T-41-41

# J16 Series Germanium Detector Operating Notes

## General

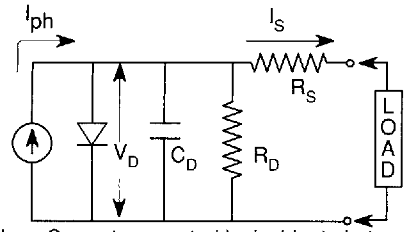
J16 Series detectors are high-quality Germanium photodiodes designed for the 800 to 1800 nm wavelength range.

The equivalent circuit for a Germanium photodiode (Fig. 2-1) 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 3 mW).

Detailed specifications are listed for J16 Series uncooled detectors on pages 4-5 and for high performance J16TE2 and J16D Series cooled detectors on pages 6-7.

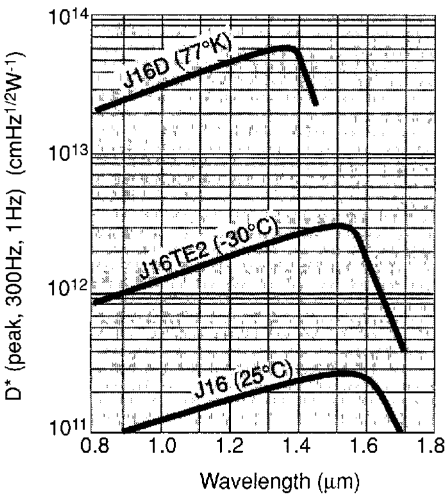
J16P and J16M Series Ge photodiode arrays are described on pages 11-13.

**Figure 2-1**
**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 2-2**
**Detectivity vs Wavelength for J16 Series Ge**




## 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. 2-3).

Temperature changes have little effect on the detector responsivity at wavelengths below the peak, but can be important at the longer wavelengths (Figs. 2-3 and 2-4). 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. 2-4).

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

**Figure 2-3**
**Typical Responsivitiy for J16 Series Ge**

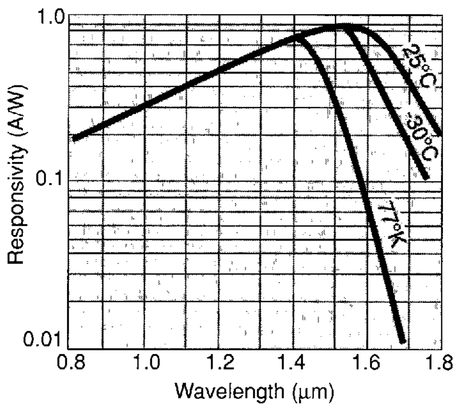
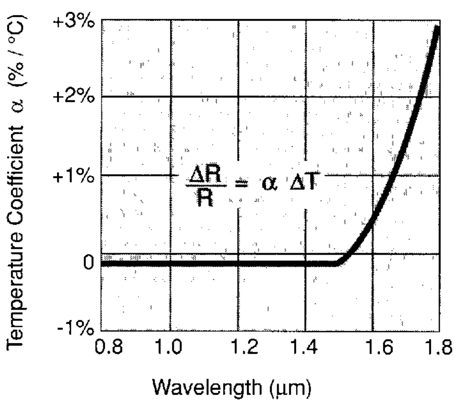



**Figure 2-4**
**Temperature Coefficient of Responsivity at 25 °C**




## Operating Circuit

The recommended operating circuit for most applications is an operational amplifier in a negative-feedback transimpedance configuration (Fig. 2-5). 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 (see "Shunt Resistance and Dark Current").

Selection of the proper op-amp is important, as the wrong choice can add excess preamp noise or limit system bandwidth. Judson has a complete line of preamps designed to match each detector type and application. Preamp recommendations are included with the detector specifications on pages 4-7.

For high frequency applications, the detector may be reverse biased and terminated into a low impedance load (Fig. 2-6). Reverse biasing the detector significantly reduces junction capacitance for faster pulse response; however, the dark currents and low-frequency noise are increased.

