J16 SERIES
GERMANIUM PHOTODIODES
Operating Instructions

TELEDYNE
JUDSON TECHNOLOGIES
A Teledyne Technologies Company

PB 1600
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CAUTION!

• To avoid heat damage to the detector, use a heat sink (such as a pair of tweezers) on the pin when soldering TO-style packages.

• Avoid touching the package window. Clean gently with a cotton swab and ethyl alcohol if needed.

• Detectors mounted on ceramics or without windows require extra caution in handling. The exposed gold bond wires are extremely fragile.

• Do not use a standard ohmmeter to measure the diode. Large forward currents may destroy the detector.

• Do not exceed maximum reverse bias voltage listed in the specification table.

• Make all circuit connections before applying power. Turn off power before disconnecting the detector.

Testing

J16 Series room temperature Germanium detectors are designed for operation under ambient conditions to +60°C.

Each device is tested for:
- Minimum responsivity at 1300nm
- Minimum shunt impedance R_D
- Maximum dark current I_D

Statistical data can be provided. Absolute calibration of response vs. wavelength from 800 to 1800 nm is available for detectors 2mm or larger.

General Specifications all **J16** Series **Ge**

Parameter	Min	Typ	Max	Units
Responsivity at 25°C				
(@ 1550nm)	.80	.90		A/W
(@ 1300nm)	.60	.65		A/W
(@ 850nm)	.20	.30		A/W
Uniformity of Response				
over Area (25°C)		±2		%
Storage Temperature	-55		+80	°C
Operating Temperature	-55		+60	°C

Device Options

Teledyne Judson offers three specialized Ge device options, designated by the part number suffix "-SC" or "-HS" (no suffix for "standard" devices).

The "-SC" device is a p-n diode, ideal for low frequency applications and DC-average power meters. It offers the highest shunt resistance available in a Ge photodiode, resulting in the lowest DC drifts. However, its higher capacitance and low reverse bias limit make it less suitable for operation above ~1 KHz (depending on active size).

The "-HS" option has a p-i-n structure for extremely low capacitance and excellent speed of response, with R_D and noise similar to the standard device. This option is ideal for pulsed laser diode monitoring and general use above ~10 KHz.

The standard device offers excellent performance at intermediate frequencies. It is suitable for general use in applications from ~100 Hz to 100 MHz.

Typical Specifications **J16** Series Room Temperature **Ge** @25°C

Model Number	Part No.	Active Size (dia.) (mm)	Shunt Resistance R_D @ V_R = 10mV (k) Min.	Shunt Resistance Typ.	Dark Current I_D @ Maximum V_R (µA) Typ.	Dark Current Max.	Maximum Reverse Voltage V_R (V)	Typical NEP @ peak and 300Hz ($pW/Hz^{1/2}$)	Capacitance C_D @ V_R = 0V (nF)	Cutoff Frequency @ Max. V_R and R_L = 50 (MHz)	Other Options
LOW CAPACITANCE OPTION ("HS")											
J16-18A-R250U-HS	460004-1	0.25	400	600	0.1	3	10	0.15	0.02	400	LD, CO2, C11, 18D
J16-18A-R500U-HS	460003-3	0.5	200	300	0.3	5	10	0.2	0.03	250	
J16-18A-R01M-HS	460011-4	1.0	100	200	1	5	10	0.3	0.15	50	
J16-5SP-R02M-HS	460006-4	2.0	25	50	4	10	5	0.6	0.6	12	5NF, LD,
J16-5SP-R03M-HS	460019-3	3.0	15	30	7	20	5	0.8	1	8	8SP, 8NF, C11
J16-8SP-R05M-HS	460008-5	5.0	10	15	10	40	5	1	3	2.5	8NF, P2, C12
J16-P1-R10M-HS	460062-3	10.0	1	2	100	400	2	4	12	0.6	P2
HIGH SHUNT RESISTANCE OPTION ("SC")											
J16-18A-R250U-SC	460004-2	0.25	1400	2400	0.025	0.05	0.25	0.1	0.14	40	LD, CO2, C11, 18D
J16-18A-R500U-SC	460003-2	0.5	700	1200	0.05	0.1	0.25	0.1	0.5	10	
J16-18A-R01M-SC	460011-1	1.0	250	350	0.1	0.2	0.25	0.2	2	2	
J16-5SP-R02M-SC	460006-3	2.0	80	120	0.2	1	0.25	0.4	8	0.5	5NF, LD,
J16-5SP-R03M-SC	460019-1	3.0	35	60	0.5	5	0.25	0.6	14	0.2	8SP, 8NF, C11
J16-8SP-R05M-SC	460008-1	5.0	14	20	1.5	10	0.25	1	36	0.1	8NF, P2, C12
J16-P1-R10M-SC	460062-2	10.0	3	5	25	50	0.25	2	120	0.03	P2
J16-P1-R13M-SC	460023-1	13.0	1.5	2.5	50	100	0.25	3	200	0.02	
STANDARD											
J16-18A-R01M	460011	1.0	100	200	1	5	10	0.3	1	15	LD, CO2, C11, 18D
J16-5SP-R02M	460006	2.0	25	50	4	10	10	0.6	4	4	5NF, LD,
J16-5SP-R03M	460019	3.0	15	30	7	30	5	0.8	7	2	8SP, 8NF, C11
J16-8SP-R05M	460008	5.0	10	15	15	50	5	1.4	18	0.8	8NF, P2, C12
J16-P1-R10M	460052	10.0	1	2	100	400	5	3.0	60	0.1	P2
J16-P1-R13M	460023	13.0	0.5	1	250	800	2	4.5	100	0.07	

