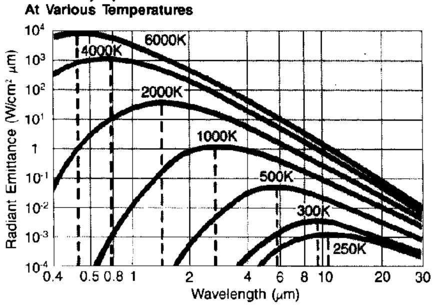
Glossary of Terms

• Bias Current (I_B)
The constant current applied across a photoconductive detector for proper operation.

• Blackbody (BB)
An ideal radiator whose radiant emittance, W, follows the Stefan-Boltzmann law. The relationship is shown below.

Blackbody Spectral Emittance At Various Temperatures



• BLIP
A detector is referred to as BLIP (Background limited) when its D* is limited by the noise associated with photons from the background radiation.

• Cutoff Frequency (f_c)
Related to time constant (τ) as follows:

$$f_c = \frac{1}{2\pi\tau}$$

• Cutoff Wavelength (λ_{co})
The long wavelength point at which the detector responsivity has fallen to a specified percent of the peak responsivity. λ_{CO} is usually specified at 20% or 50% of peak.

• D-Star (D*)
A relative sensitivity parameter used to compare performance of different detector types. D* is the signal to noise ratio at a particular electrical frequency and in a 1 Hz bandwidth when 1 watt of radiant power is incident on a 1 cm active area detector. The higher the D* value, the better the detector.

$$D^*(\text{cmHz}^{1/2}\text{W}^{-1}) = \frac{[\text{Active Area (cm}^2)]^{1/2}}{\text{NEP (W/Hz}^{1/2})}$$

• Dark Current (I_D)
The current through a photodiode when a specific reverse bias voltage is applied with no incident radiant power. Also referred to as Reverse Current.

• Junction Capacitance (C_D)
The p-n junction of a photovoltaic detector has a capacitance proportional to the active size.

• Maximum Reverse Voltage (V_R)
A photovoltaic detector can be damaged by applying more than the maximum reverse voltage V_R.

• NEP (Noise Equivalent Power)
The radiant power that produces a signal-to-noise ratio of one at the output of the detector. Defined with respect to a particular chopping frequency, wavelength and effective noise bandwidth.

$$\text{NEP @ } \lambda_P = \frac{\text{Noise (A/Hz}^{1/2})}{\text{Responsivity @ } \lambda_P \text{ (A/W)}}$$

• Open Circuit Voltage (V_{OC})
The DC voltage generated by a photovoltaic detector when connected to a high impedance load.

• Photoconductive Detector (PC)
A photon detector which exhibits an increase in conductivity as a function of radiant power.

• Photovoltaic Detector (PV)
Any photon detector utilizing a p-n junction to convert radiant power directly into electric current. Also referred to as a photodiode.

• Responsivity (R)
The detector photocurrent (or voltage) output per unit incident radiant power at a particular wavelength. Expressed in units of amps/watt (or volts/watt).

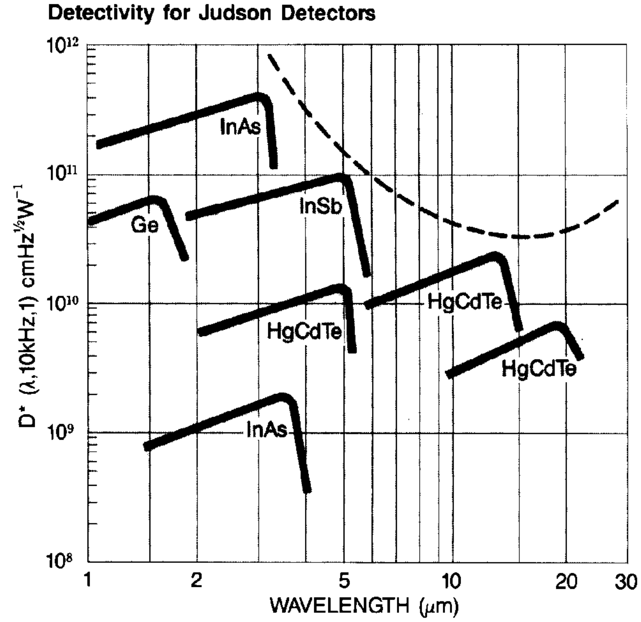
• Short Circuit Current (I_{SC})
The current generated by a photovoltaic detector when connected into a low impedance load.

• Shunt Resistance (R_D)
The resistance of a photodiode measured at zero-volt bias with no radiant power incident on the detector. R_D is the slope, dV/dI, of the current-voltage curve at zero-volt bias. Also referred to as Dynamic Impedance.

• Time Constant (τ)
The time required for the detector signal to reach 63% of its final value after the onset of a fixed incident power. Related to cutoff frequency (f_c) as follows:

$$\tau = \frac{1}{2\pi f_c}$$

Detectivity for Judson Detectors



J12 Series Indium Arsenide Detectors 1.0 to 3.6 μm

Description

The J12 Series Indium Arsenide (InAs) detectors are photovoltaic infrared diodes sensitive in the 1.0 to 3.6 μm wavelength region. Diode sensitivity, speed of response, impedance and peak wavelength can be optimized by operation at the proper temperature. Judson offers a variety of convenient packages for room temperature, thermoelectrically cooled and cryogenic liquid nitrogen operation. Linear arrays (page 28), position sensors (page 27) and special configurations are also available.

Applications

- Process Control
- Temperature Sensors
- Pulsed Laser Monitors
- Infrared Spectroscopy

● J12 Series

Room Temperature InAs Detectors

These photodiodes operate at ambient temperatures and are excellent for wide bandwidth (DC to 10MHz) applications such as infrared laser monitors and fast temperature sensors. The devices are available in .25mm, 1mm or 2mm diameter active sizes and are mounted in the 18C, 5AP or convenient LD2 BNC connector packages.

For low frequency applications (DC to 50kHz) the Model PA-5 transimpedance gain preamplifier is strongly recommended. The PA-5 has extremely low voltage noise, low offset voltage and adjustable gain for the best possible match to these low shunt resistance detectors. For high speed applications, the Model PA-100 (5Hz to 1 MHz) and Model PA-400 (1kHz to 50 MHz) voltage preamplifiers can be used. InAs detectors can be reverse biased to a maximum of 1 volt to reduce junction capacitance and improve high frequency response.

● J12TE2 Series

Thermoelectrically Cooled InAs Detectors

The J12TE2 Series detectors are high quality InAs photodiodes mounted with thermistors on two-stage thermoelectric coolers and hermetically sealed in a dry nitrogen environment. The 8B6 package is standard, with the 66S (page 17) or HSA2 (page 22) packages available as options. At the standard operating temperature of -30°C, the J12TE2 Series detectors have a much higher shunt resistance than room temperature detectors resulting in higher responsivity, lower noise and better stability for DC or chopped light applications. See Figs. 7-7, 7-8 and 7-9 on page 7 for specific operating information on the thermoelectric cooler. The Model PA-5 transimpedance gain preamplifier (page 24) is recommended for bandwidths from DC to 50kHz.

● J12TE4 Series

4-Stage Thermoelectrically Cooled InAs Detectors

The J12TE4 Series detectors are high quality InAs photodiodes mounted in the MC31 Cooling System (page 21) which includes a built-in thermistor, four-stage thermoelectric cooler and hermetically sealed evacuated package. The devices are ideal for critical military, space or industrial applications requiring high detectivity, good uniformity of response and wide bandwidth.

● J12D Series

Liquid Nitrogen Cooled InAs Detectors

The J12D Series InAs detectors offer the highest detectivity available in the 1 to 3 μm wavelength region. The detectors are mounted in either the M204 or the M205 metal dewars (page 19) with sapphire windows. The Model PA-7 or PA-9 transimpedance gain preamplifier (page 24) is recommended.

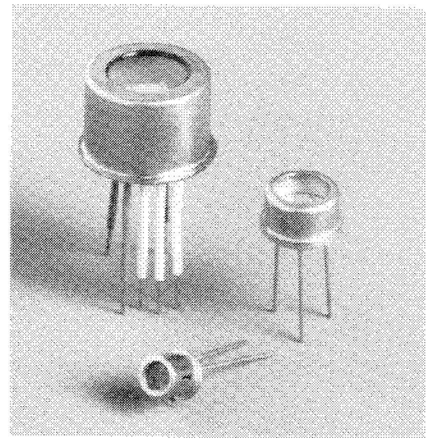
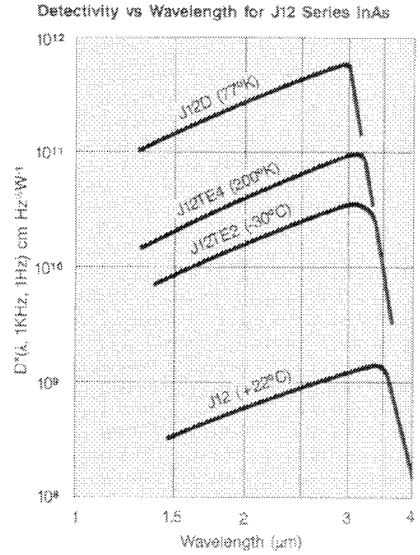


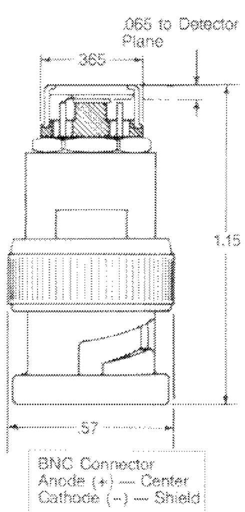
Figure 8-1
Detectivity vs Wavelength for J12 Series InAs



