Germanium Detectors
and
Position Sensors

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ISO 9001 Certified

J16

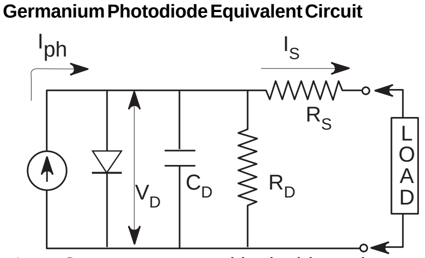
Germanium Detector Operating Notes (0.8 to 1.8 µm)

General

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

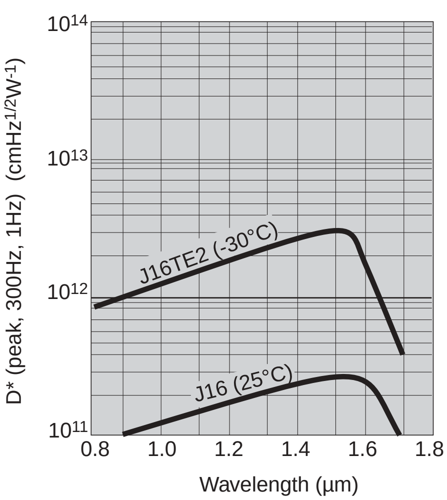
Detailed specifications are available for J16 Series room temperature detectors, parallel output arrays, Avalanche photodiodes and "two color" detectors. For applications where temperature stability of response is important near the cutoff, thermoelectrically cooled detectors are available. Position sensitive detectors and quadrant detectors are also available.

Figure 4-1
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 4-2
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. 4-3).

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

Uniformity of response within the active region of a room-temperature Ge detector is typically better than ± 1% at 1300 nm. See Fig. 6-3.

Figure 4-3
Typical Responsivity for J16 Series Ge

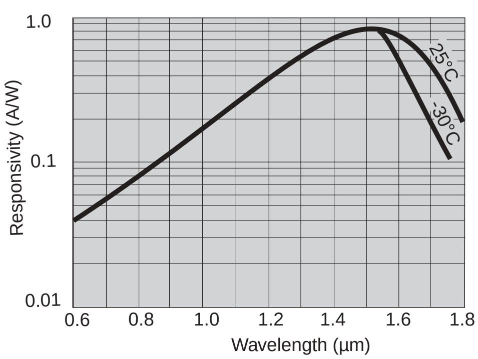
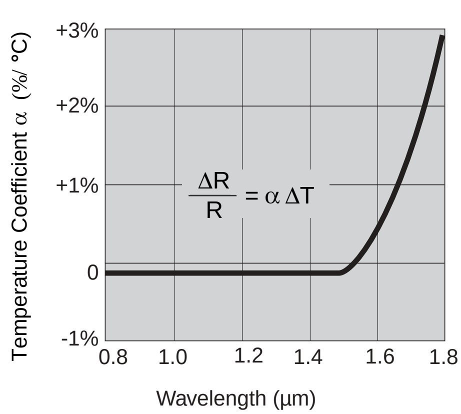


Figure 4-4
Temperature Coefficient of Responsivity at 25 °C



Operating Circuit

The recommended operating circuit for most applications is an operational amplifier in a negative-feedback transimpedance configuration (Fig. 4-5). 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.

For high frequency applications, the detector may be reverse biased and terminated into a low impedance load (Fig. 4-6). Reverse biasing the detector significantly reduces junction capacitance for faster pulse response; however, the dark currents and low-frequency noise are increased.

Figure 4-5
Basic Operating Circuit

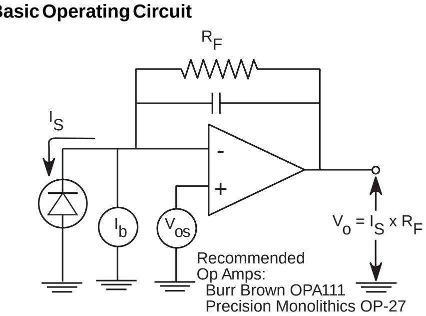
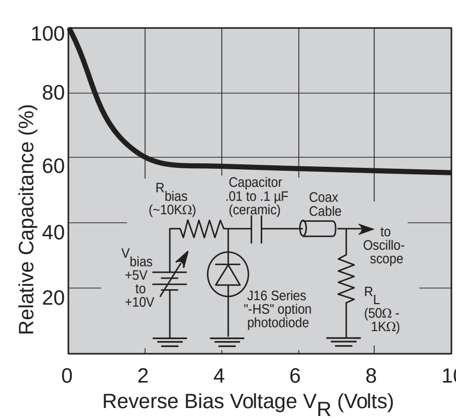


Figure 4-6
Capacitance vs Bias Voltage for High Speed



Shunt Resistance and Dark Current

When the detector is used in the basic circuit of Figure 4-5, 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: 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. 5-1).

When the detector is reverse biased and used in the high-speed circuit of Figure 4-6, the predominant dark current is a function of the applied bias voltage (Fig. 5-2).

Device Selection

Two key factors to consider when selecting a Judson Ge detector are: detector operating temperature and detector active area.

<u>1. Detector Temperature:</u> Cooling the detector reduces dark current and increases the shunt resistance R_D (Fig. 5-3). Shunt resistance data at 25°C is listed on the specification table on page 7. The data can be applied to Figure 5-3 to estimate R_D for detector temperatures from -40 to +60°C.

<u>2. Active Area:</u> Larger active areas have lower shunt resistance R_D (Fig. 5-4), 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.

Linearity

Ge photodiode responsivity in A/W (current output per input optical power) is extremely linear with low input power levels. Response linearity is ultimately limited at high input power levels by photodiode series resistance, R_S, depicted in Figure 4-1. Large amounts of output signal current I_S can significantly forward bias the photodiode junction resulting in nonlinear output response.

Response linearity to well within ±0.04dB (±1%) is maintained with input power levels up to 15dBm at 1550nm. Power levels in excess of 15dBm result in nonlinearities as depicted in Figure 5-5.

Both absorptive and reflective attenuation filters are available for increased high power linearity. Different levels of attenuation are available to meet any high power application.