221 COMMERCE DRIVE
MONTGOMERYVILLE, PA 18936-9641
PHONE: 215-368-6901
FAX: 215-362-6107
www.teledynejudson.com

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General

J16 Series detectors are high-quality Germanium photodiodes designed for the 800 to 1800 nm wavelength range.

The equivalent circuit for a Germanium photodiode (Fig. 1) is a photon-generated current source with shunt resistance R_D, parallel capacitance C_D and series resistance R_S. The value R_S is very small compared to R_D and can be disregarded except at high power levels (more than 10 mW).

Responsivity

A Ge photodiode generates a current across the p-n or p-i-n junction when photons of sufficient energy are absorbed within the active region. The responsivity (Amps/Watt) is a function of wavelength and detector temperature (Fig. 2).

Temperature changes have little effect on the detector responsivity at wavelengths below the peak, but can be important at the longer wavelengths (Figs. 2 and 3). For example, at 1.2 µm the change in response of a room temperature detector is less than 0.1% per °C, while at 1.7 µm the change is approximately 1.5% per °C (Fig. 3).

Uniformity of response within the active region of a room-temperature detector is typically better than ±2% at 1300 nm.

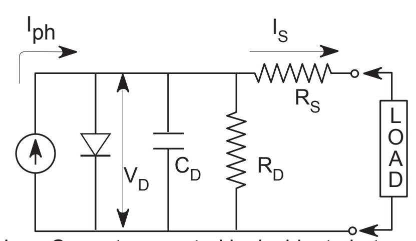
Shunt Resistance R_D

Detector shunt resistance R_D determines the DC "Dark Current" in an unbiased photodiode. Higher shunt resistance yields lower dark current.

Shunt resistance is dependent on detector size, device option, and temperature. As the detector temperature increases, shunt resistance goes down and dark currents increase. Figure 4 shows the effect of temperature on R_D.

To estimate R_D at ambient temperatures from -40°C to +60°C, the data for R_D at 25°C can be obtained from the specification table on page 1 and applied to this graph.

Figure 1
Germanium Photodiode Equivalent Circuit



I_{ph} = Current generated by incident photons
V_D = Actual voltage across diode junction
C_D = Detector junction capacitance
R_D = Detector shunt resistance
R_s = Detector series resistance
I_s = Output signal current