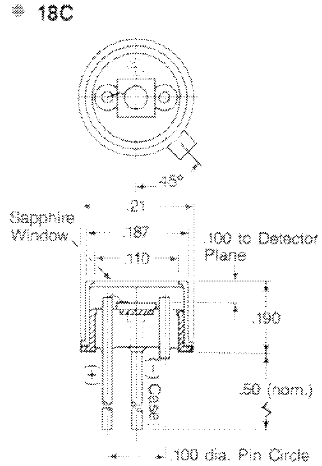
Typical Specifications **J12 Series InAs**

Model Number	Active Size (Dia.) (mm)	Operating Temperature	Cutoff Wavelength (50%) λ_{co} (µm)	Responsivity @ λ_p (A/W)	Shunt Resistance R_D @ V_R = 10mV Min. (Ω)	Shunt Resistance Typ. (Ω)	NEP @ λp and 1kHz (pW/Hz$^{1/2}$)	Capacitance C_D @ V_R = 0V (pf)	Cutoff Frequency @ R_L = 50Ω (Hz)	Packages Standard	Packages Optional
J12 Series Room Temperature InAs											
J12-18C-R250U	.25	22°C	3.6	1	70	100	20	50	10M	18C	LD2
J12-18C-R01M	1			.7	10	20	70	400	3M		
J12-5AP-R02M	2			5	5	10	200	1600	1M	5AP	
J12TE2 Series Two-Stage Thermoelectrically Cooled InAs											
J12TE2-8B6-R250U	.25	−30°C	3.45	1.5	400	600	4	50	10M	8B6	66S (Page 17) HSA2 (Page 22)
J12TE2-8B6-R01M	1				140	200	6	400	3M		
J12TE2-8B6-R02M	2				70	100	9	1600	1M		
J12TE4 Series Four-Stage Thermoelectrically Cooled InAs											
J12TE4-MC31-R01M	1	−73°C	3.3	1.5	2k	5k	1.5	400	200k	MC31S (Page 21)	Custom
J12D Series LN_2 Cooled InAs											
J12D-M204-R01M	1	77°K (−196°C)	3.1	1.5	200k	500k	.15	400	200k	M204 Metal Dewar (Page 19)	Metal Dewars (Pages 18 & 19)
J12D-M204-R02M	2				60k	300k	.3	1600	100k		

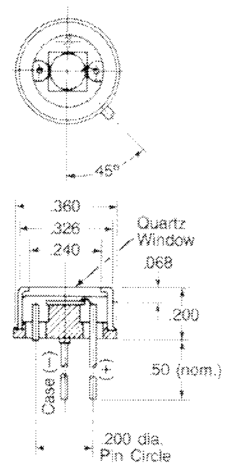
LD2



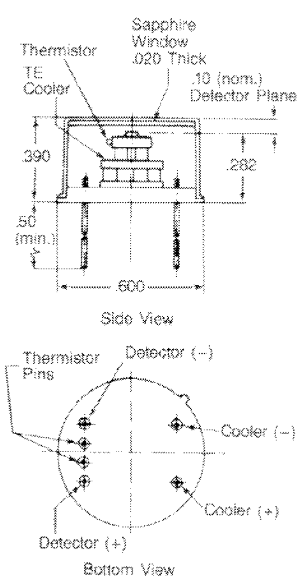
18C



5AP



8B6



J10D Series Indium Antimonide Detectors 1.0 to 5.5 μm

Description

The J10D Series detectors are high quality Indium Antimonide (InSb) photodiodes. These devices provide excellent performance in the 1.0 to 5.5 μm wavelength region. Single crystal p-n junction technology yields a high speed, low noise detector with excellent uniformity, linearity and stability.

Operation

InSb detectors are photovoltaic and generate current when exposed to infrared radiation. Peak responsivity is greater than 2 A/W at 5.0 μm. Figure 11-2 shows the equivalent circuit for the detectors, including the shunt resistance (R_D), junction capacitance (C_D) and shot noise. The shot noise results from the DC current (I_{SC}) produced by the background infrared radiation. The background I_{SC} is proportional to the detector active area (see Fig. 11-5) and thus smaller active areas have less shot noise and lower values of NEP.

Optimum performance is achieved when the InSb detector is coupled into a Judson transimpedance gain preamplifier (page 24). The PA-9 or PA-7 preamp converts detector output current to voltage while maintaining the detector at the optimum zero volt bias. The PA-9 preamplifier is specifically matched to each detector to provide maximum sensitivity, gain and bandwidth. The lower-cost adjustable gain PA-7 preamplifier is suitable for low frequency applications. (DC-10kHz).

Dewar Packages

All J10D Series InSb detectors require 77°K operating temperatures. The detector comes mounted in the standard M204 or M205 metal dewar (page 19) with a sapphire window and a cold stop. Other available metal and glass dewars are described on page 18.

Field of View (FOV)

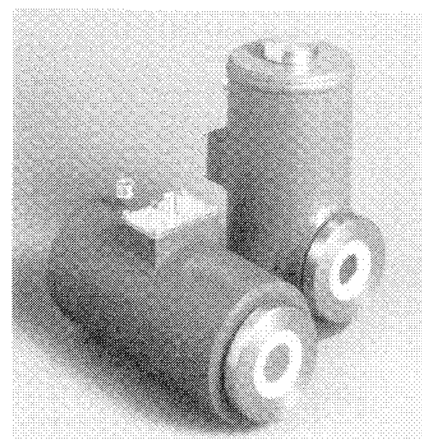
A cold field of view (FOV) stop is provided at no extra charge. Detectivity can be improved by a reduced FOV. The FOV cold stop (page 18) should restrict unwanted background radiation while still accepting all desired radiation from the optical system. A 60° FOV, corresponding to F/1 optics, is provided if the FOV is not specified.

Cold Filter

An optional cold filter can improve detectivity by eliminating background radiation in unwanted wavelength regions. The D* performance with a 1.7 to 3.5 μm cold filter is shown in Figure 11-1. Other bandpass filters are available on a custom basis.

Custom Detectors

InSb detectors in any size up to 7mm diameter and in any configuration can be provided on a custom basis. Specifications for linear arrays, linear position sensors, quad cells, and two-color detectors are given on pages 26, 27 and 28. All InSb detectors can be provided in the JTC Joule-Thomson Cryostat Cooling System (page 20) for operation without bulk liquid nitrogen.



Applications

- Thermal Imaging
- Heat-seeking Guidance
- Radiometers
- Spectrometry

Typical Specifications **J10D** Series **InSb** @ 77°K

Model Number	Active Size (Dia) (mm)	Peak Responsivity (A/W)	D* @ λ_p and 1kHz (cm Hz$^{1/2}$W^{-1})	NEP @ λp and 1kHz (pW/Hz$^{1/2}$)	Short Circuit Current I_{SC} (μA)	Open Circuit Voltage V_{OC} (mV)	Shunt Resistance R_D @ V_R = 0V (Ω)	Capacitance C_D (nf)	Cutoff Frequency @ R_L = 50Ω (Hz)	Dewar Packages Standard	Dewar Packages Optional
J10D-M204-R250U	.25			.2	.4		>10M	.03	4M		
J10D-M204-R500U	.5			.4	2		>1M	.1	3M		
J10D-M204-R01M	1			.8	7		>250k	.4	2M		
J10D-M204-R02M	2	>2	1x10^{11}	1.6	30	90 to 120	>80k	1.6	1M	M204 Metal Sideview (Page 19)	Shown on Pages 18,19 & 20
J10D-M204-R04M	4			3	110		>20k	6	400k		
J10D-M204-R07M	7			6	350		>5k	20	150k		
J10D-M204-1x4M	1x4			2	28		>80k	2	2M		

Figure 11-1

Detectivity vs Wavelength for J10D Series InSb

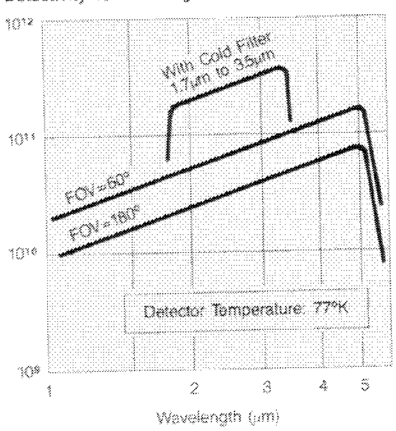


Figure 11-2

Equivalent Circuit for J10D Series InSb

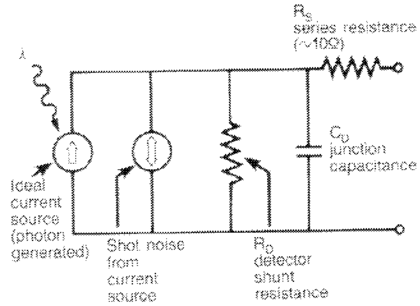


Figure 11-3

Circuit for J10D Series InSb

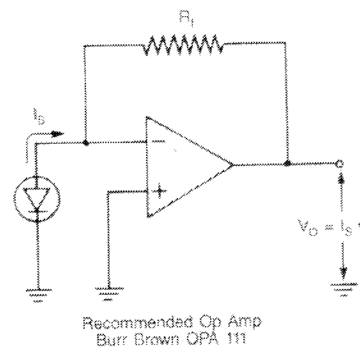


Figure 11-4

Detectivity vs Temperature for J10D Series InSb

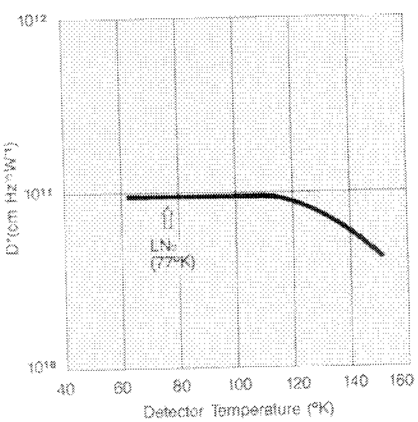


Figure 11-5

Short Circuit Current vs Active Size (60° FOV)

