1. We could raise the drive current to the emitter to increase the power. This would lower the needed value of  $R_L$  at the detector and raise the bandwidth. The down side is more power dissipation and a lower lifetime for the emitter.
2. We could polish the ends of the fibers to reduce the amount of loss. This also would lower the needed value of  $R_L$ .

3. We could change the circuit from the basic resistor (Figure 2) to the transimpedance amplifier (Figure 5).
4. We could operate with less margin.

The circuit shown in Figure 2 can be used for low frequency applications. The output is given by  $V_{OUT} = P_{IN} \times R \times R_L$ . Where  $P_{IN}$  is the power into the IF-D91B and  $R$  is the responsivity at the wavelength used. The bandwidth is limited by the IF-D91B capacitance, the circuit capacitance and  $R_L$ ,  $BW = \frac{1}{2 \times \pi \times R_L \times C_T}$ .

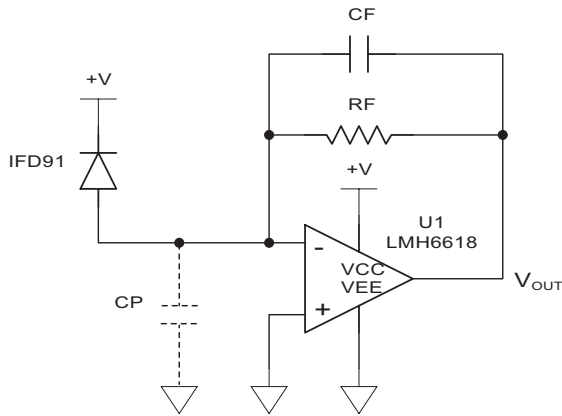


FIGURE 5. Transimpedance amplifier

The circuit shown in Figure 5 can be used for higher frequency and higher gain applications. It uses an opamp configured as a transimpedance amplifier. This will convert the current output of the IF-D91B photodiode to a voltage. The output is inverted (output low with light input). The output is given by  $V_{OUT} = -I_D \times R_F$ . Where  $I_D$  is the current from the IF-D91B. Capacitor  $C_F$  may be needed for stability to cancel the total capacitance connected to the negative input of the opamp. This capacitance is the sum of the IF-D91B capacitance, the opamp input capacitance and any stray parallel capacitance ( $C_P$ ) from the circuit board.  $C_T = C_{IFD91} + C_{U1} + C_P$ . For stability the value of  $C_F$  should be at least

$$C_F = \sqrt{\frac{C_T}{2 \times \pi \times R_F \times GBP}}$$

where  $GBP$  is the Gain Bandwidth Product of the opamp. This will give a circuit bandwidth of

$$BW = \sqrt{\frac{GBP}{2 \times \pi \times R_F \times C_T}}$$

For a non-inverted output, the IF-D91B cathode would be connected to the negative input of the opamp and the anode would be connected to a negative voltage supply.

Continuing with the previous example, the power into the IF-D91B was 31.1 uW and the detector current,  $I_D$ , was 12.4 uA. The LMH6618 Op-amp shown in Figure 5 has an input capacitance of 1.5 pF and a large signal gain bandwidth product of 15 MHz. For  $V_{OUT} = 5$  Volts the value of  $R_F$  would be 402 kOhms. We will assume the stray board capacitance is 1 pF giving a total capacitance of  $C_T = 5.5$  pF. Using the above equation for  $C_F$  gives a value of 0.38 pF. Using the equation for bandwidth yields  $BW = 1.0$  MHz which is plenty for this application.