Figure 5-1
Total Dark Current vs Detector Resistance

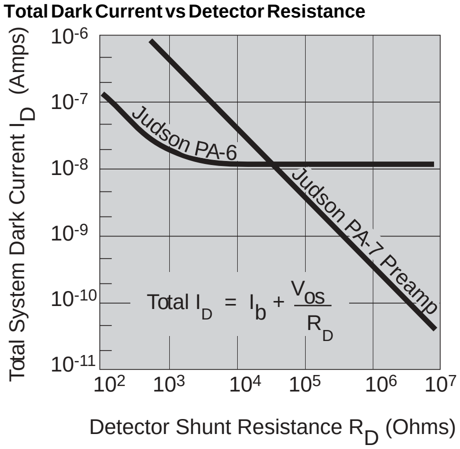


Figure 5-3
Change in Shunt Resistance vs Temperature

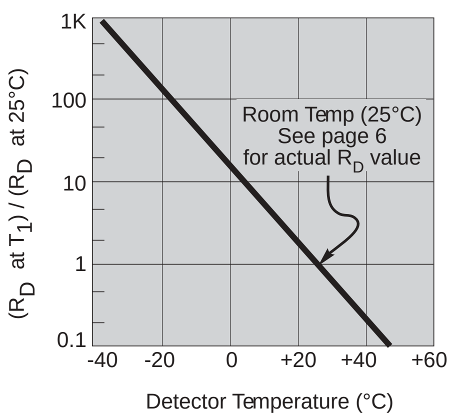


Figure 5-5
Typical 1550nm High Power Linearity

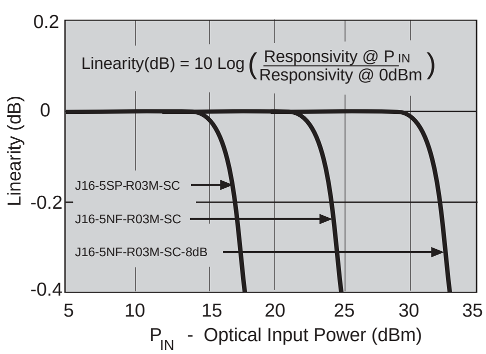


Figure 5-2
Dark Current vs Reverse Bias Voltage

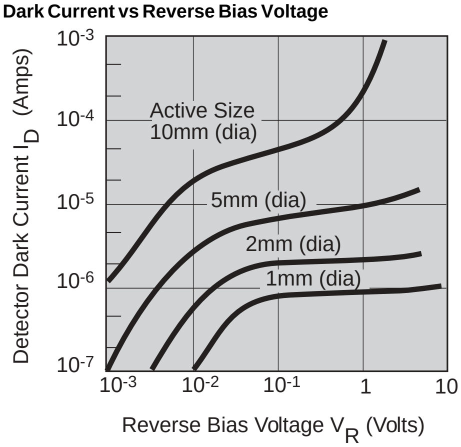


Figure 5-4
Shunt Resistance vs Size and Device Option

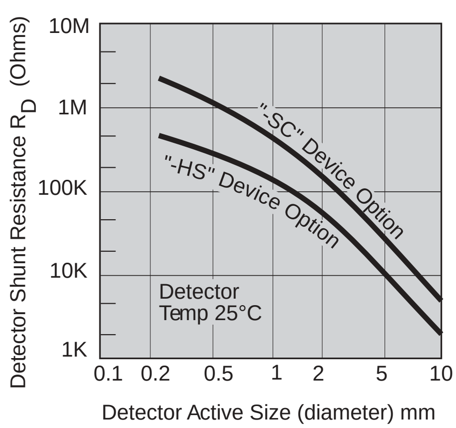
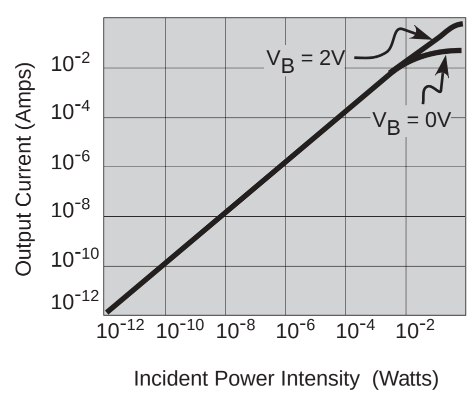


Figure 5-6
Linearity for J16 Series Ge



J16 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 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)	.80	.90		A/W
(@ 1300nm)	.60	.65		A/W
(@ 850nm)	.20	.30		A/W
Uniformity of Response over Area (25°C)		±1		%
Storage Temperature	-55		+80	°C
Operating Temperature	-55		+60	°C

Device Options

Judson offers three unique Ge device options for optimum performance in different applications (Fig. 6-2).

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 (no option) offers excellent performance for general use in applications from ~100Hz to 100KHz.

Applications

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

Figure 6-1
Spectral Response

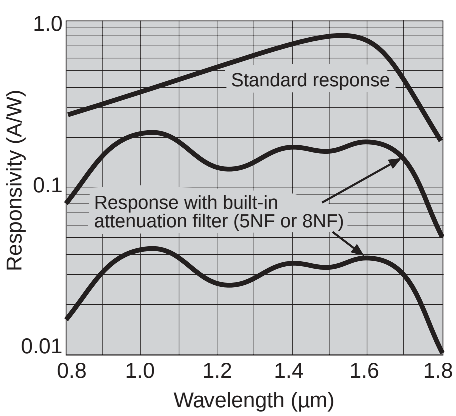


Figure 6-2
NEP vs Frequency for J16 Device Options

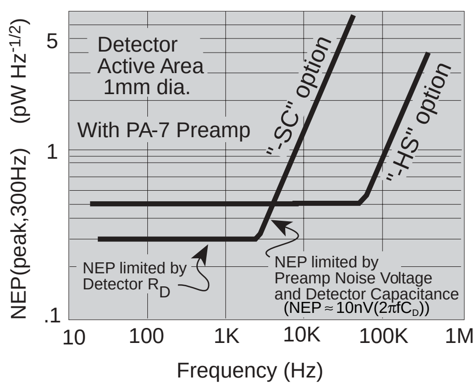
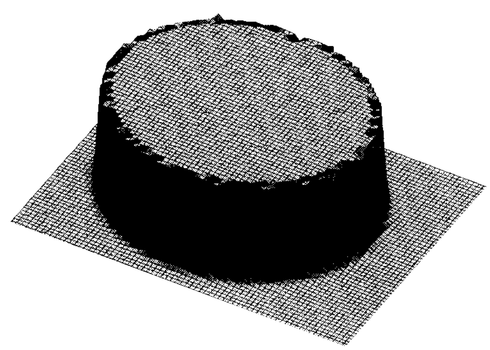


Figure 6-3
Uniformity of Response (5mm Active Area)



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

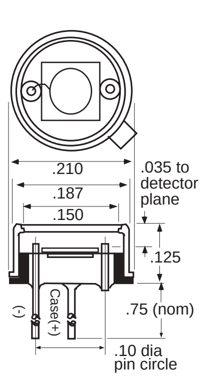
Recommended preamps are the Judson model PA-6 for detectors with R_D less than 50KΩ, and the PA-7 for detectors with R_D greater than 50KΩ (Fig. 5-1). Preamps are sold separately.

Exceptional response uniformity is realized over the entire active area of the J16 Series Ge detectors. Typical spot scan data, depicted in Figure 6-3, indicates 1300nm uniformity of response to within 1% over the entire active area.

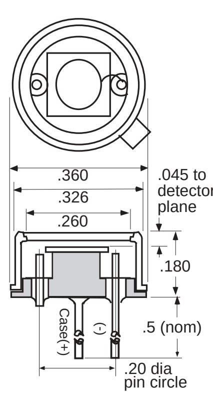
Model Number	Part No.	Active Size (dia.) (mm)	Shunt Resistance R_D @ V_R = 10mV (kΩ)		Dark Current I_D @ Maximum V_R (µA)		Maximum Reverse Voltage V_R (V)	Typical NEP @ λ_{peak} and 300Hz ($pW/Hz^{1/2}$)	Capacitance C_D @ V_R = 0V (nF)	Cutoff Frequency @ Max. V_R and R_L = 50Ω (MHz)	Other Options
			Min.	Typ.	Typ.	Max.					
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,
J16-18A-R500U-HS	460003-3	0.5	200	300	0.3	5	10	0.2	0.03	250	C11, 18D
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,
J16-18A-R500U-SC	460003-2	0.5	700	1200	0.05	0.1	0.25	0.1	0.5	10	C11, 18D
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	5	0.3	1	15	LD, CO2, C11, 18D
J16-5SP-R02M	460006	2.0	25	50	4	10	5	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	2	3.0	60	0.1	P2
J16-P1-R13M	460023	13.0	0.5	1	250	800	2	4.5	100	0.07	

Detector (+): Anode   Detector (-): Cathode   Note: Standard packages have clear glass windows. AR-coated glass windows are available upon request.

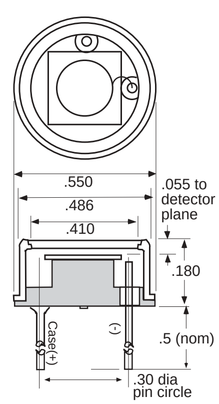
● 18A



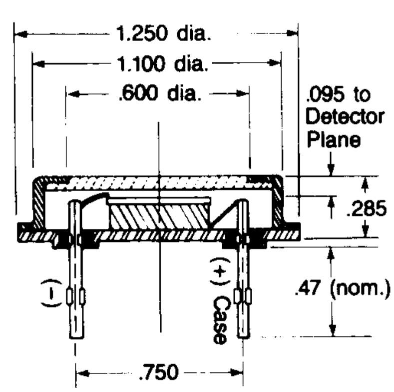
● 5SP



● 8SP



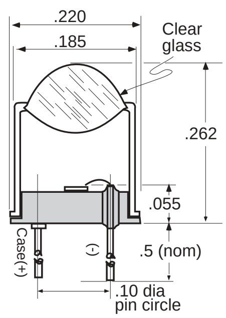
● P1



Optional Packages

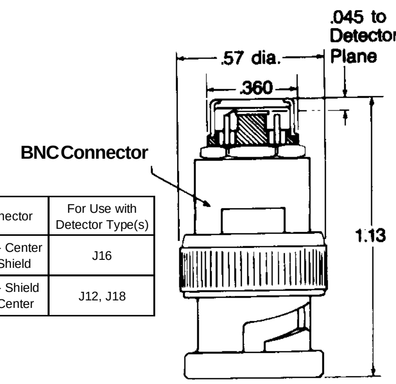
This page features the optional packages available for Judson's room temperature devices.