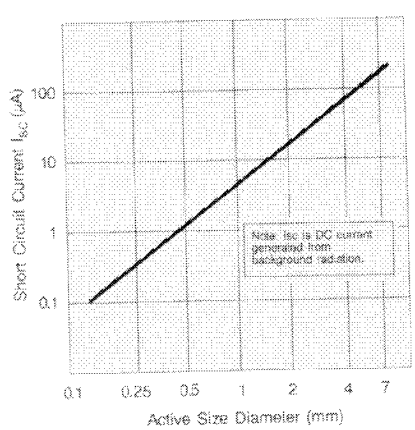
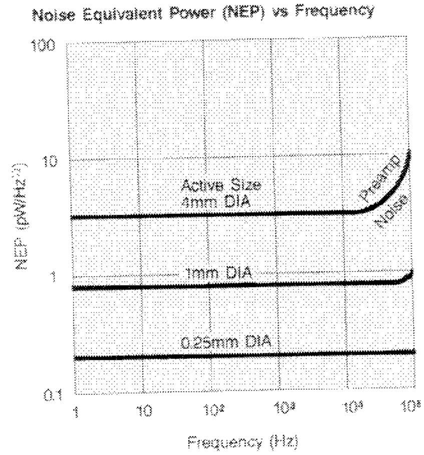


Figure 11-6

Noise Equivalent Power (NEP) vs Frequency



J15 Series Mercury Cadmium Telluride Detectors 2 to 22 μm

General

HgCdTe is a ternary semiconductor compound which exhibits a wavelength cutoff proportional to the alloy composition. The actual detector is composed of a thin layer (10 to 20 μm) of HgCdTe with metalized contact pads defining the active area. Photons with energy greater than the semiconductor band-gap energy excite electrons into the conduction band, thereby increasing the conductivity of the material. The wavelength of peak response depends on the material's band-gap energy and can easily be varied by changing the alloy composition.

In order to sense the change in conductivity, a bias current or voltage is required. Typically, detectors are manufactured in a square or rectangular configuration to maintain a uniform bias current distribution throughout the active region.

Detector Bias and Operating Circuit

A basic circuit for operating J15 Series PC HgCdTe detectors is shown in Figure 12-2. These detectors are low impedance devices, typically 10 to 150Ω, and require a low voltage noise preamplifier. A constant bias current is produced in the detector using a low noise DC voltage supply or battery with a current-limiting resistor R_B. An AC coupling capacitor blocks the DC bias voltage from the high gain preamplifier and prevents DC saturation.

For optimum performance, the model PA-100 preamp (page 23) is recommended for most J15 Series detectors. The PA-100 has built-in bias circuitry and is specially matched to each detector at the factory. The PA-100's low noise, high gain and wide bandwidth ensure proper performance for subsequent signal processing with oscilloscopes, A-D converters, lock-in amplifiers, etc.

D* and Responsivity vs. Bias

The responsivity and detectivity of all J15 Series HgCdTe detectors are a function of bias current. Figure 12-3 shows an example of relative responsivity and detectivity for a 1mm J15D14 Series LN_2 cooled detector. At low bias currents, the responsivity increases nearly linearly with bias. At high bias currents, self-heating of the detector eventually causes the responsivity to fall.

The point of maximum responsivity is generally not the recommended bias for the detector. System performance depends on the overall signal-to-noise ratio or detectivity. At low bias current the preamplifier noise or system noise may dominate. At high bias levels the 1/f surface noise often becomes unacceptably high. Each detector is supplied with a data sheet specifying the optimum bias current with the PA-100 preamp. The optimum bias may vary from application to application depending on background radiation levels.

Figure 12-1
Schematic of HgCdTe PC Detector

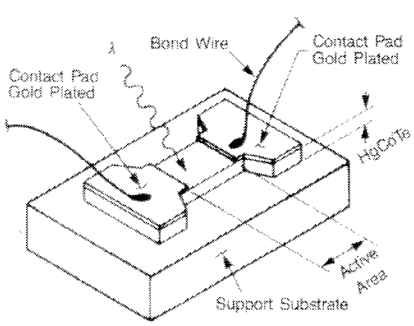
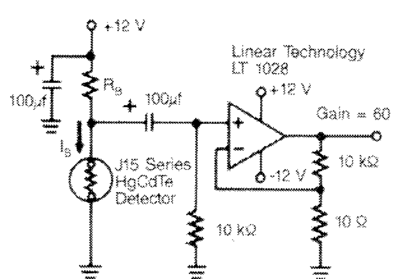
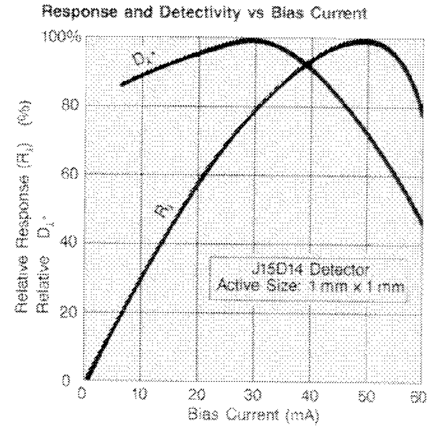


Figure 12-2
Operating Circuit for J15 Series HgCdTe



Note: 1) Adjust R_B for proper bias current (I_B)

Figure 12-3
Response and Detectivity vs Bias Current

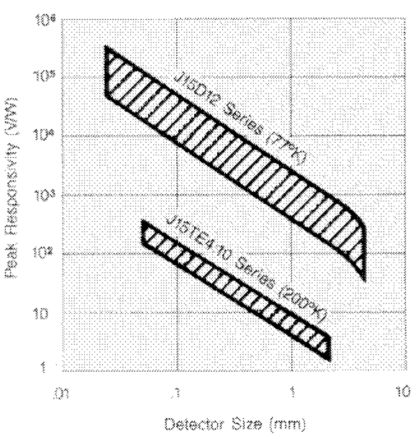


Responsivity vs. Active Size

The voltage responsivity of all J15 Series HgCdTe PC detectors varies significantly with the active size of the element as shown in Fig. 13-1. Responsivity also depends on cutoff wavelength, field of view restriction, operating temperature and bias current. Responsivity for even "identical" detectors may range over a factor of 2 due to variations in material composition. The actual peak and blackbody responsivity data at optimum bias are supplied with each detector.

As with all photon detectors, the optimum system performance is achieved with the smallest size detector capable of collecting the available incident radiation. Focusing optics are highly recommended for reducing radiation spot sizes and thereby improving signal-to-noise performance.

Figure 13-1
Typical Responsivity for J15 Series HgCdTe

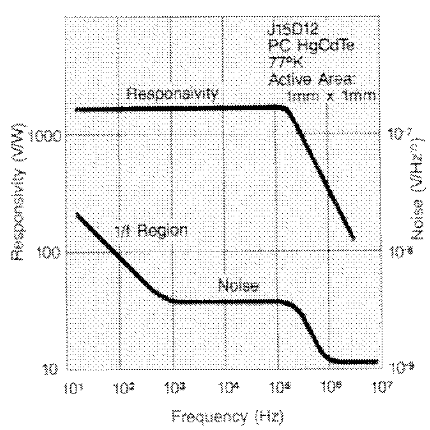


Responsivity and Noise vs. Frequency

The frequency response of HgCdTe detectors is related to the lifetime τ of the electrons in the HgCdTe crystal, and τ depends on material composition and operating temperature. Figure 13-2 is an example of responsivity and noise vs. frequency for a J15D12 Series LN_2 cooled detector. The actual time constant for each detector type can be found in the specification tables. The 3dB cutoff frequency f_c is given by $f_c = (2\pi\tau)^{-1}$.

All HgCdTe PC detectors exhibit excess low frequency noise which increases approximately as $f^{-1/2}$ below a certain "corner" frequency (typically 1kHz). The optimum detectivity is achieved over a wide range from the corner frequency up to the cutoff frequency f_c. The actual responsivity, noise and detectivity data at 10kHz are supplied with each detector.

Figure 13-2
Example of Responsivity and Noise vs Frequency



Linearity and Temperature Effects

Each J15 Series HgCdTe is specifically designed for a particular operating temperature range. Responsivity and detectivity will generally increase with decreasing temperature.

HgCdTe PC detectors have a wide dynamic range (see Fig. 13-4). However, a reduction in responsivity may occur at very high incident power levels.

Figure 13-3
Detectivity vs Temperature for J15TE Series HgCdTe

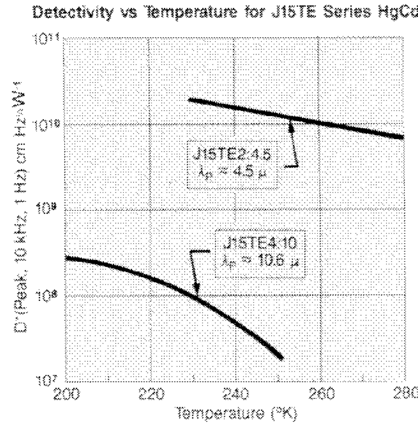
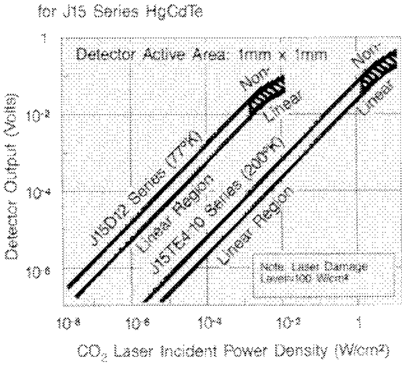


Figure 13-4
Linearity Limitation @ 10.6μm
for J15 Series HgCdTe



J15D Series Mercury Cadmium Telluride Detectors 2 to 22 μm

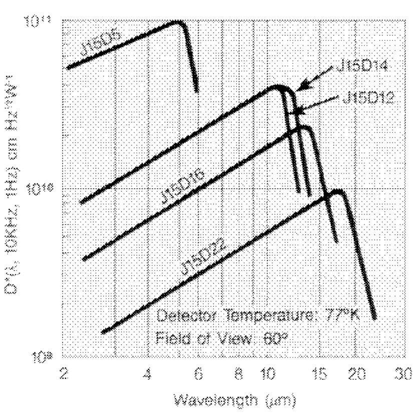
Description

The J15D Series detectors are Mercury Cadmium Telluride (HgCdTe) photoconductive (PC) detectors designed for operation in the 2 to 22 μm wavelength region. The wavelength of peak response depends on the specific alloy composition used. See pages 12 and 13 for general HgCdTe operating information. All J15D Series detectors are designed for cryogenic operation at 77°K. Judson's superior technology and careful device selection can provide background limited (BLIP) detectors with state-of-the-art performance.

