# J16TE Thermoelectrically Cooled Germanium Detectors

Judson technologies

### General

J16TE Series detectors are Judson's high-quality Ge photodiodes mounted on thermoelectric coolers for reduced dark current, improved sensitivity and superior stability.

The TE coolers require less than 3W of DC power. The built-in thermistor can be used to monitor or control the detector temperature.

J16TE Series detectors are mounted in TO-style packages which are filled with dry nitrogen and hermetically sealed.

### J16TE1 Series
### 1-Stage Thermoelectrically Cooled Ge

J16TE1 Series detectors are Judson's large-area Germanium detectors packaged on one-stage thermoelectric coolers. Active diameters of 10 and 13mm allow maximum light collection. The low-cost cooler can be used at -10°C for reduced dark currents or at higher tempertures for improved stability of response in elevated or variable ambient temperatures.

### J16TE2 Series
### 2-Stage Thermoelectrically Cooled Ge

J16TE2 Series detectors are Ge photodiodes on high-performance two-stage coolers. DC offset current and dark current are significantly reduced at the -30°C operating temperature (Figs. 11-4 and 11-5).

These low offsets and dark currents make J16TE2 Series detectors ideal for ultrasensitive fiber optic power meters. They offer accurate measurements of optical power levels as low as -80dBm (10pW) in the DC mode and -90dBm (1pW) with an optical chopper and lock-in amplifier.

### Thermoelectric Cooler Operation

Figures 11-7 and 11-8 show typical TE1 and TE2 cooler power requirements. A simple convection heat sink is required for maximum cooling.

Figure 11-9 shows the effect of heat sink temperature on J16TE2 detector temperature.

### Preamplifiers

The PA-7 preamplifier offers DC stability, low noise, adjustable gain and wide bandwidth (DC to 50KHz). The PA-9 fixed-gain preamplifier offers lowest noise at higher frequencies (1KHz to 100KHz).

At high frequencies, the detector capacitance and preamp voltage noise contribute significantly to the system noise (Fig. 11-6).

Typical Specifications **J16TE Series Thermoelectrically Cooled Ge at specified operating temperature**

| Model Number | Part Number | Active Size (dia.) (mm) | Operating Temperature | Responsivity @ (A/W) | Shunt Resistance RD @ VR = 10mV | | Typical NEP @ λpeak and 300Hz | Capacitance CD @ VR = 0V (nF) | Maximum Reverse Voltage VR |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Min. (MΩ) | Typ. (MΩ) | ($pW/Hz^{1/2}$) | | (V) |
| J16TE1 Series One-Stage Thermoelectrically Cooled Ge | | | | | | | | | |
| J16TE1-P6-R10M-HS | | 10 | -10°C | 0.6 | 0.04 | 0.08 | 0.6 | 12 | 2 |
| J16TE1-P6-R10M-SC | 460191 | | | | 0.12 | 0.2 | 0.3 | 120 | 0.25 |
| J16TE1-P6-R13M-HS | | 13 | | | 0.03 | 0.06 | 0.7 | 120 | 2 |
| J16TE1-P6-R13M-SC | 460137 | | | | 0.06 | 0.12 | 0.4 | 200 | 0.25 |
| J16TE2 Series Two-Stage Thermoelectrically Cooled Ge | | | | | | | | | |
| J16TE2-8A6-R01M-HS | 460250 | 1 | -30°C | 0.6 | 15 | 40 | 0.04 | 0.15 | 10 |
| J16TE2-8A6-R01M-SC | 460033-1 | 1 | | | 40 | 100 | 0.02 | 2 | 0.25 |
| J16TE2-8A6-R02M-HS | 460257 | 2 | | | 5 | 13 | 0.07 | 0.6 | 5 |
| J16TE2-8A6-R02M-SC | 460055-1 | 2 | | | 20 | 50 | 0.03 | 8 | 0.25 |
| J16TE2-8A6-R03M-SC | 460156 | 3 | | | 2 | 4 | 0.15 | 1 | 5 |
| J16TE2-8A6-R03M-SC | 460260 | 3 | | | 10 | 20 | 0.06 | 14 | 0.25 |
| J16TE2-8A6-R05M-HS | 460134 | 5 | | | 1 | 3 | 0.16 | 3 | 5 |
| J16TE2-8A6-R05M-SC | 460022-2 | 5 | | | 5 | 15 | 0.07 | 36 | 0.25 |