● 18D



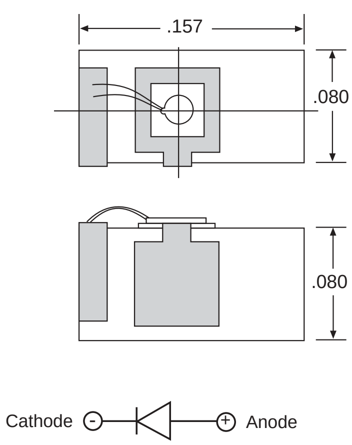
The 18D package gives an optical gain of 3 times responsivity.

● LD, LD2

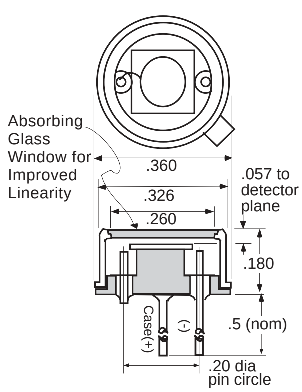


Package	BNC Connector	For Use with Detector Type(s)
LD	Cathode (-) - Center Anode (+) - Shield	J16
LD2	Cathode (-) - Shield Anode (+) - Center	J12, J18

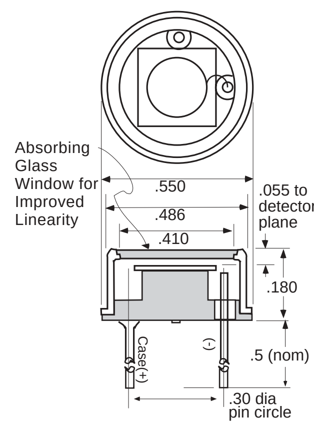
● C02



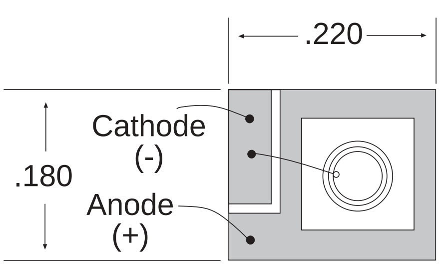
● 5NF



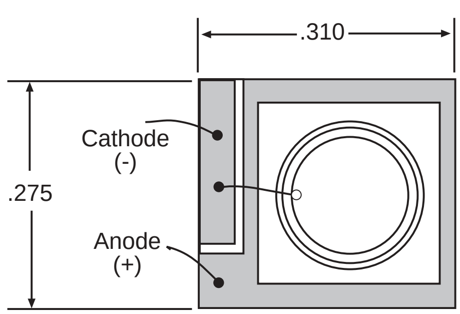
● 8NF



● C11

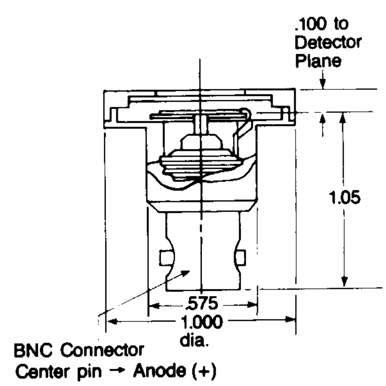


● C12



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

● P2



Germanium Arrays Parallel Output NIR Arrays (0.8 to 1.8 µm)

Description

Standard packaging and element configurations result in low cost and quick delivery for Judson's high-quality photodiode arrays.

The 4, 16 and 32 element arrays respond to infrared radiation from 500nm to 5.0µm depending on material type. The photodiode arrays come mounted in a dual inline package with or without a thermoelectric cooler or in a TO-66 package with three stage thermoelectric cooling where higher cooling performance is needed for thermal imaging applications.

Judson's NIR arrays have a parallel output format with common substrate and one pinout for each element. This format allows for independent readings from each channel.

A separate transimpedance op-amp circuit is recommended for each channel. The Judson Model PA-7:4C, PA-7:16C and PA-7:32C preamps are convenient 4, 16 and 32 channel modules with receptacles for the array package. Transimpedance gain is specified by the user. Heat sink modules are available for detector arrays with thermoelectric coolers.

Applications

- Clinical Analyzers
- Near-IR Spectroscopy for Analysis of:
  - Protein
  - Blood Samples
  - Agricultural Products
- Fiber Optics:
  - Far-Field Laser Diode Pattern Analysis
  - Infrared Fiber Testing

Package

J16P Series arrays are mounted in the Judson "40P" package, a 40 pin, dual-in-line package with glass window (Fig. 9-1).

Pins 1 and 21 are connected to the common substrate. Elements of the 16-element array are connected to pins 23-38. The 32-element array is mounted with odd-numbered elements connected to pins 3-18 and even-numbered elements connected to pins 23-38.

The gap between elements is 0.01mm.

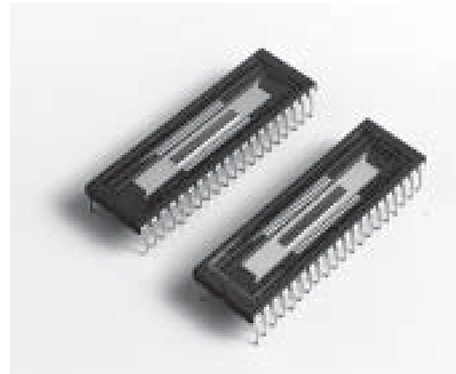
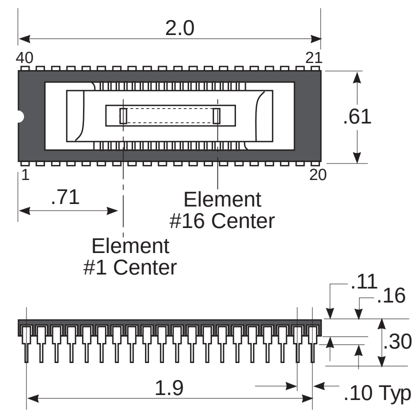


Figure 9-1
J16P- 40P-S01M:16E



Typical Specifications **Near IR Series Arrays**

Model Number	Part No.	Wavelength Region (µm)	Operating Temp.	No. of Elements	Element Size w x h (mm)	Element Center to Center Spacing	Responsivity @ Peak (A/W)	NEP @ Peak (W/Hz1/2)	Minimum Shunt Impedance	Maximum Reverse Bias (V)	Capacitance @ 0V Bias (nF)
J16P-40P-S01M:16E-SC	460061	0.6-1.8	295	16	1x1	1	0.8	6.1261E-12	2.00E+05	0.25	2
J16P-40P-500UX1M:32E-SC	460143	0.6-1.8	295	32	0.5x1.0	0.5	0.9	3.8505E-12	4.00E+05	0.25	1.3

J16A Ge Avalanche Photodiodes (APDs) (0.8 to 1.5 µm)

Description

The J16A series Germanium Avalanche Photodiodes are designed for high-speed applications at 800 and 1300 nm. Judson APDs offer low dark currents and bandwidths up to 1.5 GHz with active sizes of 100 µm and 300 µm diameter.

The J16A Series APDs have undergone extensive reliability testing. Reliability has been demonstrated to be better than 10 FITs corresponding to less than 1% failure rate over 20 years service. Reliability data available upon request.

Applications

- Local Area Networks
- OTDRs
- Transmission Systems

Multiplication Characteristics

An internal gain mechanism makes the J16A the solid state counterpart of the photomultiplier tube. This internal gain is known as the Multiplication Factor (M) and is a function of the reverse bias voltage V_R applied to the diode (Fig. 10-1).

Breakdown Voltage and Dark Current

The avalanche breakdown voltage V_B is the reverse bias voltage at which the diode's dark current becomes infinite. In practice, the dark current used to define breakdown voltage is 100 µA (Fig. 10-3).

Cutoff Frequency

The cutoff frequency f_c is the frequency at which the output signal power is down by 3dB. In the high multiplication region, the product of M and bandwidth becomes a constant, called the gain-bandwidth product, and cutoff frequency decreases with increasing M (Fig. 10-4).