Applications

- Thermal Imaging
- CO_2 Laser Detection
- FTIR Spectroscopy
- Missile Guidance
- Night Vision

Figure 14-1
Example of Detectivity vs Wavelength for J15D Series HgCdTe



J15D5 Series

HgCdTe PC Detectors (2-5 μm)

The J15D5 Series HgCdTe detectors peak at 5 μm and are recommended for thermal imaging or infrared tracking applications which require liquid nitrogen cooled PC detectors. Excellent performance in the 3 to 5 μm wavelength region can also be obtained from the J15TE4 and J15TE2 Series thermoelectricaly cooled HgCdTe detectors shown on pages 16 and 17.

J15D12 Series

HgCdTe PC Detectors (2 to 12 μm)

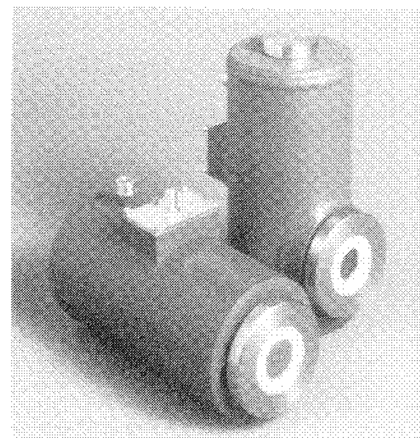
The J15D12 Series HgCdTe detectors peak at 11 μm with a cutoff wavelength greater than 12 μm. The devices offer optimum performance in the 8 to 12 μm wavelength region with high responsivity, near BLIP performance and fast response time. Applications include thermography, CO_2 laser detection and missile guidance.

The detector is mounted in the M204 or the M205 metal dewar. Glass or metal dewars in a wide variety of alternative configurations are available as options (page 18). The standard window material is ZnS (visible to 14 μm) with A-R coated Germanium (2 to 14 μm) available at a nominal extra cost.

Minimum and typical detectivities for all standard sizes with a 60° FOV cold stop are listed in the adjoining specification table. Cold stops for reduced FOV's are provided at no extra cost and may improve detectivity since detector performance is often background limited. Custom cold filters can also be used to improve detectivity by eliminating radiation in unwanted wavelength regions.

All Judson HgCdTe PC detectors are fully passivated and can be provided on a miniature flat pack for mounting by the customer.

The J15D12 Series detectors can be manufactured in a wide variety of special configurations including linear arrays, quad cells and two-color sandwich devices (see pages 26, 27 and 28). The JTC Joule-Thomson Cryostat Cooling System (page 20) or custom closed cycle refrigerator cooling systems allow for operation of all detectors without bulk liquid nitrogen.



J15Dxx Series

HgCdTe PC Detectors for FTIR Spectroscopy

The J15D14, J15D16, J15D22 and J15D24 Series HgCdTe detectors are specifically designed for conventional or Fourier Transform Infrared (FTIR) spectroscopy. The J15D14 Series offers the highest sensitivity for "narrow band" measurements from 750 to 5000 cm^{-1}. The 1mm active size is recommended for conventional sampling and the 0.25mm active size is best for microscope applications. The J15D16 Series offers extended wavelength coverage for "midband" applications (600 to 5000 cm^{-1}) while still maintaining good detectivity. The J15D22 Series or J15D24 Series are the detectors of choice for general "wide band" spectroscopy, (425 to 5000 cm^{-1}), with much higher sensitivity and speed when compared to alternative pyroelectric devices.

Detectors are mounted in the standard M204 or M205 metal dewars. A variety of alternative dewars designed to fit most FTIR manufacturers' instruments are available as options. Standard window materials for FTIR detectors are ZnS for narrow band, ZnSe for midband, and KRS-5 for wide band. All windows have "wedged" surfaces to prevent unwanted interference effects. Detectivity performance data and a spectral response curve are provided with each detector.

Typical Specifications **J15D Series HgCdTe** @ 77°K

Model Number	Active Size (Square) (mm)	Cutoff Wavelength (20%) λ_{co} (μm)	Peak Wave-length λ_p (μm)	Peak D* @ 10kHz, 60° F.O.V. (cm Hz$^{1/2}$ W^{-1}) Min.	Peak D* Typ.	Typical Respon-sivity (V/W)	Typical Time Constant τ (μsec)	Typical Resis-tance R_{DET} (Ω/sq)	Typical Bias Current I_B (mA)	Dewar Packages Standard	Dewar Packages Optional
J15D5 Series HgCdTe (2–5μm)											
J15D5-M204-S050U	.05	~5.5	~5	8×10^{10}	1×10^{11}	2×10^{5}	1	100 to 800	~2	M204 (Page 19)	Pages 18,19 & 20
J15D5-M204-S01M	1			5×10^{10}	8×10^{10}	2×10^{3}	5		~20		
J15D12 Series HgCdTe (2–12μm)											
J15D12-M204-S025U	.025	>12	11 ± 1	3×10^{10}	5×10^{10}	1×10^{5}	.15	20 to 120	~1	M204 Metal Sideview (Page 19)	Shown on Pages 18, 19, & 20
J15D12-M204-S050U	.050			3×10^{10}	5×10^{10}	5×10^{4}	.2		~3		
J15D12-M204-S075U	.075			3×10^{10}	5×10^{10}	3×10^{4}	.3		~4		
J15D12-M204-S100U	.10			3×10^{10}	5×10^{10}	2×10^{4}	.4		~6		
J15D12-M204-S250U	.25			3×10^{10}	5×10^{10}	5×10^{3}	.5		~8		
J15D12-M204-S500U	.5			3×10^{10}	4×10^{10}	3×10^{3}	.5		~16		
J15D12-M204-S01M	1			2.5×10^{10}	3×10^{10}	1×10^{3}	.5		~30		
J15D12-M204-S02M	2			2×10^{10}	2.5×10^{10}	250	.5		~50		
J15D12-M204-S04M	4			1×10^{10}	1.5×10^{10}	100	.5		~50		
J15Dxx Series HgCdTe for FTIR Spectroscopy											
J15D14-M204-S250U	.25	>13.5 (750cm^{-1})	~13	3×10^{10}	5×10^{10}	5×10^{3}	.5	20 to 100	~8	M204 Metal Sideview (Page 19)	Shown on Pages 18, 19, & 20
J15D14-M204-S01M	1			3×10^{10}	4×10^{10}	1×10^{3}	.5		~30		
J15D16-M204-S250U	.25	~16.6 (600 cm^{-1})	~14	2×10^{10}	4×10^{10}	3×10^{3}	.3		~8		
J15D16-M204-S01M	1			2×10^{10}	3×10^{10}	800	.3	18 to 120	~30		
J15D22-M204-S250U	.25	~22 (450 cm^{-1})	~16	5×10^{9}	1×10^{10}	300	.1		~15		
J15D22-M204-S01M	1			5×10^{9}	1×10^{10}	150	.1		~40		
J15D24-M204-S01M	1	~24	~16	3×10^{9}	5×10^{9}	40	.1	20–80	~40		

J15TE Series Mercury Cadmium Telluride Detectors 2 to 5 μm; 10.6 μm

J15TE2 Series

HgCdTe Detectors
(2 to 5 μm)

The J15TE2 Series detectors are high quality Mercury Cadmium Telluride PC detectors mounted with thermistors on two-stage thermoelectric coolers and hermetically sealed with dry nitrogen in TO-style packages (8B6, 66S, or HSA2).

These detectors are designed for industrial and military applications that require good sensitivity in the 2 to 5 μm wavelength region without liquid nitrogen cooling. The J15TE2 Series detectors have distinct advantages when compared to the widely used PbSe detectors, including: high detectivity; selective peak wavelength response; fast response times; and low bias voltage.

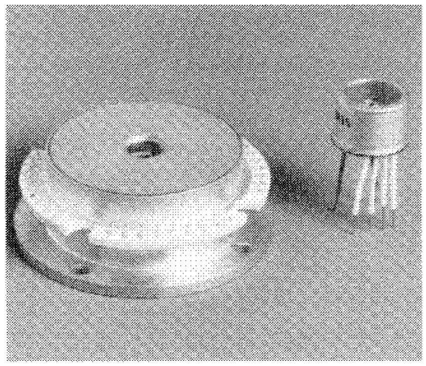
The actual cutoff and peak response wavelengths are a function of material composition for HgCdTe detectors. The standard cutoff wavelengths available for J15TE2 Series devices are 4.0 μm, 4.5 μm and 5.0 μm.

Specific operating information for the two-stage thermoelectric cooler is shown in Figures 7-7, 7-8 and 7-9 on page 7. The Model TC2 Temperature Controller and Power Supply can be used for powering the thermoelectric cooler. The Model PA-100 voltage gain preamplifier with a bandwidth from 5Hz to 1MHz is recommended for these detectors.