Figure 2
Typical Responsivitiy for J16 Series Ge

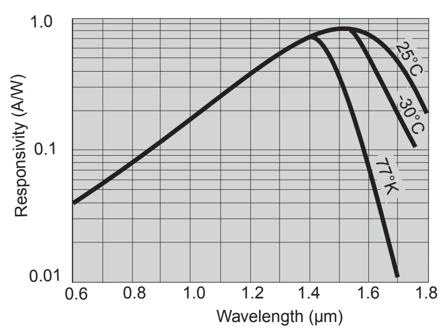


Figure 3
Temperature Coefficient of Responsivity at 25 °C

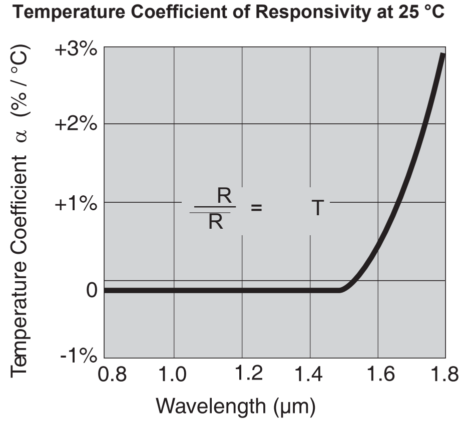


Figure 4
Change in Shunt Resistance vs Temperature

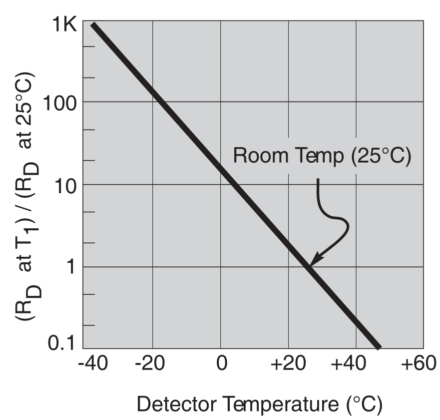
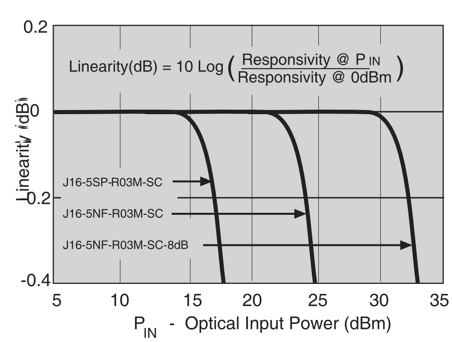


Figure 5
Typical 1550nm High Power Linearity



Operating Circuits

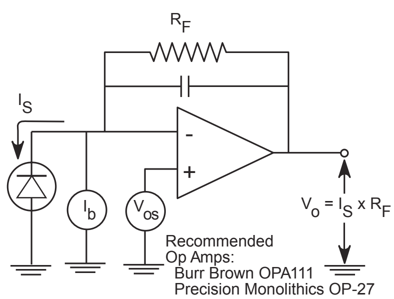
The recommended circuit for most applications is an op-amp in a negative-feedback transimpedance configuration (Fig. 6). The feedback circuit converts the detector output current to a voltage, while the op-amp maintains the detector near zero-volt bias for lowest noise.

An undesirable DC offset current, or "dark current", will be produced in this configuration. It is a function of the preamp input bias current I_b, the preamp input offset voltage V_{os}, and the detector shunt resistance R_D. This total "dark current" is:

$$\text{Total } I_D = I_b + (V_{os} / R_D)$$

Selection of the proper op-amp is important for low preamp noise and best system bandwidth. For higher R_D detectors, choose a preamp with low bias current; for lower R_D detectors, choose a preamp with low offset voltage (Fig. 7).

Figure 6
Basic Operating Circuit



Operation at DC to 200Hz

For DC or very low frequencies, use the “SC” in conjunction with figure 6. To select R_F:

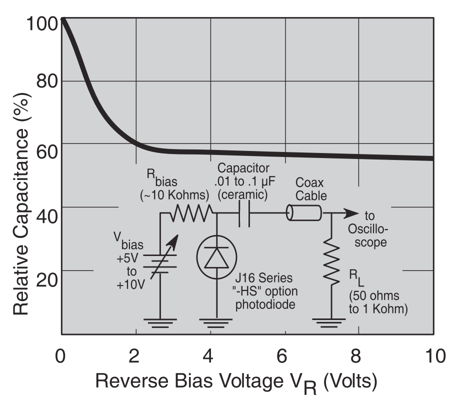
R_F should be at least greater than R_D or preamp Johnson Thermal noise will dominate the system.