Figure 10-2
J16A-18A Package

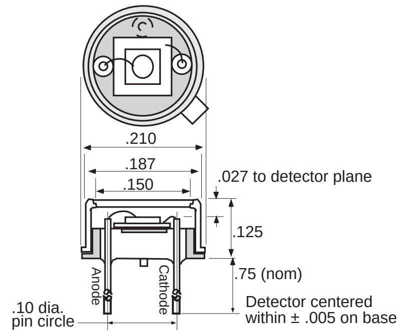


Figure 10-1
Multiplication Characteristics

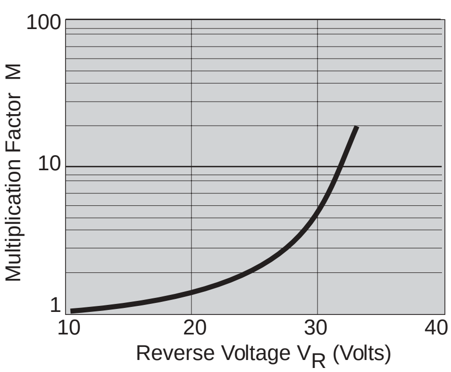


Figure 10-3
Dark Current and Reverse Voltage

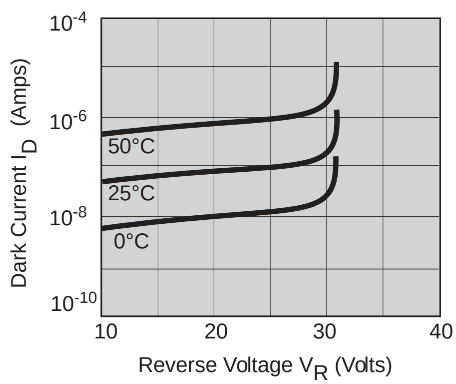
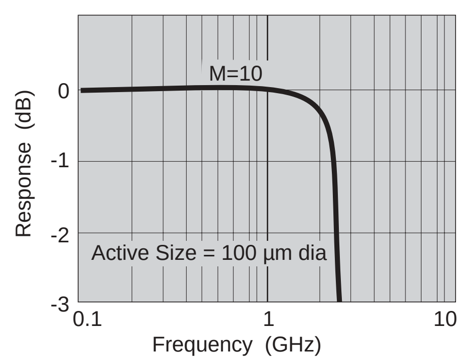


Figure 10-4
Frequency Response



Parameter		Test Conditions	J16A-18A-R100U Active Size 100µm dia.			J16A-18A-R300U Active Size 300µm dia.			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Quantum Efficiency	η	λ = 1300nm	60	70	--	60	70	--	%
Responsivity	R	M = 1	0.63	0.73	--	0.63	0.73	--	A/W
Breakdown Voltage	V_B	I_D = 100µA	20	25	40	20	25	40	V
Temp Coefficient of V_B	γ		0.1	--	--	0.1	--		%/°C
Dark Current	I_D	$V_R = 0.9\ V_B$	--	0.3	0.5	--	1.4	3	µA
Multiplied Dark Current	I_{DM}	M = 1	--	100	150	--	300	400	nA
Cutoff Frequency (-3dB)	f_c	λ = 1300nm, M = 10, RL = 50Ω	1000	1500	--	300	500	--	MHz
Excess Noise Factor	F	λ = 300nm, f = 30MHz	--	9	--	--	9	--	--
Excess Noise Figure	x	BW = 1MHz, M = 10, I_{ph} = 2µA	--	0.95	--	--	0.95	--	--
Capacitance	C	f = 1MHz, M = 10	--	1.5	2	--	8	10	pF
Forward Current	I_f	Maximum Rating			100			100	mA
Reverse Current	I_R	Maximum Rating			1			3	mA

J16A Germanium APDs (30µm and 50µm)

Description

The J16A-FC1-R30U and J16-FC1-R50U are Germanium Avalanche Photodiodes (APDs) with singlemode fiber pigtails designed for use in optical transmission systems operating at high-bit-rates and over long distances. The J16A-CO3-R30U and J16A-CO3-R50U packages are small alumina chip cariers designed for low parasitic capacitance and ease of installation onto a hybrid circuit. The 30µm and 50µm photosensitive diameters are optimized to achieve both higher coupling efficiency with singlemode fiber and higher electrical performances (low dark current, low capacitance and wide bandwidth) at the same time. The APD chip uses planar, fully implanted structure yielding low dark current and high reliability. A laser welding assembly process assures long term stability of fiber coupling and a -40°C to +85°C operating temperature range.

Features

- Meets extended environmental conditions
- JT package with 125µm cladding / 9µm core singlemode fiber coupled to 30µm and 50µm diameter Ge APD
- Storage and operating temperature: -40°C to +85°C
- High quantum efficiency: 80% @ 1300nm
- Cutoff frequency: 4.0 GHz
- Low dark currents: 100nA
- Low multiplied dark current: 5nA

Applications

- High-bit-rate optical transmission systems
- Optical Time Diode Reflectometer (OTDR)

Absolute Maximum Ratings (Tc = 25C)

Parameter	Symbol	Ratings		Ratings		Unit
		J16A-CO3-R30U	J16A-FC1-R30U	J16A-CO3-R50U	J16A-FC1-R50U	
Storage Temperature	Tstg	-40°C to +85°C		-40°C to +85°C		C
Operating Case Temperature	Top	-40°C to +85°C		-40°C to +85°C		C
Forward Current	If	20		50		mA
Reverse Current	Ir	500		500		µA

J16A Germanium APDs (30µm and 50µm)

30 Micron Optical and Electrical Characteristics (Tc = 25C)

Parameter	Symbol	Test Conditions	J16A-C03-R30U			J16A-FC1-R30U			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Quantum Efficiency/(Responsivity)	η / (ℜ)	M = 1 1060nm	70/(0.60)	80/(0.68)	---	70/(0.60)	75/(0.68)	---	%/(A/W)
		1300nm	70/(0.73)	85/(0.88)	---	70/(0.73)	80/(0.83)	---	%/(A/W)
		1550nm	50/(0.62)	60/(0.74)	---	50/(0.62)	60/(0.74)	---	%/(A/W)
Breakdown Voltage	Vb	Id = 100µm	25	30	40	25	30	40	V
Temperature Coefficient	γ		---	0.1	---	---	0.1	---	%/C
Dark Current	Id	Vr = 0.9Vb	---	100	200	---	1000	200	nA
		Vr = 10V	---	30	100	---	30	100	nA
Unmultiplied Dark Current	Ipo	M = 1	---	5	10	---	5	10	nA
Cutoff Frequency	fc	M=10 1300nm Ipo=0.1µA	3000	4000	---	3000	4000	---	MHz
Excess Noise Factor	F	f = 1KHz	---	7	---	---	7	---	---
	x	M=10 1300nm Ipo=0.1µA	---	0.85	---	---	0.85	---	---
Capacitance	C	Vr = 20V f = 1MHz	---	0.6	---	---	1.0	---	pF

50 Micron Optical and Electrical Characteristics (Tc = 25C)

Parameter	Symbol	Test Conditions	J16A-C03-R50U			J16A-FC1-R50U			Units
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Quantum Efficiency/(Responsivity)	η / (ℜ)	M = 1 1060nm	70/(0.60)	80/(0.68)	---	70/(0.60)	75/(0.68)	---	%/(A/W)
		1300nm	70/(0.73)	85/(0.88)	---	70/(0.73)	80/(0.83)	---	%/(A/W)
		1550nm	50/(0.62)	60/(0.74)	---	50/(0.62)	60/(0.74)	---	%/(A/W)
Breakdown Voltage	Vb	Id = 100µm	25	30	40	25	30	40	V
Temperature Coefficient	γ		---	0.1	---	---	0.1	---	%/C
Dark Current	Id	Vr = 0.9Vb	---	150	300	---	150	300	nA
		Vr = 10V	---	40	100	---	40	100	nA
Unmultiplied Dark Current	Ipo	M = 1	---	10	20	---	10	20	nA
Cutoff Frequency	fc	M=10 1300nm Ipo=0.1µA	2000	3000	---	2000	3000	---	MHz
Excess Noise Factor	F	f = 1KHz	---	7	---	---	7	---	---
	x	M=10 1300nm Ipo=0.1µA	---	0.85	---	---	0.85	---	---
Capacitance	C	Vr = 20V f = 1MHz	---	1.0	---	---	1.2	---	pF

J16Si Dual Wavelength "Sandwich" Detectors (0.6 to 1.8 µm)

Description

Two color detectors consist of a high performance Silicon detector mounted in a "sandwich" configuration over another detector.