**Figure 2-5**
**Basic Operating Circuit**

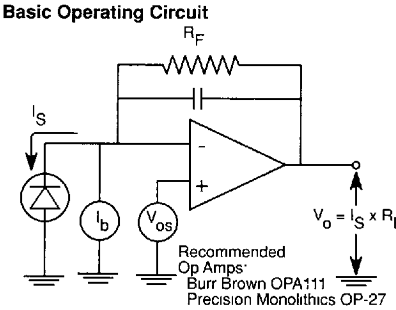
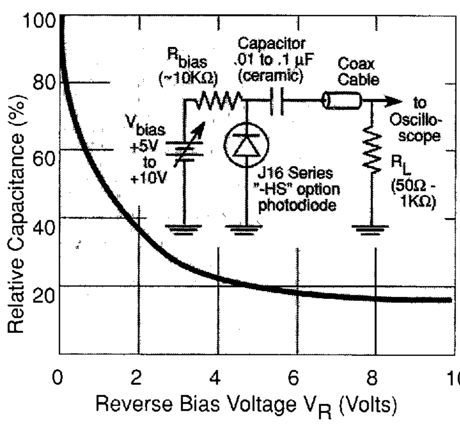



**Figure 2-6**
**High Speed Circuit**



# 0.8 to 1.8 $\mu$m

## Shunt Resistance and Dark Current

When the detector is used in the basic circuit of Figure 2-5, an undesirable DC offset current, or "dark current", will be produced. 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:

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

High shunt resistance detectors will result in lowest overall DC "dark current". Preamp selection is also important; for higher shunt impedance detectors, choose a preamp with low bias current; for lower shunt impedance detectors, choose a preamp with low offset voltage (Fig. 3-1).

When the detector is reverse biased and used in the high-speed circuit of Figure 2-6, the predominant dark current is a function of the applied bias voltage (Fig. 3-2).

## Device Selection

Three main factors to consider when selecting a Judson Ge detector are: detector operating temperature, detector active area, and Judson's unique device option.

1. Detector Temperature: Cooling the detector reduces dark current by increasing the shunt resistance $R_D$ (Fig. 3-3). Judson offers a complete line of room temperature and cooled devices; shunt resistance data at 25°C is listed on the specification table of page 4. The data can be applied to Figure 3-3 to estimate $R_D$ for detector temperatures from -40 to +60°C.

2. Active Area: Larger active areas have lower shunt resistance $R_D$ (Fig. 3-4), and therefore higher dark currents. When low noise is critical, the smallest detector acceptable for the application should be selected. Focusing optics may be added for increased light collection.

3. Device Option: Judson offers three unique Ge device options for optimum performance in different applications (Fig. 3-5).

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 new "-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. **New**