J15TE4:5 Series

HgCdTe Detectors
(2 to 5 μm)

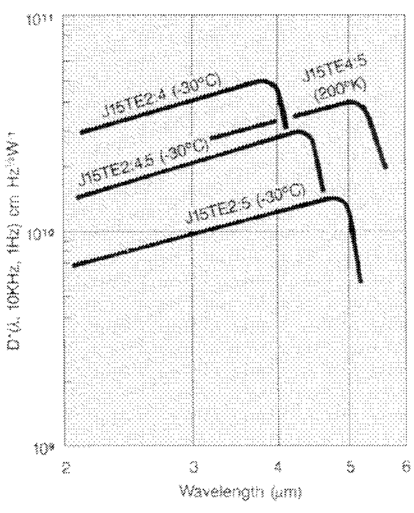
The J15TE4:5 Series detectors are high quality HgCdTe PC detectors mounted in the MC31 Cooling System (page 21) which includes a four-stage thermoelectric cooler, hermetically sealed evacuated package, and built-in thermistor. The devices are designed for sophisticated military and industrial applications requiring the highest possible sensitivity without liquid nitrogen cooling. The Model TC4 Temperature Controller and Power Supply and the Model PA-100 preamplifier are recommended for proper operation.



Applications:

- Thermal Imaging
- Industrial Process Control
- Heat Seeking Guidance
- Laser Warning Receiver
- Laser Heterodyne Detector
- Laser Monitor

Figure 16-1
Detectivity vs Wavelength for J15TE Series HgCdTe



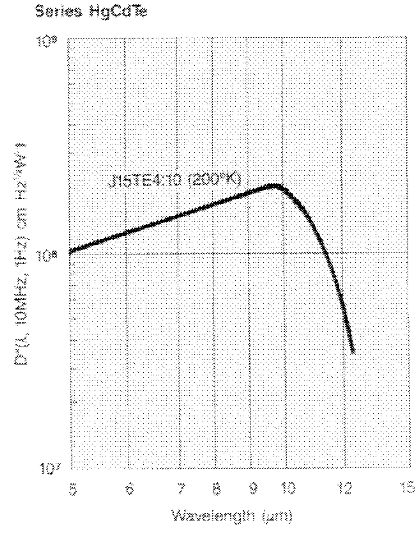
J15TE4:10 Series

HgCdTe Detectors
(10.6 μm)

The J15TE4:10 Series HgCdTe detectors are high quality HgCdTe PC detectors mounted in the MC31 Cooling System (page 21), which includes a four-stage thermoelectric cooler, hermetically sealed evacuated package, and built-in thermistor. Detector operating temperature is 200°K. The devices are designed for pulsed or modulated CO_2 laser applications at 10.6 μm requiring the highest sensitivity without liquid nitrogen cooling. The HgCdTe detectors offer significant advantages over alternative pyroelectric detectors, including: high detectivity from 100Hz to 16MHz; low microphonics; and immunity to EMI.

The Model TC4 Temperature Controller and Power Supply is recommended for powering the thermoelectric cooler. See page 21 for the four-stage thermoelectric cooler performance characteristics. The PA-100 preamplifier is recommended for 5Hz to 1MHz operation. Higher frequency preamplifiers are available as options.

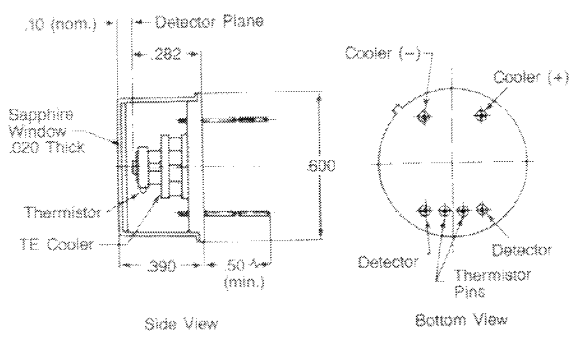
Figure 16-2
Detectivity vs Wavelength for J15TE4:10 Series HgCdTe



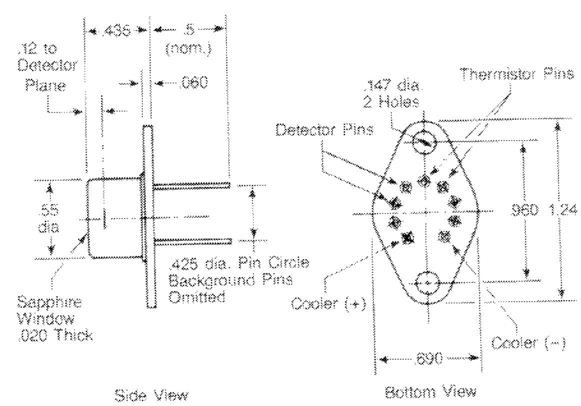
Typical Specifications

Model Number	Active Size (Square) (mm)	Operating Temperature (°C)	Cutoff Wavelength λ_{co} (50%) (μm)	Peak Wavelength λ_p (μm)	Peak D* @ 10kHz ($cm\,Hz^{1/2}W^{-1}$) Min.	Peak D* Typ.	Typical Responsivity λ_p (V/W)	Time Constant τ (μsec)	Typical Bias Current I_B (mA)	Packages Standard	Packages Optional
J15TE2 Series HgCdTe Two-Stage Thermoelectrically Cooled (2–5 μm)											
J15TE2:4-8B6-S250U	.25	-30	>4	>4	$3x10^{10}$	$5x10^{10}$	$16x10^3$	5	.5 to 5	8B6	66S HSA2 (Page 22)
J15TE2:4-8B6-S01M	1				$3x10^{10}$	$5x10^{10}$	$4x10^3$				
J15TE2:4.5-8B6-S250U	.25		>4.5	>4.4	$2x10^{10}$	$3x10^{10}$	$8x10^3$	3			
J15TE2:4.5-8B6-S01M	1				$2x10^{10}$	$3x10^{10}$	$2x10^3$				
J15TE2:5-8B6-S250U	.25		>5.0	>4.8	$1x10^{10}$	$1.5x10^{10}$	$4x10^3$	2			
J15TE2:5-8B6-S01M	1				$1x10^{10}$	$1.5x10^{10}$	$1x10^3$				
J15TE4:5 Series HgCdTe Four-Stage Thermoelectrically Cooled (2–5 μm)											
J15TE4:5-MC31-S250U	.25	-75 (200°K)	>5.5	>5.0	$3x10^{10}$	$4x10^{10}$	$8x10^3$	5	.5 to 5	MC31G (Page 21)	Custom
J15TE4:5-MC31-S01M	1				$3x10^{10}$	$4x10^{10}$	$2x10^3$				
J15TE4:10 Series HgCdTe Four-Stage Thermoelectrically Cooled (10.6 μm)											
J15TE4:10-MC31G-S250U	.25	-75 (200°K)	~11	~10	$1x10^8$	$3x10^8$	20	.01	10 to 40	MC31G (Page 21)	Custom
J15TE4:10-MC31G-S01M	1				$1x10^8$	$3x10^8$	5				
J15TE4:10-MC31G-1x3M	1x3.6				$1x10^8$	$3x10^8$	2				

8B6



66S



Dewar Packages

Description

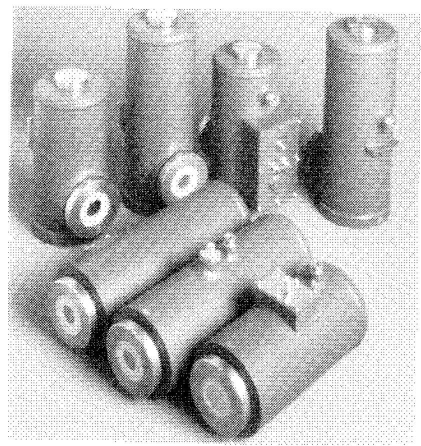
The cryogenic dewars available for Judson detectors requiring 77°K operating temperature are listed below. Repumpable metal dewars are recommended for laboratory or R & D applications. Metal dewars offer many advantages, including: rugged construction; low cost; long hold time; optional mounting flanges; wide variety of window materials; and shorter delivery time. Metal dewars may require re-evacuation every one to two years.

Long life, permanently sealed glass dewars have the advantage of small size and superior performance under mechanical vibration. Generally, glass dewars require longer delivery times.

Dewars with customer specified mechanical configurations or longer LN_2 hold times are available on a custom basis.

Cold Filters

A cold filter is a cryogenically cooled filter mounted inside the dewar which is used to reduce background radiation from unwanted wavelengths. The filter improves theoretical D* for background limited (BLIP) detectors. Shortpass and bandpass filters are available by custom order.



Cold Stops

The cold stop is a field of view (FOV) limiting aperture cryogenically cooled to prevent unwanted background radiation from reaching the detector. The FOV is specified as two times the half angle $\phi/2$ measured from the edge of the detector. Radiation at larger angles will be blocked by the cold stop aperture. The theoretical D* improvement for BLIP detectors is more accurately determined from the half angle $\theta/2$ measured from the center of the detector.

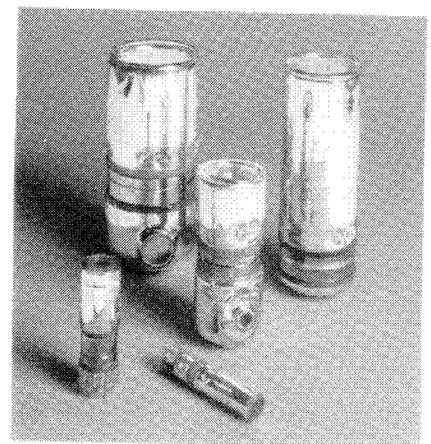
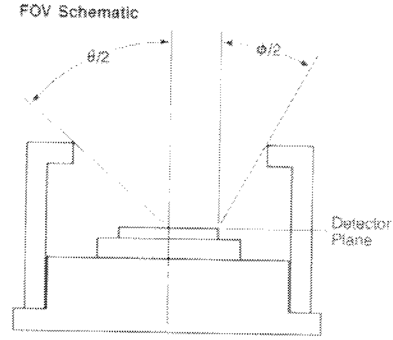


Figure 18-1
FOV Schematic



Dewar Packages For **J10D, J12D, J15D** and **J16D** Series

Dewar Model	Type	Size	LN_2 Hold Time	Available Windows
M204	Metal Sideview	2.5" Φx 5.25" H	> 8 Hours	Sapphire (Vis. - 7μm) ZnS (Vis. - 14μm) ZnSe, (Vis. - 20 μm) KRS-5, (Vis. - 30μm) Ge (2 - 14μm)
M205	Metal Downview	2.5" Φx 5.25" H	> 8 Hours	
M200	Metal Sideview	2.5" Φx 6.75" H	> 12 Hours	
M201	Metal Downview	2.5" Φx 6.75" H	> 12 Hours	
DB	Glass Sideview	2.0" Φx 5.0" H	> 5 Hours	Sapphire, Ge
DC	Glass Downview	1.65" Φx 5.0" H	> 4 Hours	Sapphire
DG	Glass (J. T. Cryostat)	.75" Φx 2.5" H	.204" Bore	Sapphire, Ge
DE	Glass (J. T. Cryostat)	.5" Φx 2.5" H	.204" Bore	Sapphire

M204 or M205

Standard Metal Dewars

The M204 sideview and M205 downview are the recommended standard metal dewars for all Judson cryogenically cooled detectors, including J16D Ge, J12D InAs, J10D InSb, and J15D HgCdTe. An SMA to BNC coax-cable and LN_2 fill funnel are provided with each dewar.