# J16TE Thermoelectrically Cooled Germanium Detectors

Figure 11-1 J16TE1-P6

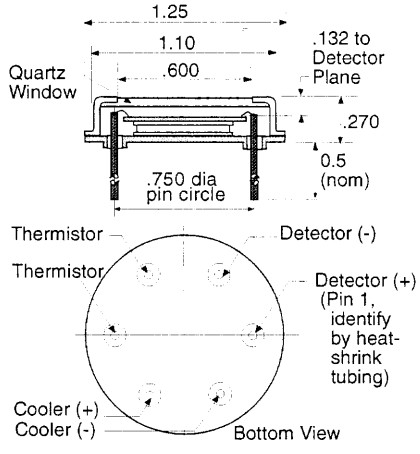



Figure 11-2 J16TE2-8A6

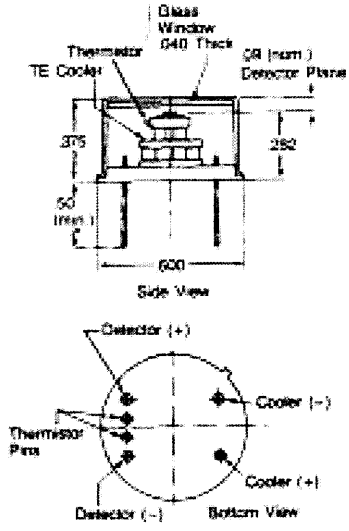



Figure 11-3 J16TE2-66G

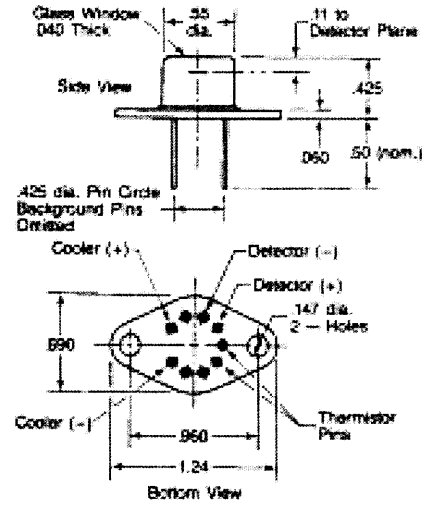



Figure 11-4
"DC Offset Current" vs Temperature (Near 0V Bias)

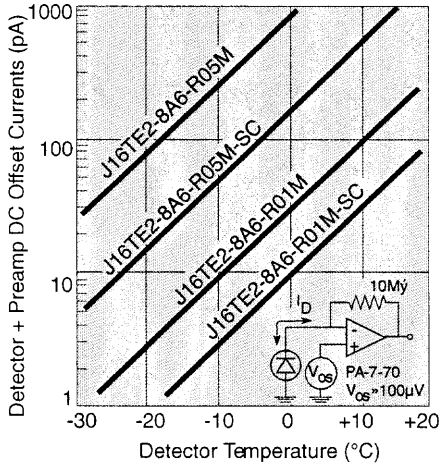



Figure 11-5
Dark Current vs Temperature

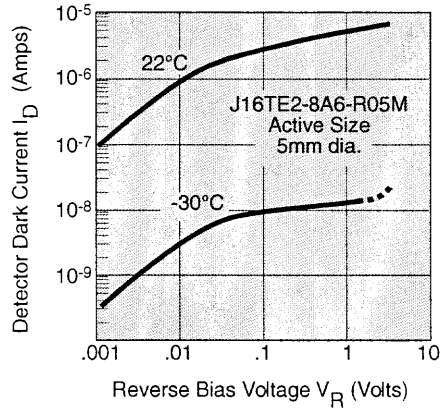



Figure 11-6
Total Noise Equivalent Power vs Frequency (-30°C)