The Silicon photodiode responds to radiation from 400 nm to 1000 nm. Longer wavelengths pass through the silicon and are detected by the detector underneath.

J16Si Series detectors are ideal for optic power measurements that need to differentiate between 800nm and either 1300nm or 1550nm. They are also useful for two-color temperature measurements (see chart). The J14SI Series is used when the temperature measurement range needs to be expanded.

Applications

- Dual-Wavelength Power Meters
- Wavelength Demultiplexers
- Pyrometers

Figure 11-1
Typical Responsivity for J16Si Series

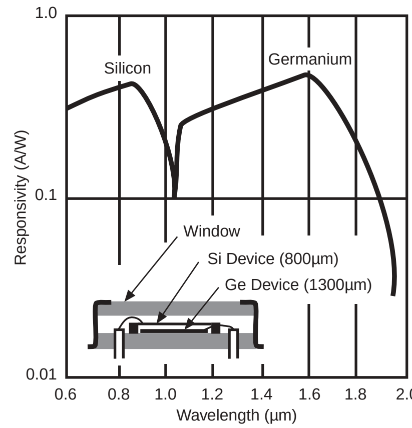


Figure 11-2 Dual-Wavelength Power Meter Application

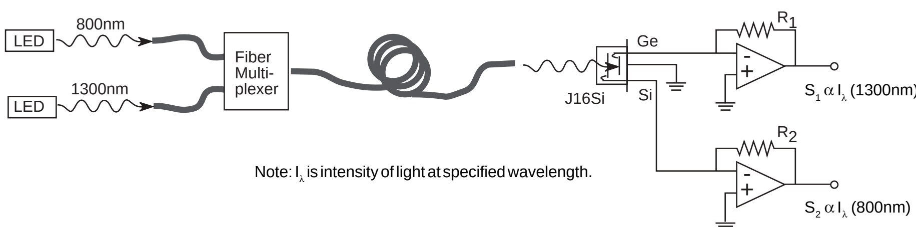


Figure 11-3
5A4 Package

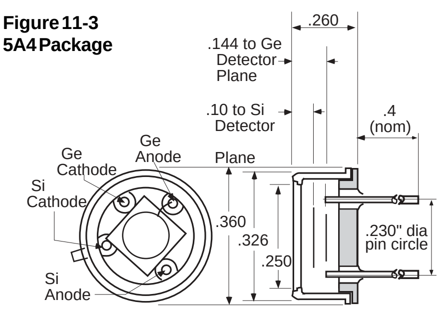
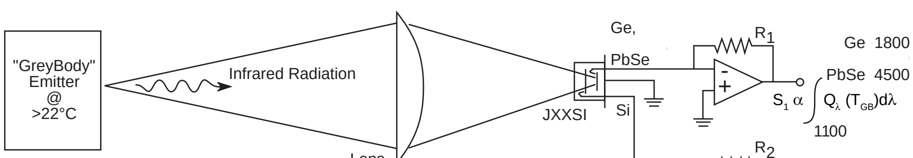
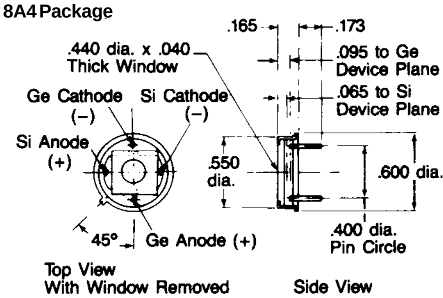


Figure 11-4 Two-color Temperature Sensor Application



Notes:
1. $Q_\lambda(T_{GB})$ is photon flux per unit wavelength interval from greybody source.
2. Ratio S_1/S_2 can be used to determine greybody temperature T_{GB} regardless of emissivity or absolute signal levels.

Figure 11-5
8A4 Package



Typical Specifications **Bicolor Series Detectors** @ 22°C

Model Number	Part Number	Operating Temp.	Active Size (mm)	Element	Wavelength Range (µm)	Responsivity	Typical Shunt Resistance RD @VR=10mV (ohms)	Typical NEP @ Ipeak and 300 Hz (W/Hz½)	Package
J16Si-5A4-R02M-SC	460066-1	22C	3.5 2.0	Si Ge	400-1000 1100-1800	0.45 A/W@800nm 0.65 A/W@1300nm	50M 120K	4.0E-14 6.0E-13	5A4
J16Si-8A4-R03M-SC	460063-1	22C	5.0 3.0	Si Ge	400-1000 1100-1800	0.45 A/W@800nm 0.65 A/W@1300nm	50M 60K	4.0E-14 8.0E-13	8A4
J16Si-8A4-R05M-SC	460129	22C	5.0 5.0	Si Ge	400-1000 1100-1800	0.45 A/W@800nm 0.65 A/W@1300nm	50M 20K	4.0E-14 1.4E-12	8A4
J14Si-5S4-S03M	1500605	22C	3.5 3.0	Si PbSe	400-1000 1100-4000	0.45 A/W@800nm 2500V/W @4000nm	50M 0.1 to 2.0M	4.0E-14 1.5E-10	5S4
J14SiTE2-8S16-S01M	1500618	-40C	3.5 1.0	Si PbSe	400-1000 1100-5000	0.45 A/W@800nm 9000V/W @4500nm	50M 0.4 to 10.0M	4.0E-14 3.0E-11	8S16

Detector	Target Temp. Range	Storage Temp.		Operating Temp.	
		Min.	Max.	Min.	Max.
J16Si	500C - 200C	-55C	+80C	-55C	+60C
J14Si	22C - 2000C				

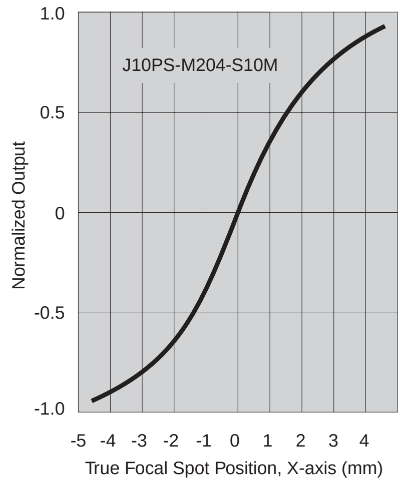
J16PS Room Temperature Germanium Position Sensors

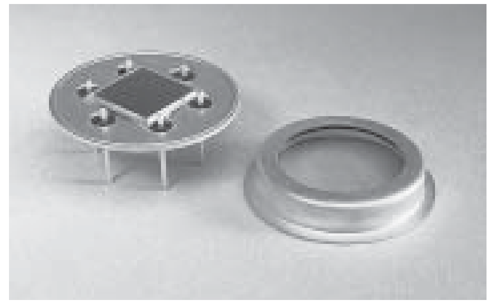
■ J16PS

Position Sensors

A Ge position sensor consists of a single element photodiode with a quadrupole electrode geometry. These devices can provide linear X-Y beam position information for lasers and other infrared beams. Positioning information is determined as shown in Fig. 35-1. The PA6:4C preamplifier is recommended for Judson position sensitive detectors.

