Operating Instructions

J16 Series
GERMANIUM PHOTODIODES

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 voltage listed in the specification table.
- Make all circuit connections before applying power. Turn off power before disconnecting the detector.
- 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 Rsh 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 100MHz.

Typical Specifications J16 Series Room Temperature Ge @25°C

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Part No.</th>
<th>Active Size (dia.)</th>
<th>Shunt Resistance $R_{sh}$ @ V = 10mV (k)</th>
<th>Dark Current $I_D$ @ Maximum $V_R$ (µA)</th>
<th>Maximum Reverse Voltage $V_R$ @ 300Hz</th>
<th>Typical NEP @ $V_R = 0V$ (pW/Hz$^{1/2}$)</th>
<th>Capacitance $C_D$ @ Max. $V_R$ and $R_{sh}$ = 50 (nF)</th>
<th>Cutoff Frequency (MHz)</th>
<th>Other Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>J16-18A-R250U-HS</td>
<td>460004-1</td>
<td>0.25 400 600 0.1 3 10 0.15</td>
<td>.20</td>
<td>0.25</td>
<td>0.6</td>
<td>.20</td>
<td>0.1</td>
<td>LD, CO2, C11, 18D</td>
<td></td>
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<tr>
<td>J16-18A-R500U-HS</td>
<td>460007-3</td>
<td>0.5 200 300 0.3 5 10 0.2</td>
<td>.30</td>
<td>0.30</td>
<td>0.6</td>
<td>.30</td>
<td>0.1</td>
<td>5NF, LD, C11, 18D</td>
<td></td>
</tr>
<tr>
<td>J16-18A-R01M-HS</td>
<td>46011-4</td>
<td>1.0 100 200 1 5 10 0.3</td>
<td>.15</td>
<td>0.15</td>
<td>0.6</td>
<td>.15</td>
<td>0.2</td>
<td>8SP, 8NF, C11, 18D</td>
<td></td>
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<tr>
<td>J16-18A-R01M-SC</td>
<td>460006-4</td>
<td>2.0 25 50 4 10 5 0.6</td>
<td>.6</td>
<td>0.6</td>
<td>0.6</td>
<td>.6</td>
<td>0.1</td>
<td>8NF, P2, C12</td>
<td></td>
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<tr>
<td>J16-18A-R01M-HS</td>
<td>460019-5</td>
<td>3.0 15 30 7 20 5 0.8</td>
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<td>.1</td>
<td>0.2</td>
<td>2SP, 8NF, C11, 18D</td>
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<tr>
<td>J16-18A-R01M-SC</td>
<td>460008-5</td>
<td>1.0 10 15 10 40 5 1 0.2</td>
<td>8NF, P2, C12</td>
<td></td>
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<td></td>
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</tbody>
</table>

JUDSON TECHNOLOGIES
TELEDYNE
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.
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:

$$I_D = I_b + \left( \frac{V_{os}}{R_D} \right)$$

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).

Operation at DC to 200Hz

For DC or very low frequencies, use the "SC" option 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.

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-400-P offers an external bias pin, 50 detector load at the preamp input, and 30dB gain for frequencies up to 50MHz.
Information in this document is believed to be reliable. However, no responsibility is assumed for possible inaccuracies or omission. Specifications are subject to change without notice.