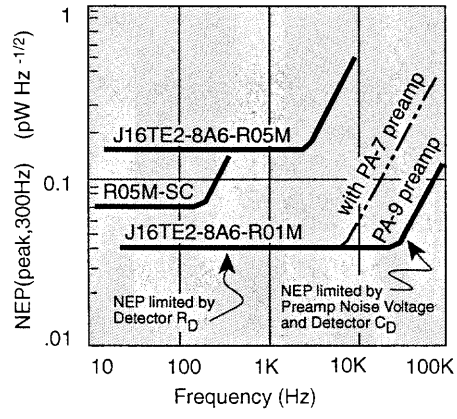



Figure 11-7 J16TE1
Detector Temperature vs TE1 Cooler Current

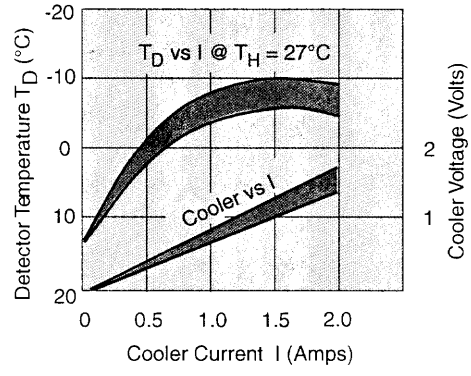



Figure 11-8 J16TE2
Detector Temperature vs TE2 Cooler Current

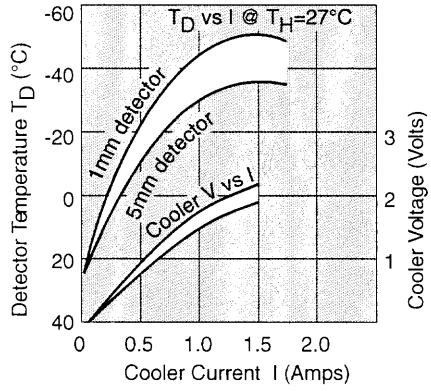
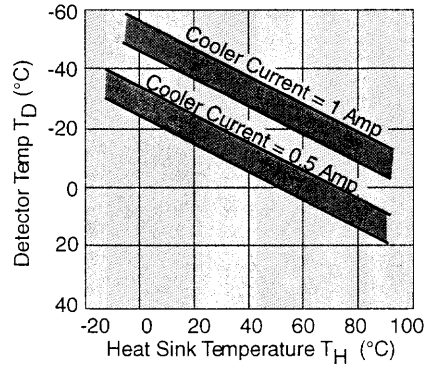



Figure 11-9 J16TE2
Detector Temperature vs Heat Sink Temperature at Constant Current



# Preamplifiers for use with Germanium Detectors

## General

Current Mode Preamplifiers convert the current output of a photovoltaic Ge, InAs, or InSb detector into a voltage output. They amplify the signal for subsequent use with oscilloscopes, lock-in amplifiers, or A-to-D converters.

Three different preamp models each offer specific advantages, depending on detector type and bandwidth requirements. A comparison of preamp noise figure as a function of detector reactance is graphed in Fig. 53-1.

All units (except multi-channel models) have switch-selectable gain.

## PA-7

The PA-7 is an excellent general purpose preamplifier for most high shunt resistance ($R_D$ > 25KΩ) detectors, including small area J16 Series Ge and all J16TE2 Series cooled Ge. It has extremely low current noise and current offset.

For most applications, the PA-7-70 with high gain of $10^7$ V/A offers best performance and versatility. However, for applications where $10^7$ V/A gain is unusable (due to bandwidth or DC saturation), the PA-7-60 or PA-7-50 are suitable alternatives.

## PA-6

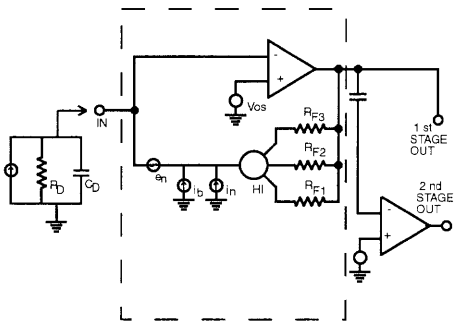
The PA-6 is a general purpose preamplifier recommended for intermediate shunt resistance (400Ω<$R_D$<50KΩ) detectors, including large area J16 Series room temperature Ge. The PA-6 has very low voltage noise and offset voltage, which significantly reduces low-frequency noise and DC drift. Standard gain settings are listed in the specification table below; custom gain settings are available.