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

**Figure 3-1**
**Total Dark Current vs Detector Resistance**

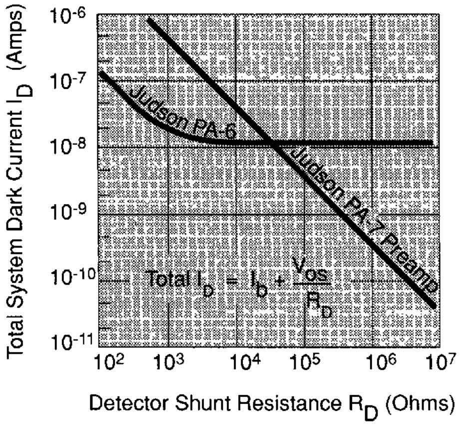



**Figure 3-3**
**Change in Shunt Resistance vs Temperature**

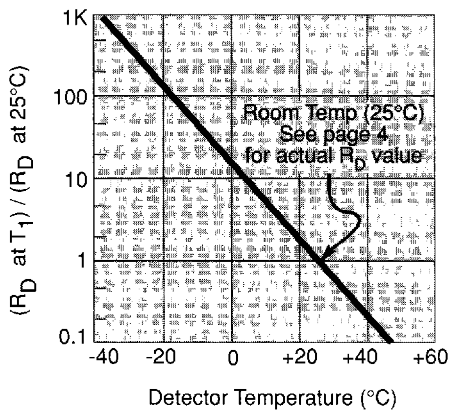



**Figure 3-5**
**NEP vs Frequency for J16 Device Options**

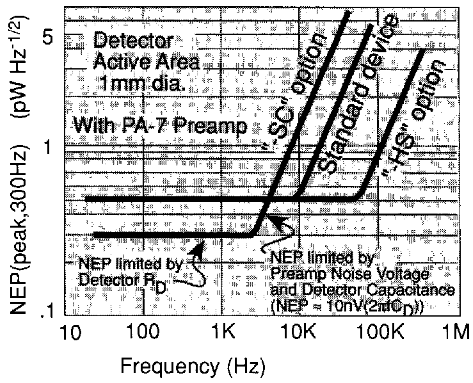



**Figure 3-2**
**Dark Current vs Reverse Bias Voltage**

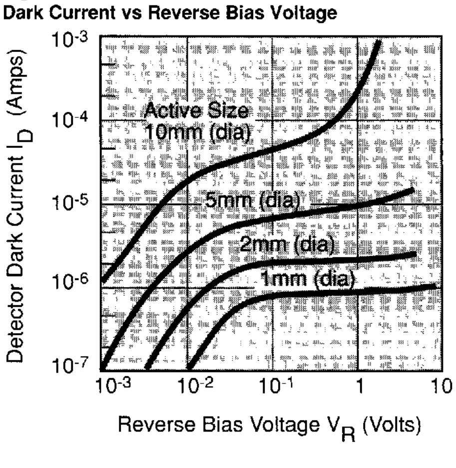



**Figure 3-4**
**Shunt Resistance vs Size and Device Option**

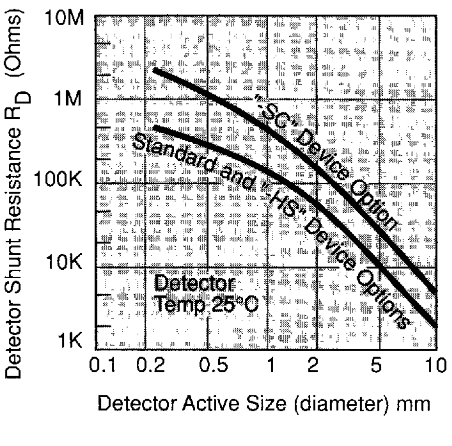
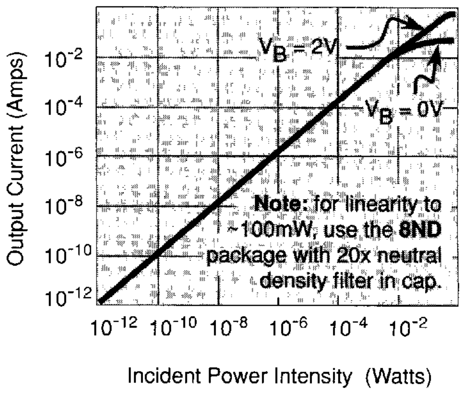



**Figure 3-7**
**Linearity for J16 Series Ge**



# J16 Series

## Room Temperature Germanium Detectors

## 0.8 to 1.8 µm

### General

J16 Series room temperature Germanium detectors are designed for operation under ambient conditions to +60°C. Judson's Germanium photodiodes have high responsivity, good linearity, fast response times, uniform response and excellent long-term stability.

Please review the detailed operating information on pages 2-3 for assistance in selecting the proper detector for your application.

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

| Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|
| Responsivity at 25°C | | | | |
| (@ 1550nm) | .8 | .9 | | A/W |
| (@ 1300nm) | .6 | .65 | | A/W |
| (@ 850nm) | .15 | .2 | | A/W |
| Uniformity of Response over Area (25°C) | | ±2 | | % |
| Storage Temperature | -55 | | +80 | °C |
| Operating Temperature | -55 | | +60 | °C |

### Device Options

EG&G Judson offers three specialized Ge device options, designated by a part number suffix "-SC" or "-HS" (no suffix for "standard" devices). For details please see "Device Selection" on page 3.

### Responsivity Calibration

J16 Series Ge detectors are 100% tested for minimum responsivity at 1300nm. For an additional fee, Judson will calibrate response vs wavelength from 800 to 1800 nm (for detector size 2mm and larger only.)

### Preamplifiers

Recommended preamps are the Judson model PA-6 for detectors with $R_D$ less than 50KΩ, and the PA-7 for detectors with $R_D$ greater than 50KΩ (Fig. 3-1). The model PA-400 is suggested for high speed operation (to 50MHz). Preamps are sold separately; specifications begin on page 42.