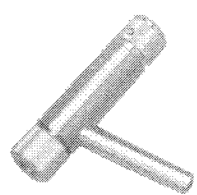
Features:

- Rugged Construction
- 8 hour Hold Time
- Precision Window Holder
- Accurate Centering of Detector
- Sideview or Downview
- Repumpable
- 12″ SMA to BNC cable
- Fill Funnel

VOM-1

Valve Operator for Metal Dewars

Metal dewars require re-evacuation every one to two years to maintain specified LN_2 hold time. The VOM-1 is necessary for connecting metal dewars to vacuum systems. A repumping service for metal dewars is offered by Judson.



VOM-1

Figure 19-1
Style M204 Metal Sideview Dewar

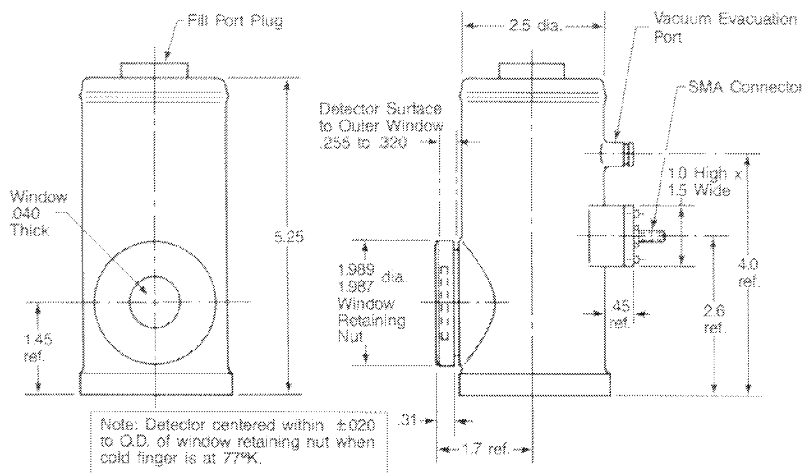
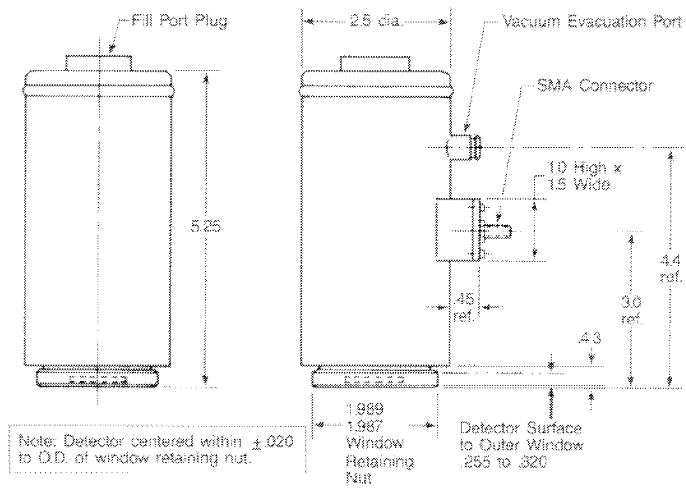


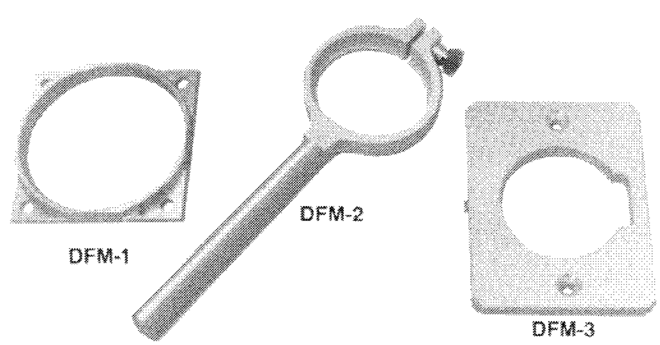
Figure 19-2
Style M205 Metal Downview Dewar



DFM Series

Dewar Flange Mounts

Dewar flange mounts are available for permanent mounting of standard metal dewars. The DFM-1 (bottom mount for sideview dewars), the DFM-2 (ring mount, attached to the window holder) and the DFM-3 (front mount attached to the window holder) are shown in the adjacent photograph. Drawings are available upon request.



DFM-1 DFM-2 DFM-3

JTC Joule-Thomson Cryostat System

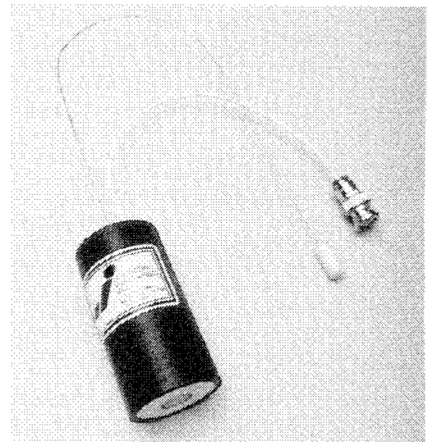
Description

The Joule-Thomson Cryostat System (JTC) provides a convenient method for cooling detectors to 77°K without using bulk liquid nitrogen. The cryostat converts pressurized nitrogen gas to cryogenic liquid nitrogen with no electrical power requirement. A conventional 14,000 NTP liter, 6000 psi nitrogen cylinder can maintain the JTC for up to 200 hours of continuous operation.

The J42902 demand flow cryostat offers low gas consumption and temperature fluctuations of less than ± 1°K. The optional J9159 non-demand flow cryostats have temperature fluctuations of ± 0.1°K, but with much higher gas consumption.

Features:

- No Bulk LN_2 Required
- Reliable
- Fast Cooldown Time
- Continuous Operation



Each JTC includes:

- (A) Infrared Detector in DG Glass Dewar
- (B) Outer Protective Metal Jacket
- (C) Silicon Diode Temperature Sensor
- (D) Demand Flow JT Cryostat (J42902-2)
- (E) Coaxial Cable for Detector Output
- (F) Tubing and Fitting Assembly (J9169, J8994)
- (G) Molecular Sieve Gas Filter (J5684)

Figure 20-1 JTC

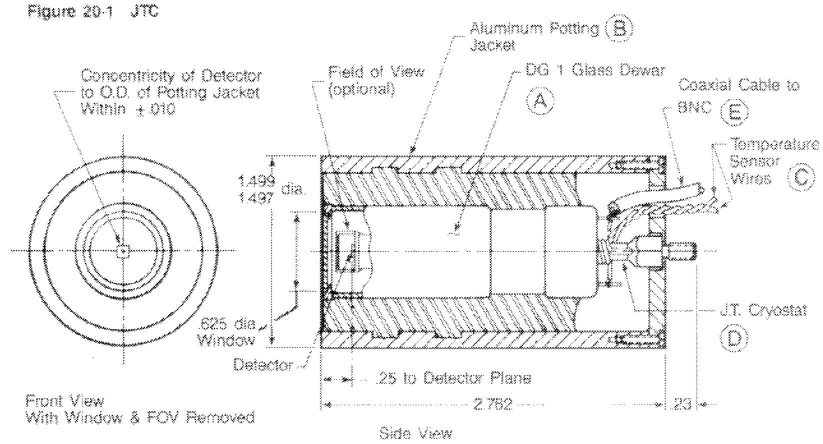


Figure 20-2
Example of J.T. Cryostat Performance

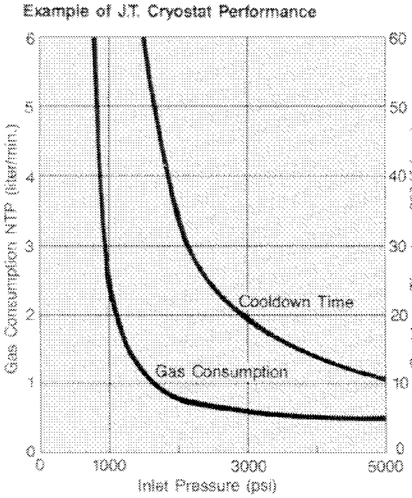
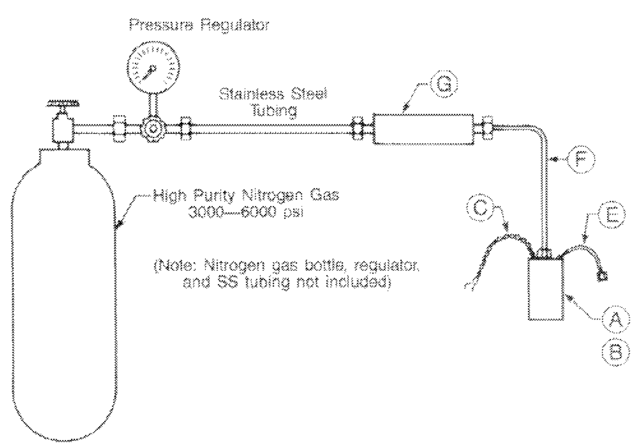


Figure 20-3
Example of Demand Flow JT Cryostat Operation



PA-100 PA-400 Voltage Preamplifiers

PA-100

HgCdTe Preamplifier

The Model PA-100 is a low noise voltage preamplifier designed for all J15 Series HgCdTe detectors. An externally accessible bias resistor is used to set the constant bias current required for PC HgCdTe detectors. When purchased with a detector, the external bias resistor will be factory-selected for optimum detectivity. If ordering the preamplifier separately, please specify the detector resistance and required bias current I_B.