## PA-5

The PA-5 is recommended for low impedance detectors ($R_D$<400Ω), including J12 Series room temperature InAs and J12TE2 Series InAs. It has extremely low voltage noise and low voltage offset. However, its high current noise and current offset make it unsuitable for detectors with high impedance.

Standard gain is $10^5$, $10^4$, and $10^3$ V/A (switch-selectable). Custom gain settings are available.

**Figure 52-1**
**Equivalent Circuit for Transimpedance Preamplifier**




Typical Specifications Model **PA-5, PA-6** and **PA-7** Current Mode Preamplifiers @25°C

| Model | | PA-7 Series | | | PA-6 Series | | PA-5 | Units |
|---|---|---|---|---|---|---|---|---|
| | | PA-7-70 | PA-7-60 | PA-7-50 | PA-6-60 | PA-6-50 | PA-5-50 | |
| Transimpedance | High | $10^7$ | $10^6$ | $10^5$ | $10^6$ | $10^5$ | $10^5$ | |
| Gain: | Med | $10^6$ | $10^5$ | $2.5x10^4$ | $10^5$ | $2.5x10^4$ | $10^4$ | V/A |
| (Switch Selected) | Low | $10^5$ | $2.5x10^4$ | $10^4$ | $2.5x10^4$ | $10^4$ | $10^3$ | |
| Bandwidth | @ High Gain | 8 | 60 | 150 | 60 | 150 | 200 | |
| $R_D$>10KΩ, $C_D$<0.2nF | @ Med Gain | 60 | 150 | 200 | 150 | 200 | 200 | KHz |
| (See Figs. 53-2, 53-3) | @ Low Gain | 150 | 200 | 200 | 200 | 200 | 200 | |
| Input Offset Voltage ($V_{os}$) | | ±100 | ±100 | ±100 | ±20 | ±20 | ±20 | μV |
| Input Bias Current ($i_b$) | | ±0.001 | ±0.001 | ±0.001 | ±12 | ±12 | ±30 | nA |
| Voltage Noise Density ($e_n$)@1KHz | | 8 | 8 | 8 | 3 | 3 | 1 | nV $Hz^{-1/2}$ |
| Voltage Noise from 0.1 to 10Hz | | 1.5 | 1.5 | 1.5 | .080 | .080 | .035 | μVpp |
| Current Noise Density ($i_n$)@1KHz† | | .04 | .13 | .04 | .5 | .64 | 1 | pA $Hz^{-1/2}$ |
| Output Impedance | | < 100 | | | | | | Ω |
| Maximum Output Voltage | | ± 10 | | | | | | Vpp |
| Power Requirements | | +12V and -12VDC @ 10mA | | | | | | |
| Recommended for Detector Series: | | J16, J16TE1, J16TE2, J16D, J10D | | | J16, J12TE2, J12TE3 | | J12 J12TE2 | |

† At High Gain Setting.

# Preamplifiers for use with Germanium Detectors

Figure 53-1
Preamplifier Noise Figure @ 1kHz (See page 44)