## Applications

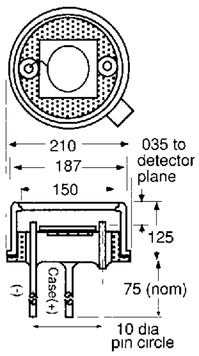
- Optical Power Meters
- Fiber Testing
- Laser Diode Control
- Optical Communications
- Temperature Sensors

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

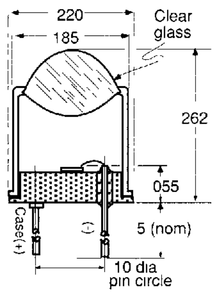
| Model Number | Active Size (dia.) (mm) | Shunt Resistance $R_D$ @$V_R$ = 10mV (kΩ) Min. | Typ. | Dark Current $I_D$ @ Maximum $V_R$ (µA) Typ. | Max. | Maximum Reverse Voltage $V_R$ (V) | Typical NEP @ $\lambda_{peak}$ and 300Hz (pW/Hz$^{1/2}$) | Capacitance $C_D$ @ $V_R$ = 0V (nF) | Cutoff Frequency @ Max. $V_R$ and $R_L$ = 50Ω (MHz) | Packages (see page 5) Standard | Options |
|---|---|---|---|---|---|---|---|---|---|---|---|
| J16-18A-R250U-HS | 0.25 | 400 | 600 | 1 | 3 | 10 | 0.50 | 0.02 | 750 | 18A | LD C02 C11 18D |
| J16-18A-R250U-SC | | 1400 | 2400 | 0.025 | .05 | 0.25 | 0.10 | 0.14 | 40 | | |
| J16-18A-R500U-HS | 0.5 | 200 | 300 | 3 | 5 | 10 | 0.7 | 0.03 | 500 | | |
| J16-18A-R500U-SC | | 700 | 1200 | 0.05 | 0.1 | 0.25 | 0.2 | 0.50 | 10 | | |
| J16-18A-R01M-HS | 1.0 | 100 | 200 | 2 | 5 | 10 | 0.9 | 0.12 | 400 | | |
| New J16-18A-R01M | | 100 | 200 | 2 | 5 | 5 | 0.5 | 1 | 15 | | |
| J16-18A-R01M-SC | | 250 | 350 | 0.1 | 0.2 | 0.25 | 0.3 | 2 | 2 | | |
| J16-5SP-R02M-HS | 2.0 | 25 | 50 | 5 | 10 | 5 | 0.8 | 0.6 | 25 | 5SP | 5AR[1] LD 8SP 8ND[2] C11 |
| J16-5SP-R02M | | 25 | 50 | 5 | 10 | 5 | 0.8 | 4 | 4 | | |
| J16-5SP-R02M-SC | | 80 | 120 | 0.2 | 1 | 0.25 | 0.5 | 8 | 0.5 | | |
| J16-5SP-R03M-HS | 3.0 | 15 | 30 | 10 | 30 | 5 | 1 | 1 | 15 | | |
| J16-5SP-R03M | | 15 | 30 | 10 | 30 | 5 | 1 | 7 | 2 | | |
| J16-5SP-R03M-SC | | 35 | 60 | 0.5 | 5 | 0.25 | 0.7 | 14 | 0.2 | | |
| J16-8SP-R05M-HS | 5.0 | 10 | 15 | 10 | 25 | 5 | 2 | 3 | 5 | 8SP | 8AR[1] 8ND[2] P2, C12 |
| J16-8SP-R05M | | 5 | 10 | 15 | 50 | 5 | 2 | 18 | 0.8 | | |
| J16-8SP-R05M-SC | | 14 | 20 | 1.5 | 10 | 0.25 | 1 | 36 | 0.1 | | |
| J16-P1-R10M-HS | 10.0 | 1 | 2 | 200 | 400 | 2 | 4 | 12 | 1 | P1 | P2 |
| J16-P1-R10M | | 1 | 2 | 200 | 400 | 1 | 4 | 60 | 0.1 | | |
| J16-P1-R10M-SC | | 3 | 5 | 25 | 50 | 0.25 | 2 | 120 | 0.04 | | |
| J16-P1-R13M | 13.0 | 0.5 | 1.0 | 400 | 800 | 1 | 6 | 100 | 0.07 | | |
| J16-P1-R13M-SC | | 1.5 | 2.5 | 50 | 100 | 0.25 | 3 | 200 | 0.02 | | |