A battery or well filtered power supply is recommended since the preamplifier power input also provides the detector bias.

The Model PA-100 can also be used with J12 Series Indium Arsenide (InAs) photodiodes (without the bias current) for frequency response to 1MHz.

PA-400

High Speed Voltage Preamplifier

The Model PA-400 is a high frequency voltage preamplifier with bandwidth from 1kHz to 50MHz for J16 Series Germanium (Ge) or J12 Series Indium Arsenide (InAs) detectors. The unit has a 50 ohm input impedance. Reverse bias voltage can be applied via an external pin to reduce detector capacitance. When ordering, specify type of detector for matching. The detector performance will be preamplifier limited with the Model PA-400, and detectivity may be significantly reduced for high impedance detectors.

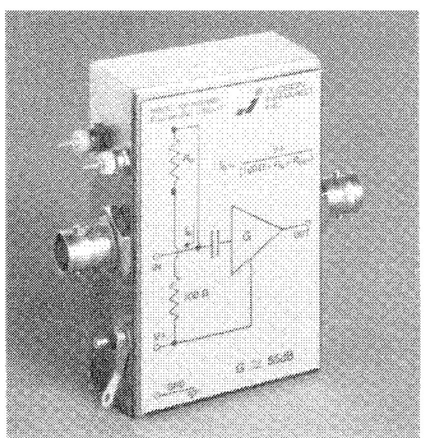


Figure 23-1
Equivalent Circuit for PA-100

Bias Current

$$I_B = \frac{V+}{(R_B + 100\,\Omega + R_{DET})}$$

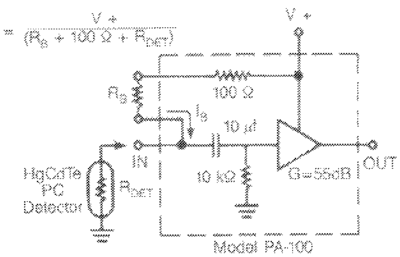
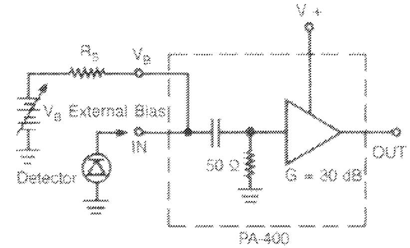


Figure 23-2
Equivalent Circuit for PA-400



Typical Specifications PA-100 and PA-400

Model	PA-100	PA-400
Gain	55dB (500X)	30dB(~30x)
Bandwidth	5Hz to 1MHz	1kHz to 50MHz
Input Noise Voltage	0.8 nV/Hz$^{1/2}$	0.8nV/Hz$^{1/2}$
Input Impedance	10kΩ	50Ω
Output Impedance	500Ω	50Ω
Maximum Output	1V	1V
Detector Bias	Built in	External
Power Requirement	+12V @ 40mA	+12V @ 40mA

PA-x Current Mode Preamplifiers

General

Current Mode preamplifiers convert the current output of any Judson Ge, InAs, or InSb detector into a voltage output for subsequent use with Oscilliscopes, Lock-in amplifiers, or A-D converters.

Five different models are available, each offering specific advantages depending on detector type and bandwidth requirements. All units have switch selectable gain except for the PA-9.

PA-9

The PA-9 is ideal for cryogenically cooled PV detectors including J10D Series InSb, J12D Series InAs, and J16D Series Ge. The PA-9 has low current noise and ultra low voltage noise with superior high frequency performance. When ordered with the detector, the preamp will be matched for maximum gain and sensitivity. Alternatively, the customer may specify gain and/or the minimum bandwidth required.

PA-8

The PA-8 is a "chopper-stabilized" preamp designed for DC applications with J16 Series room temperature Ge detectors. It offers both low offset voltage and low offset current to minimize the DC dark currents and drift of the detector. The PA-8 has adjustable gain from 10^4 V/A to 10^8 V/A and is ideally suited for fiber optic average power or attenuation measurements.

PA-7

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

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 the low frequency noise and DC drift.

PA-5

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

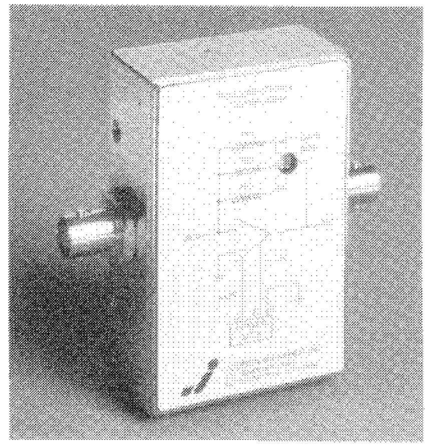
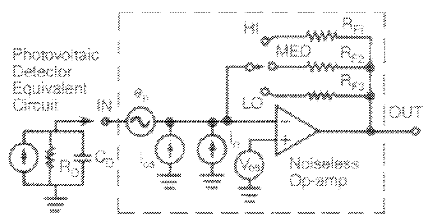


Figure 24-1
Equivalent Circuit for Transimpedance Preamplifiers



e_n: Voltage Noise Density
i_n: Current Noise Density
V_{os}: Input Offset Voltage
i_{os}: Input Offset Current
R_D: Detector Resistance
C_D: Detector Junction Capacitance

Typical Operating Characteristics @ T = 25°C

Model		PA-9	PA-8	PA-7	PA-6	PA-5	Units
Transimpedance Gain:	Hi	10^7	10^8	10^7	10^6	10^5	
Switch Selected	Med	10^6	10^6	10^6	10^5	10^4	V/A
(Except PA-9: One Gain Only)	Low	10^5	10^4	10^5	10^4	10^3	
Bandwidth:	@ Hi Gain	100	1	6	30	200	
Source Capacitance	@ Med Gain	300	10	20	100	200	kHz
1000 pf or Less	@ Low Gain	750	10	60	200	200	
Input Offset Voltage (V_{os})		±2000	±2	±100	±20	±20	μV
Input Offset Current (i_{os})		±.001	±.001	±.001	±12	±30	nA
Voltage Noise Density (e_n)@1kHz		1.5	15	8	3	1	$nV/Hz^{1/2}$
Voltage Noise from 0.1 to 10 Hz		1.0	2	1.5	.080	.035	$μV_{pp}$
Current Noise Density (i_n)@1kHz		.04	.04	.04	.5	1	$pA/Hz^{1/2}$
Power Requirements		+12V and −12V @ 10mA					

Figure 25-1

Preamplifier Noise Figure @ 1 k Hz

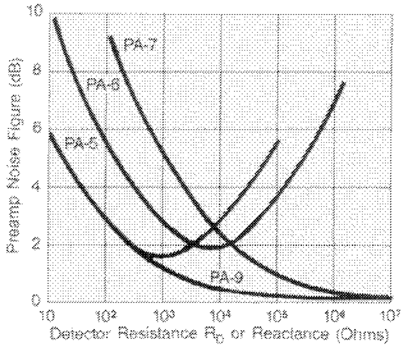


Figure 25-2

System Bandwidth vs Detector Capacitance

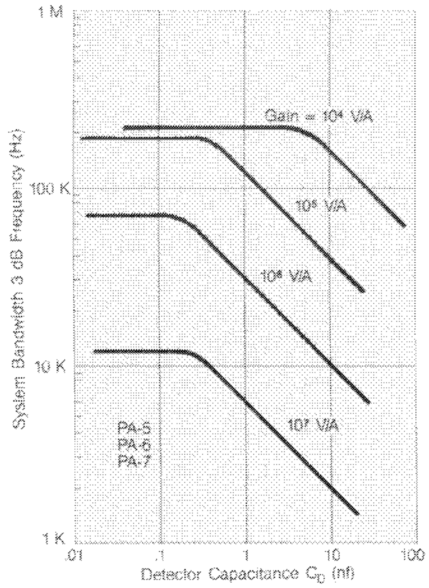


Figure 25-3

System Bandwidth vs Detector Resistance

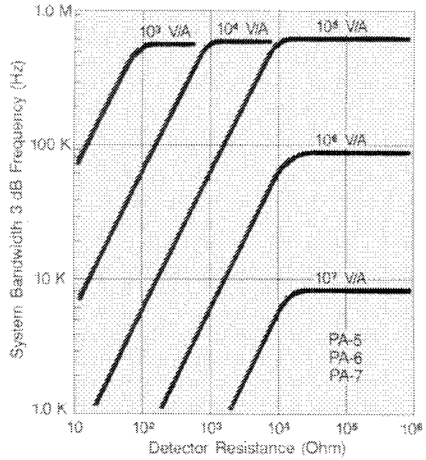


Figure 25-4

DC Offset Output Voltage vs Source Resistance

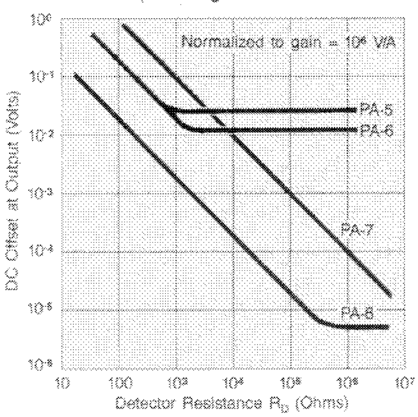


Figure 25-5

PA-9 Bandwidth vs Detector Resistance

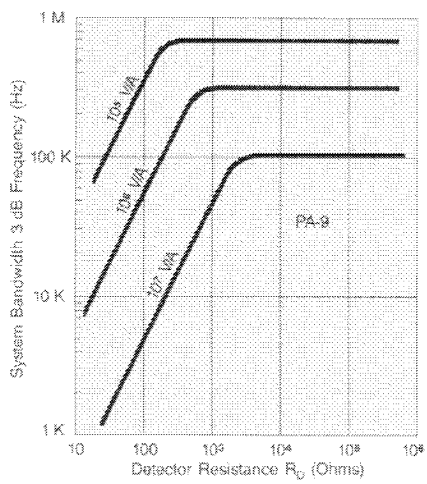
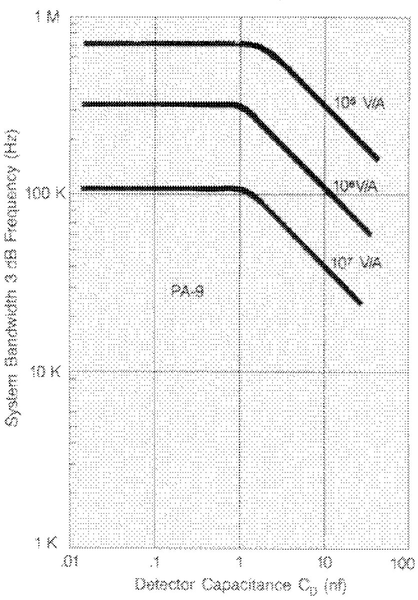