FIgure 35-2
Example of Position Linearity

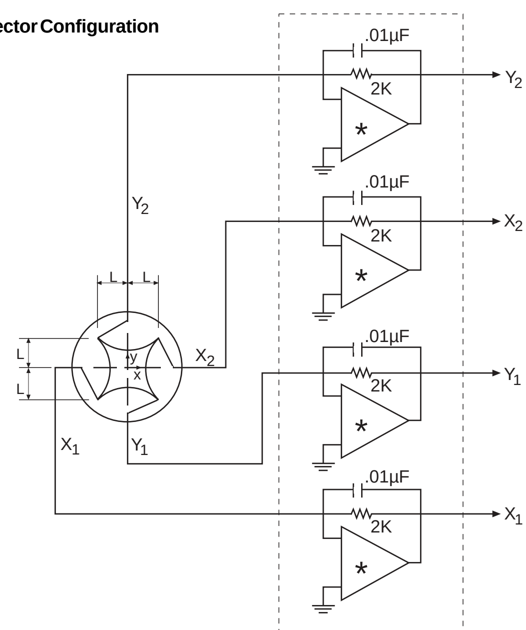




Typical Specifications **Linear Position Sensors**

Model Number	Part Number	Detector Type	Wavelength Range (µm)	Active Size "2L" (mm)	Linear Position Zone (Dia.) (mm)	Typical Position Resolution (µm)	Typical Interelectrode Resistance (Ω)	Peak Responsivity	Detector Temperature	Package Type
J16PS-P6-S10M-HS	460284	Ge	0.8-1.8	10 x 10	6	5	~ 100	0.6	22°C	TO3
J16PS-8E6-S05M-HS	460743	Ge	0.8-1.8	5 x 5	3	5	~ 100	0.6	22°C	TO8

FIgure 35-1
Position Sensor Detector Configuration



Device Options

Judson's unique "-HS" option Ge position sensing device 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.

$$\frac{x}{L} = \frac{(X_2 + Y_1) - (X_1 + Y_2)}{X_1 + X_2 + Y_1 + Y_2}$$

$$\frac{y}{L} = \frac{(X_2 + Y_2) - (X_1 + Y_1)}{X_1 + X_2 + Y_1 + Y_2}$$

J16PS Room Temperature Germanium Quadrant Arrays

J16QUAD

Quadrant Detectors

A Ge quadrant detector consists of four separate detector elements arranged in a quadrant geometry with element separations as noted in the table below. The PA7:4 preamplifier is available for J16Quad detectors.

Device Options

Judson offers three unique Ge device options for optimum performance in different applications (Fig. 6-2).

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.

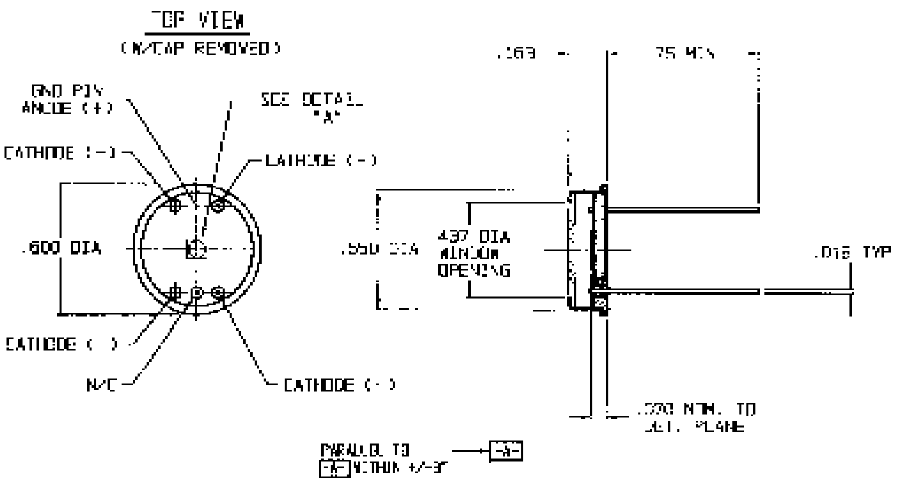
The standard device (no option) offers excellent performance for general use in applications from ~100Hz to 100KHz.

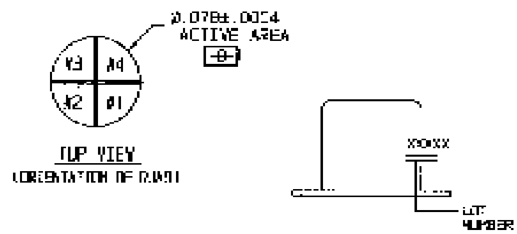
Typical Specifications **Quadrant Detectors**

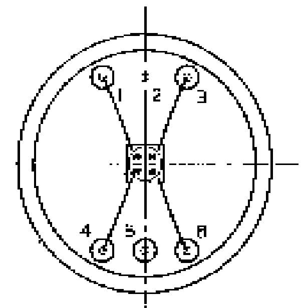
Model Number	Total Active Size (dia.)	Shunt Resistance R_D @ V_R = 10mV (KΩ)		Dark Current I_D @ Maximum V_R (μA)		Maximum Reverse Voltage V_R	Typical NEP @ λ_{peak} and 300Hz	Capacitance C_D @ V_R = 0V	Cutoff Frequency @ Max. V_R and R_L = 50Ω	Gap Between Quadrants
	(mm)	Min.	Typ.	Typ.	Max.	(V)	($pW/Hz^{1/2}$)	(nF)	(MHz)	
LOW CAPACITANCE OPTION ("HS")										
J16QUAD-8D6-R02M-HS	2.0	100	200	1	5	10	0.3	0.15	50	15μm
J16QUAD-8D6-R05M-HS	5.0	20	40	5	15	5	0.8	1	8	20μm
HIGH SHUNT RESISTANCE OPTION ("SC")										
J16QUAD-8D6-R02M-SC	2.0	250	350	0.1	0.2	0.25	0.2	2	2	15μm
J16QUAD-8D6-R05M-SC	5.0	55	90	0.35	3	0.25	0.6	14	0.2	20μm
STANDARD										
J16QUAD-8D6-R02M	2.0	100	200	1	5	5	0.3	1	15	15μm
J16QUAD-8D6-R05M	5.0	25	50	4	10	5	0.6	4	4	20μm

See page 14 for device configurations.

J16QUAD-8D6-R02M





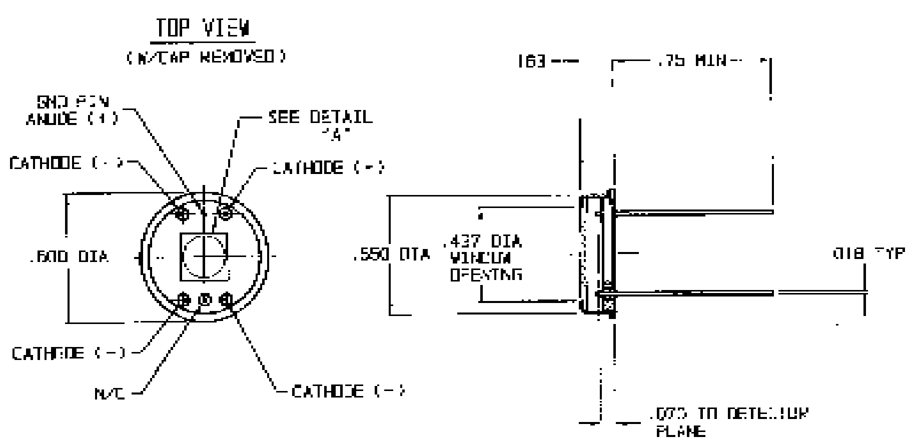


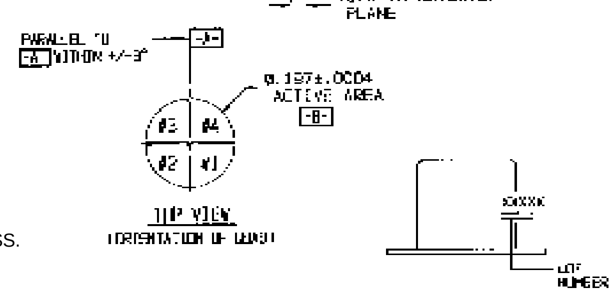
DETAIL "A"

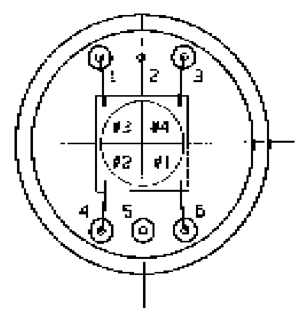
NOTES:
1. DETECTOR CENTERED TO WITHIN ± 0.015
WITH RESPECT TO -A- AND -B- OF QUAD.
2. WINDOW MATERIAL: BOROSILICATE GLASS.

PIN	FUNCTION
1	DET, QUAD ELEM #3, CATHODE (-)
2	DET, GND, ANODE (+)
3	DET, QUAD ELEM #4, CATHODE (-)
4	DET, QUAD ELEM #2, CATHODE (-)
5	N/C
6	DET, QUAD ELEM #1, CATHODE (-)

J16QUAD-8D6-R05M







DETAIL "A"

NOTES:
1. DETECTOR CENTERED TO WITHIN ± 0.015
WITH RESPECT TO -A- AND -B- OF QUAD.
2. WINDOW MATERIAL: BOROSILICATE GLASS.