• Larger R_F gives higher gain.

• Maximum R_F is limited by DC saturation from the detector offset current. The detector can be biased in this configuration to improve linearity at high power levels. However, this bias produces dark current in the detector (see figure 9) and increases low frequency noise.

Suggested preamplifiers are Teledyne Judson Model PA-6 for detector R_D less than 25KΩ and Teledyne Judson Model PA-7 for detectors with higher R_D. For very low signal levels, a second stage AC-coupled amplifier, a mechanical chopper and a lock-in amplifier are suggested.

Figure 8
High Speed Circuit



Operation at 200Hz to 200KHz

For intermediate frequencies, the standard material option (no suffix) is recommended with figure 6. The same considerations apply in selecting R_F but at these frequencies R_F is also limited by bandwidth requirements. Gain-bandwidth information for Teledyne Judson pre-amps is listed in the Teledyne Judson Brochure.

Suggested preamplifiers are Teledyne Judson Model PA-6 for detector R_D less than 25K and Teledyne Judson Model PA-7 for detectors with higher R_D

Operation at >200KHz

The “HS” material option and small active sizes are recommended for best high-speed performance. Reverse biasing and terminating into a low impedance load as shown in figure 8 gives fastest response. However, the noise is increased by bias-induced dark currents (Fig 9).

A 50 load offers fastest response but highest Johnson Thermal noise. For lower noise and higher gain, do not use a smaller impedance than required to achieve the desired frequency response.

The Teledyne Judson preamp Model PA-el PA-400-P offers an external bias pin, 50 detector load at the preamp input, and 30dB gain for frequencies up to 50MHz.

Figure 7
Total Dark Current vs Detector Resistance

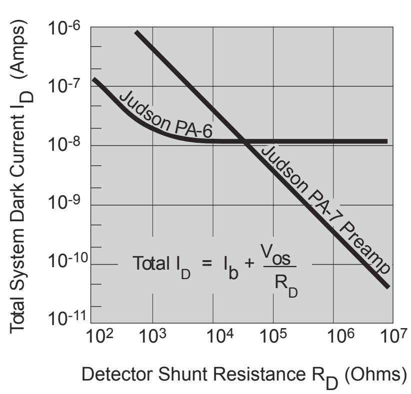


Figure 9
Dark Current vs Reverse Bias Voltage

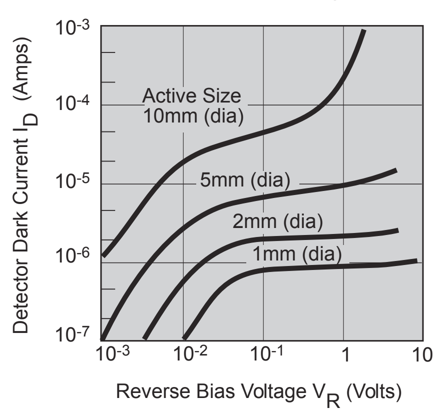
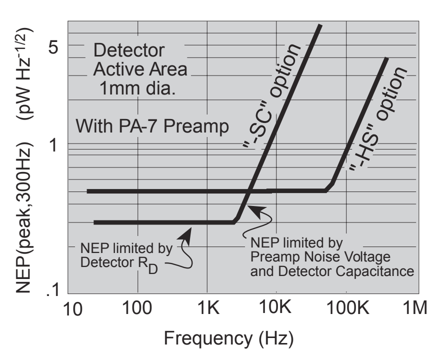


Figure 10
NEP vs Frequency for J16 Device Options



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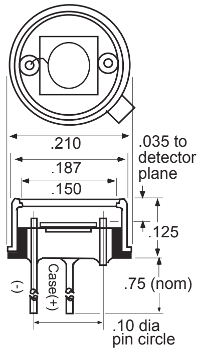
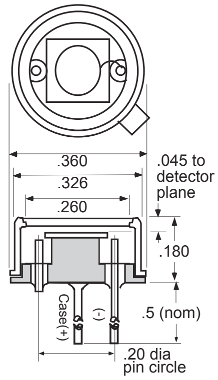
Packages