**Note 1:** The **5AR** and **8AR** packages have AR-coated glass windows to prevent back reflectance to source. Reflectance < 0.5% at 1300nm and < 0.2% at 1550nm.
**Note 2:** The **8ND** package includes Neutral Density Filter with 5% transmission. Extends device linear range to >100mW at 0V bias, reduces effective responsivity by 95%.

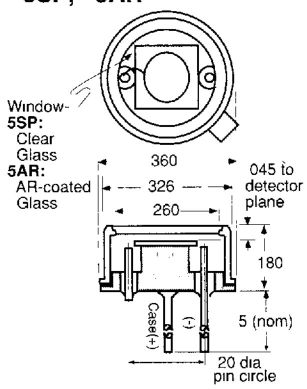
● **18A**



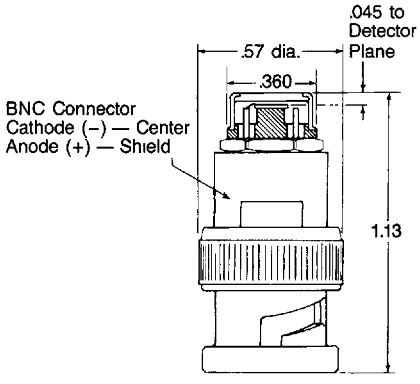

● **18D**



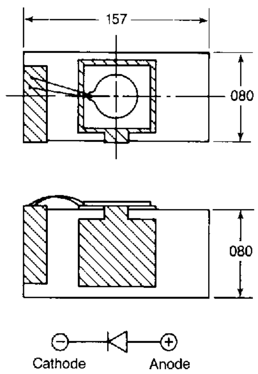

● **5SP, 5AR** New



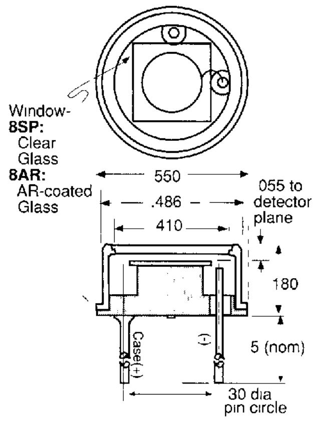

● **LD**



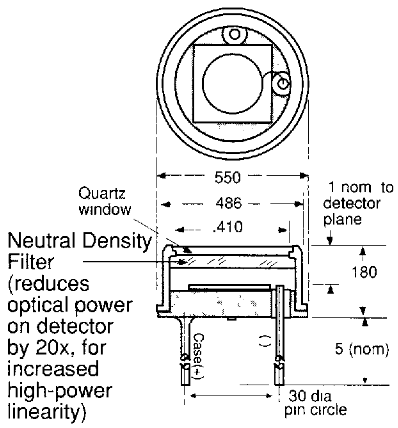

● **C02**



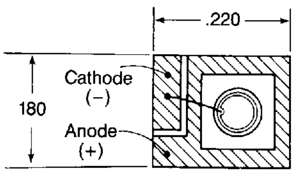

● **8SP, 8AR** New



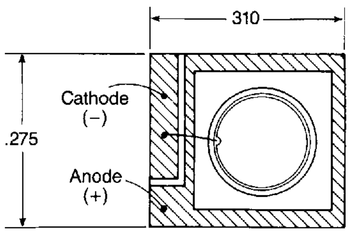

● **8ND** New




● **C11**

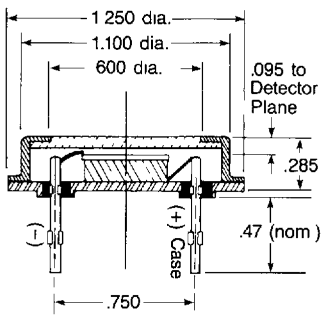



● **C12**




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

● **P1**




● **P2**