PIN	FUNCTION
1	DET, QUAD ELEM #3, CATHODE (-)
2	DET, GND, ANODE (+)
3	DET, QUAD ELEM #4, CATHODE (-)
4	DET, QUAD ELEM #2, CATHODE (-)
5	N/C
6	DET, QUAD ELEM #1, CATHODE (-)

J16D Nitrogen Cooled Germanium Detectors

General

The J16D Series Ge detectors offer the ultimate sensitivity for 800 to 1400nm detection. Cooling the Ge photodiode to 77°K results in extremely high shunt impedance for Noise Equivalent Power (NEP) typically below 0.01 pW/Hz$^{1/2}$.

Applications

- Fiber Testing
- NIR Spectroscopy

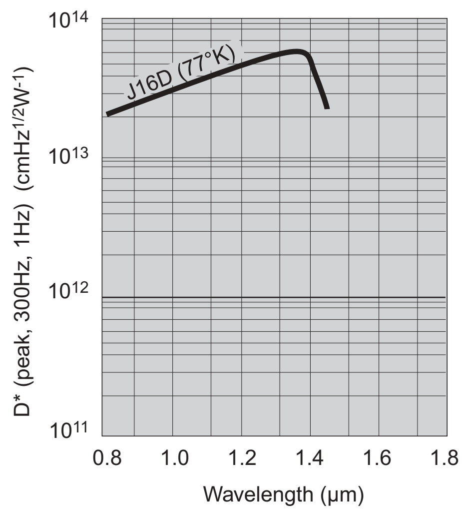
Dewar Packages

J16D detectors are packaged in glass or metal dewars with sapphire windows. J16D detectors have extremely high shunt impedance R_D and therefore very low intrinsic noise. When used in environments where vibration is present, the microphonic noise from the dewar leads may dominate the detector noise. Under these conditions, a glass dewar is recommended, as the leads are imbedded in the glass and immune to vibrations. Care must be taken with external connections to avoid noise from vibrations outside the dewar. Metal dewars are suitable for other applications and can be periodically re-evacuated.

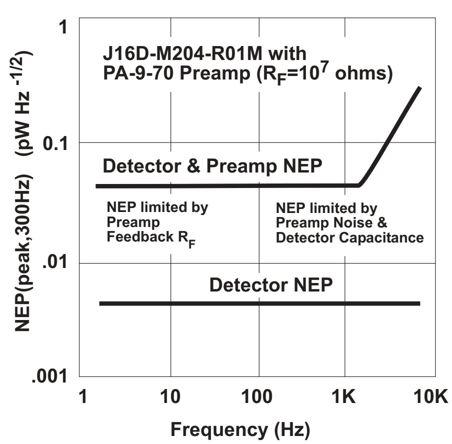
Preamplifiers and System Noise

Optimum J16D detector performance is achieved with Judson transimpedance gain preamplifers. The PA-9 or PA-7 preamplifier converts the detector output current to a voltage, while maintaining the detector at the optimum zero volt bias. The PA-9 fixed-gain preamp is specifically matched to each detector to provide maximum sensitivity, gain and bandwidth. The PA-7 preamp offers adjustable gain and is suitable for DC and low-frequency applications. At high frequencies, the detector capacitance and preamp voltage noise contribute significantly to the system noise.

J16D Detectivity vs Wavelength



J16D Noise Equivalent Power vs Frequency



Typical Specifications **J16D Series Ge @ 77°K**

Model Number	Active Size (dia.)	Responsivity @ 1300nm	Shunt Resistance R_D @ V_R = 10mV (ohms)		Typical NEP @ λ_{peak} and 300Hz	Capacitance C_D @ V_R = 0V	Maximum Reverse Voltage (V_R)	Packages	
	(mm)	(A/W)	Min.	Typ.	(pW/Hz1/2)	(nF)	(V)	Standard	Options
J16D-M204-R01M	1	0.5	1G	10G	.004	0.15	10	M204	Dewars
J16D-M204-R05M	5	0.5	1G	10G	.004	3	5	M204	Dewars

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

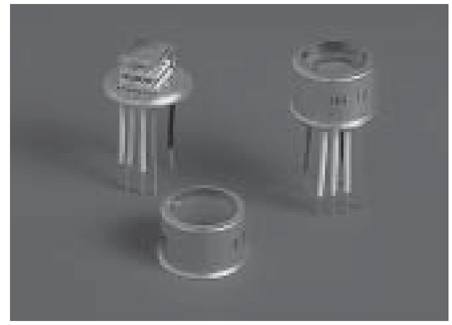
J16TE2 Series detectors are Ge photodiodes on high-performance two-stage coolers. DC offset current and dark current are significantly reduced at the -30°C operating temperature (Figs. 11-4 and 11-5).

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 Tempera-ture	Respon-sivity @ (A/W)	Shunt Resistance RD @ VR = 10mV Min. (MΩ)	Shunt Resistance RD @ VR = 10mV Typ. (MΩ)	Typical NEP @ λpeak and 300Hz (pW/Hz$^{1/2}$)	Capacitance CD @ VR = 0V (nF)	Maximum Reverse Voltage VR (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-HS	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

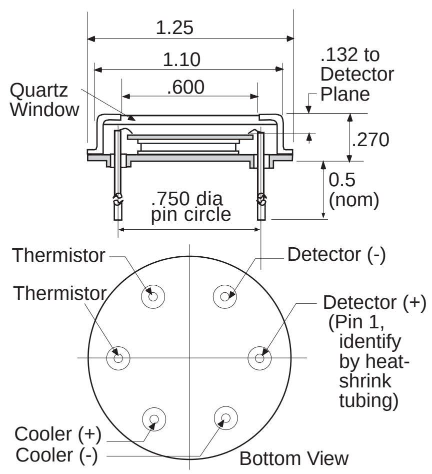


Figure 11-2 J16TE2-8A6

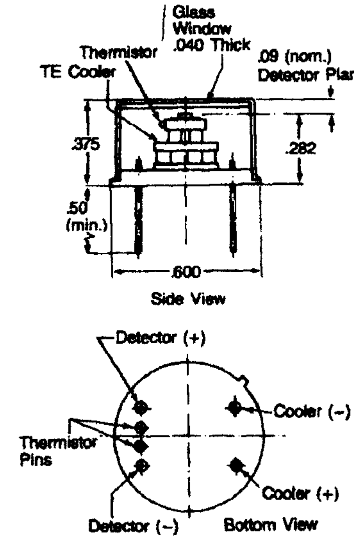


Figure 11-3 J16TE2-66G

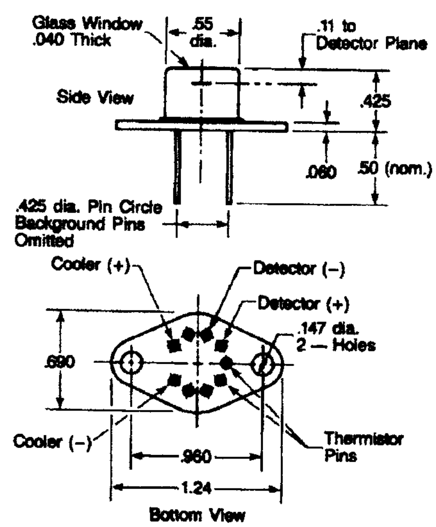


Figure 11-4
"DC Offset Current" vs Temperature (Near 0V Bias)

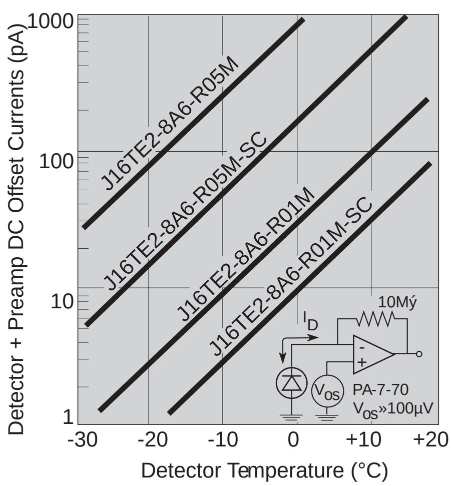


Figure 11-5
Dark Current vs Temperature

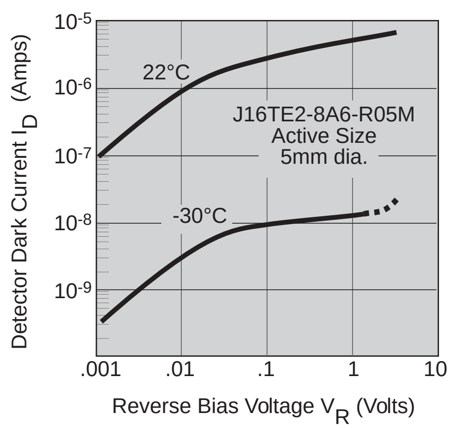


Figure 11-6
Total Noise Equivalent Power vs Frequency (-30°C)