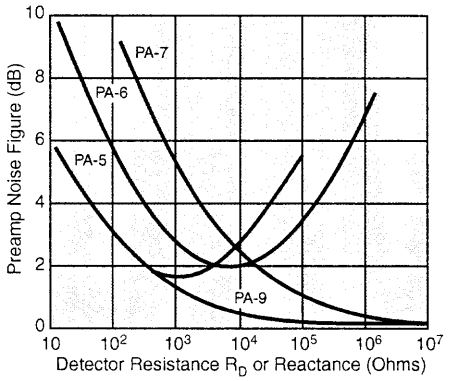



Figure 53-2
System Bandwidth vs Detector Capacitance

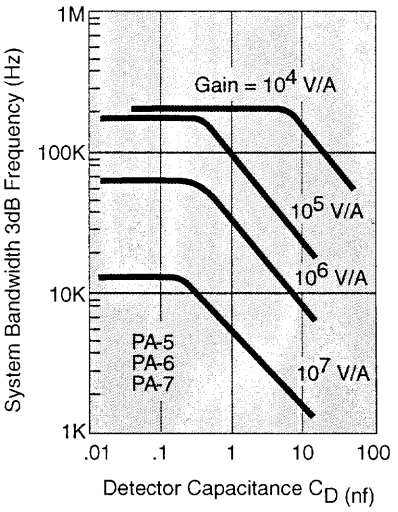



Figure 53-3
System Bandwidth vs Detector Resistance

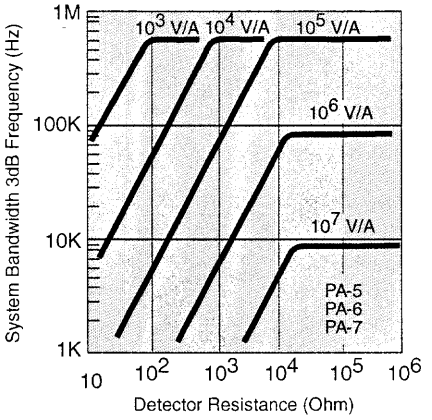
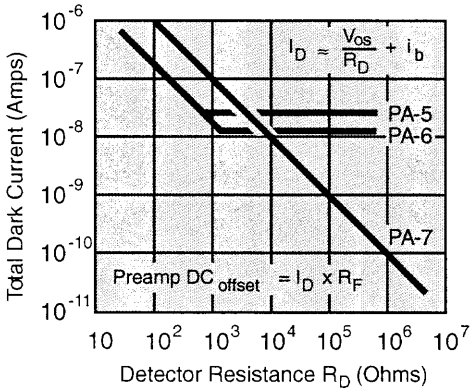



Figure 53-4
Dark Current vs Resistance and Preamp




## PA-7:4C, PA-7:16C, and PA-7:32C

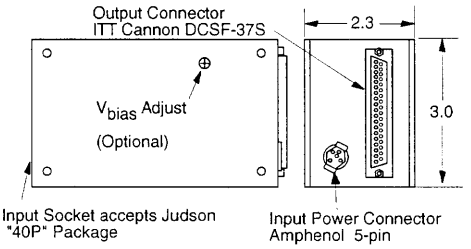
### Multi-Channel Preamplifiers

The PA-7:4C, PA-7:16C and PA-7:32C Series multi-channel preamplifiers are designed primarily for use with Judson's Germanium Array Series and X-Y Sensors.

The preamp gain is fixed as specified at the time of purchase. Standard gain settings are $10^7$ or $10^6$ V/A; others are available on a custom basis.

While zero-volt bias is recommended for J16P Series arrays in most applications, the preamp is also available with an optional detector bias adjust. Biasing the photodiodes improves response time and high-power linearity, but also increases dark current.

Figure 53-5
PA-7:4C, PA-7:16C and PA-7:32C Multi-channel Preamplifier




Typical Specifications Multi-Channel Preamplifiers

| Model | # of Channels | Gain (V/A) | Bandwidth (Max) See Figs. 53-2, 53-3 |
|---|---|---|---|
| PA-7:4C-70 | 4 | | |
| PA-7:16C-70 | 16 | $10^7$ | DC to 10KHz |
| PA-7:32C-70 | 32 | | |
| PA-7:4C-60 | 4 | | |
| PA-7:16C-60 | 16 | $10^7$ | DC to 60KHz |
| PA-7:32C-60 | 32 | | |
| PA-5:4C-1E3 | 4 | $10^3$ | DC to 200KHz |

| | | |
|---|---|---|
| Input Offset Voltage ($V_{os}$) | ±200 | µV |
| Input Bias Current ($i_b$) | ±40 | pA |
| Voltage Noise Density ($e_n$) @1KHz | $18nVHz^{-1/2}$ | |
| Voltage Noise from 0.1 to 10 Hz | 2 | µVpp |
| Current Noise Density† $i_n$ @ 1KHz | $.01pAHz^{-1/2}$ | |
| Output Impedance | < 100 | Ω |
| Maximum Output Voltage | ±10 | Vpp |
| Power Requirements | ±15 | VDC |
| PA-7:4C (4 channel) | @ 40 | ma |
| PA-7:16C (16 channel) | @ 40 | ma |
| PA-7:32C (32 channel) | @ 80 | ma |
| Use with Detector Series: | Ge Arrays | |

† At Gain = $10^7$ V/A. Lower gains increase Current Noise Density.