All dimensions are in inches. Detector (+) -- Anode Detector (-) -- Cathode

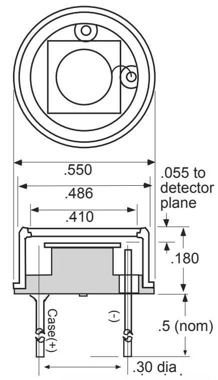
■ 18A



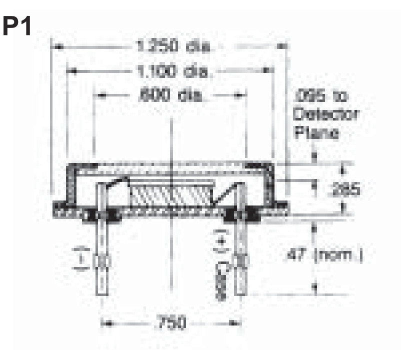
■ 5SP



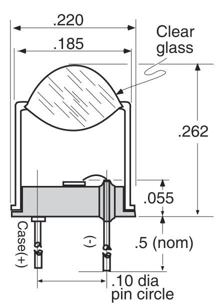
■ 8SP



■ P1

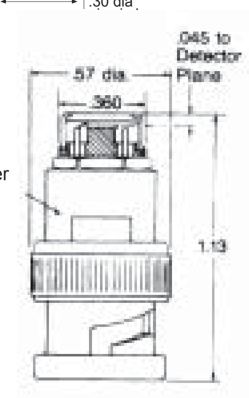


■ 18D

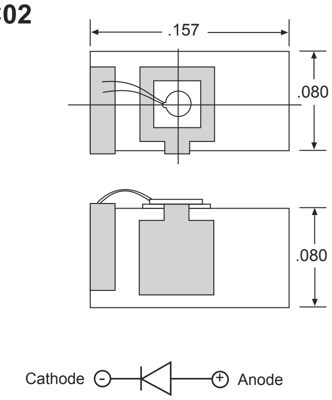


■ LD

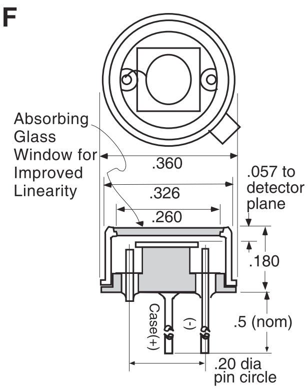
BNC Connector
Cathode (-) - Center
Anode (+) - Shield



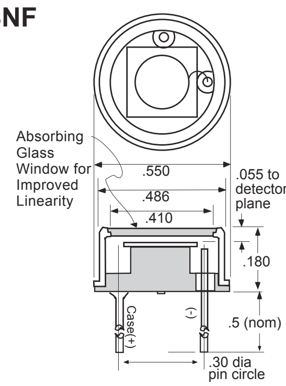
■ C02



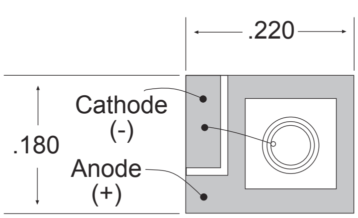
■ 5NF



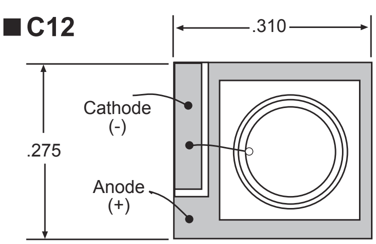
■ 8NF



■ C11

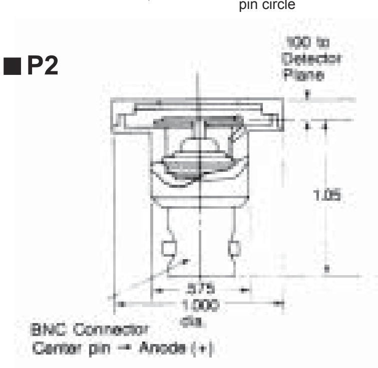


■ C12



Note: .010 thick ceramic substrate used for both C11 and C12.

■ P2



221 COMMERCE DRIVE
MONTGOMERYVILLE, PA 18936-9641
PHONE: 215-368-6901
FAX: 215-362-6107
www.teledynejudson.com