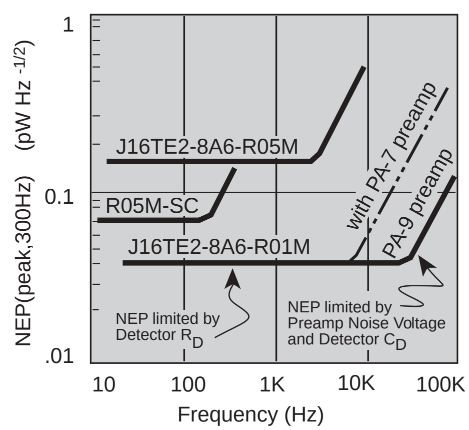


Figure 11-7 J16TE1
Detector Temperature vs TE1 Cooler Current

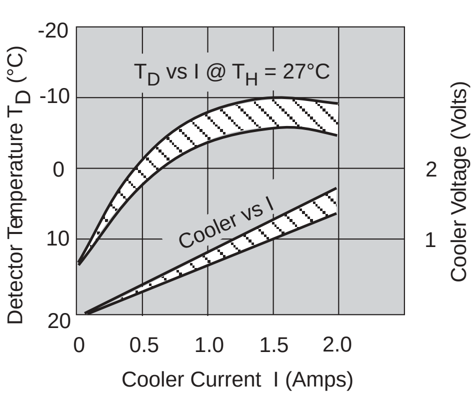


Figure 11-8 J16TE2
Detector Temperature vs TE2 Cooler Current

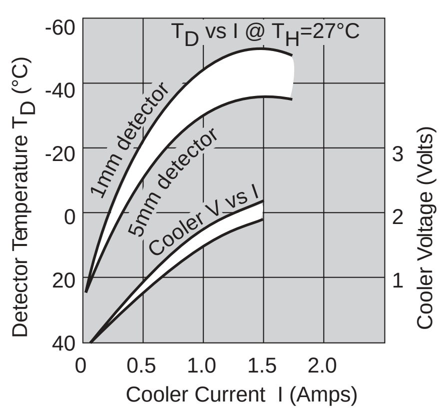
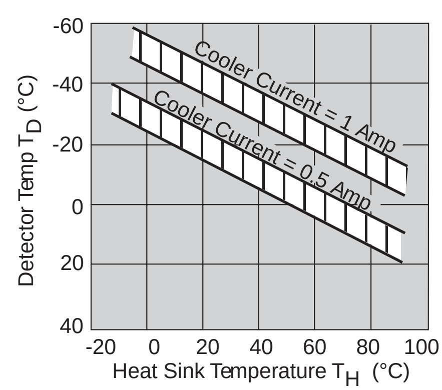


Figure 11-9 J16TE2
Detector Temperature vs Heat Sink Temperature at Constant Current



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.

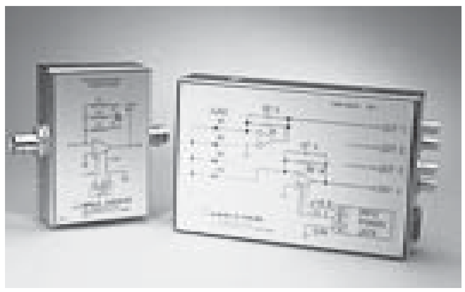
PA-7

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.

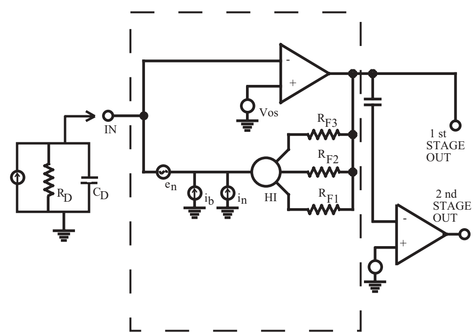


PA-5

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>10K$_\Omega$,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

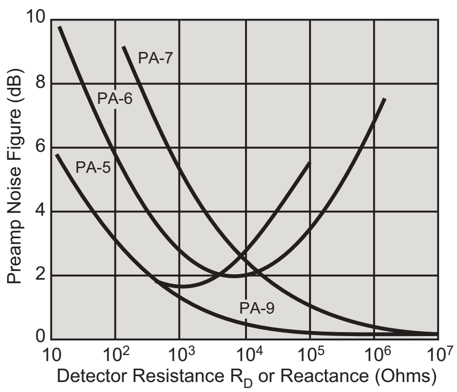


Figure 53-2
System Bandwidth vs Detector Capacitance

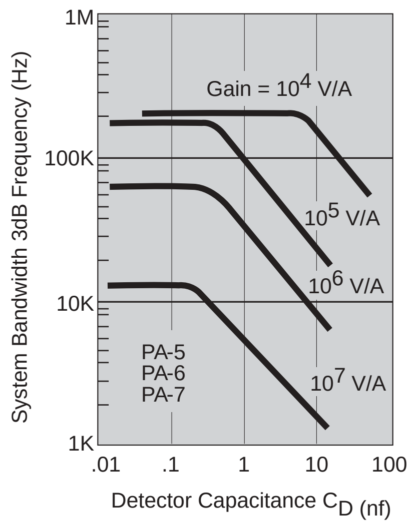


Figure 53-3
System Bandwidth vs Detector Resistance

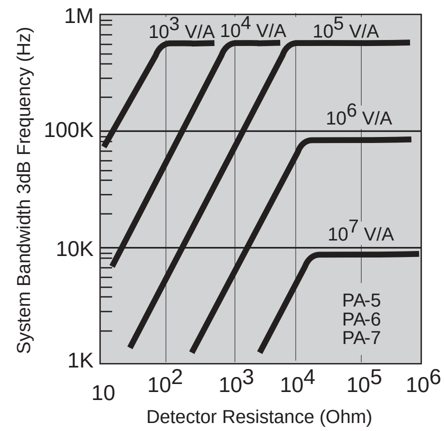
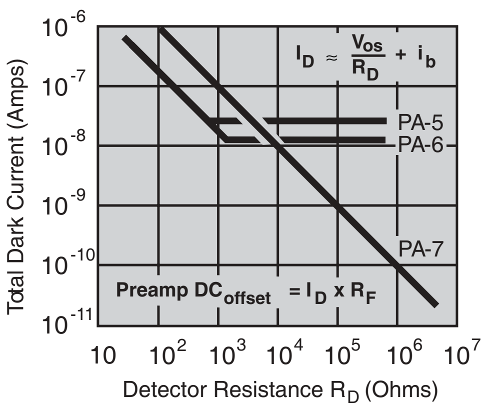


Figure 53-4
Dark Current vs Resistance and Preamp



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

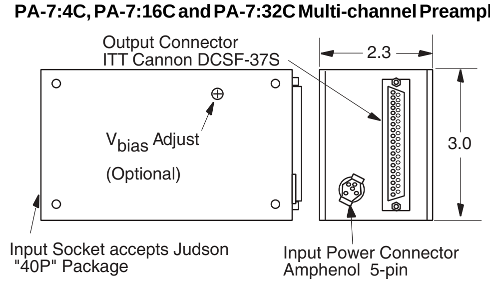
Multi-Channel Preamplifiers

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.

In addition to our Germanium product line, Judson Technologies offers a wide range of high performance standard, custom and space qualified detector products and accessories.

- Indium Arsenide detectors and arrays
- Indium Antimonide detectors and arrays
- Mercury Cadmium Telluride detectors and arrays
- Lead Selenide detectors and arrays
- Lead Sulfide detectors and arrays
- Indium Gallium Arsenide detectors and arrays
- Dewars, backfill and vacuum packages
- Thermoelectric, Joule Thomson and closed cycle linear and rotary coolers
- Preamplifiers
- Temperature controllers and readout electronics

Please contact us for more information on these products at 215-368-6900 or on the web at www.judsontechnologies.com.

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July, 2003