Figure 25-6

PA-9 Bandwidth vs Detector Capacitance



Two-Color Detectors

J16Si Series

Ge/Si Two-Color Detectors

The J16Si Series device consists of a high performance silicon (Si) detector mounted in a "sandwich" configuration over a germanium (Ge) detector. The Si photodiode responds to radiation from 400 to 1000nm while the Ge photodiode responds to radiation from 1100 to 1800nm. The J16Si Series detectors are ideal for fiber optic power measurements requiring maximum sensitivity at both 800 and 1300nm. These devices are also used for two-color temperature measurements from 500 to 2000°C. Separate transimpedance gain preamplifiers are recommended for each detector.

Applications:

- Power Meters
- Wavelength Demultiplexers
- Pyrometers

Figure 26-1
Typical Responsivity for J16Si Series

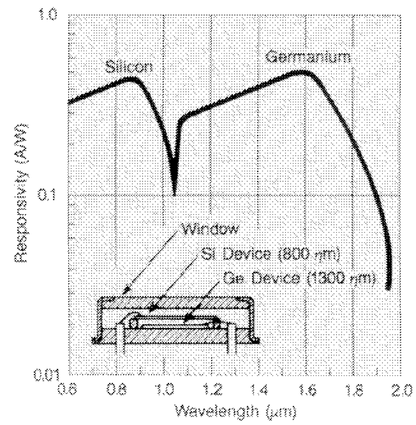
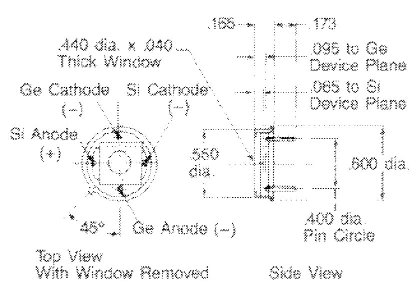


Figure 26-2 J16 Si

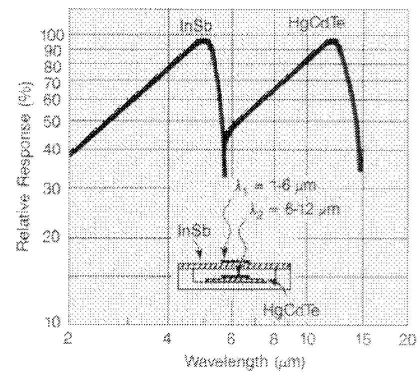


J15InSb Series

HgCdTe/InSb Two-Color Detectors

The J15InSb Series device consists of a high quality InSb detector mounted in a "sandwich" configuration over a HgCdTe detector. The detector focal planes are spaced within 0.5mm and their centers are aligned to within 0.15mm. The InSb detector responds to incident radiation from 1 to 5 μm while the HgCdTe detector responds to radiation from 6 to 13 μm. The detectors operate at 77°K and are mounted in the standard style M204 or M205 metal dewar. Individual preamplifiers are required for each detector.

Figure 26-3
Relative Response vs Wavelength for J15InSb Series



Typical Specifications **J16Si** Series @ **22°C**

Model		Active Size (Dia.) (mm)	Wavelength Range (nm)	Peak Responsivity (A/W)	NEP @ λ_p (W/Hz$^{1/2}$)	Shunt Resistance @ 0V (Ω)
J16Si-8A4-R02M	Ge	2	1000–1800	.6	1×10^{-12}	18k
	Si	5	400–1000	.45	1×10^{-14}	40M
J16Si-8A4-R05M	Ge	5	1000–1800	.6	2×10^{-12}	3k
	Si	5	400–1000	.45	1×10^{-14}	40M

Typical Specifications **J15InSb** Series @ **77°K**

Model		Active Size (Square) (mm)	Wavelength Range (μm)	Peak Responsivity	Peak D* (cm Hz$^{1/2}$W^{-1})	Dewar Packages Standard	Dewar Packages Optional
J15InSb-M204-S01M	HgCdTe	1	6–13	1000 V/W	2×10^{10}	M204 Metal Sideview (Page 19)	Shown on Pages 18, 19 & 20
	InSb	1	1–5.5	2 A/W	1×10^{11}		
J15InSb-M204-S02M	HgCdTe	2	6–13	200 V/W	1×10^{10}		
	InSb	2	1–5.5	2 A/W	1×10^{11}		

Position Sensitive Detectors

J16PS J12PS J10PS

Position Sensors

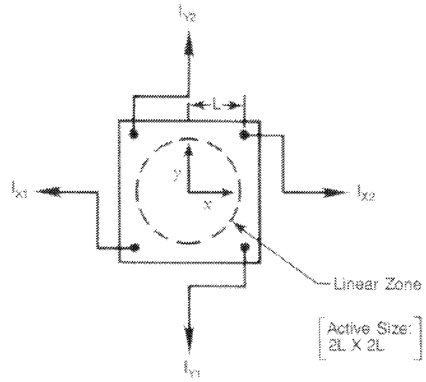
A Ge, InAs, or InSb position sensor consists of a single element photodiode with a quadrupole electrode geometry. These devices can provide linear X-Y beam position information for lasers and other infrared beams. Positioning information is determined as shown in Fig. 27-1. Request Product Bulletin #203 for additional information.

J16QUAD J10QUAD J15QUAD

Quadrant Detectors

A Ge, InSb or HgCdTe quadrant detector consists of four separate detector elements arranged in a quadrant geometry with element separations of approximately 0.05mm.

Figure 27-1
Position Sensor Detector Configuration

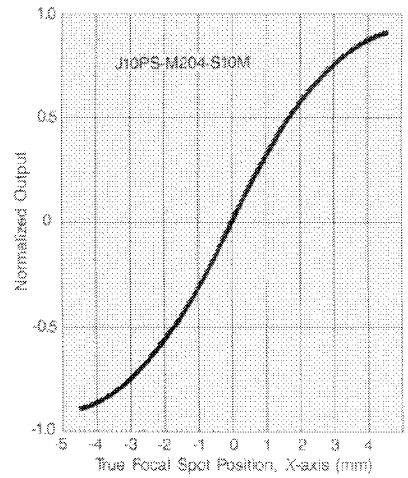


Conversion Formula:

$$x \approx L \left[\frac{(I_{X2} + I_{Y1}) - (I_{X1} + I_{Y2})}{I_{X1} + I_{X2} + I_{Y1} + I_{Y2}} \right]$$

$$y \approx L \left[\frac{(I_{X2} + I_{Y2}) - (I_{X1} + I_{Y1})}{I_{X1} + I_{X2} + I_{Y1} + I_{Y2}} \right]$$

Figure 27-2
Example of Position Linearity



Typical Specifications Linear Position Sensors

Model	Detector Type	Wavelength Range (µm)	Active Size "2L" (mm)	Linear Position Zone (Dia.) (mm)	Typical Position Resolution (µm)	Typical Interelectrode Resistance (Ω)	Peak Responsivity (A/W)	Detector Temperature	Package Type
J16PS-8F6-S05M	Ge	.8–1.8	5x5	3	25	~100	0.6	22°C	TO-8
J16PS-M204-R10M	Ge	.8–1.8	10x10	6	25	~100	0.5	—	Dewar
J12PS-8B12-S05M	InAs	1–3.5	5x5	3	50	~100	0.5	-30°C	T.E.
J10PS-M204-S05M	InSb	1–5.5	5x5	3	25	~100	2.0	77°K	Dewar
J10PS-M204-S10M	InSb	1–5.5	10x10	6	25	~100	2.0	77°K	Dewar

Typical Specifications Quadrant Detectors

Model	Detector Type	Total Active Size "S" (mm)	Operating Temperature	Wavelength Range (µm)	Packages: Standard	Packages: Optional
J16QUAD-8D6-R02M	Ge	2 (Dia.)	Room Temperature	.8–1.8	6 Pin TO-8	
J16QUAD-8D6-R05M	Ge	5 (Dia.)	Room Temperature	.8–1.8		
J10QUAD-M204-R02M	InSb	2 (Dia.)	77°K	1–5.5	M204 Metal Sideview Dewar (Page 19)	Dewars Shown on Pages 18,19 & 20
J10QUAD-M204-R05M	InSb	5 (Dia.)	77°K	1–5.5		
J15QUAD-M204-S02M	HgCdTe	2x2	77°K	2–13		
J15QUAD-M204-S04M	HgCdTe	4x4	77°K	2–13		

Arrays

General

Any of EG&G Judson's detector types can be provided in multi-element array configurations. Pictured are examples of arrays that have been fabricated to custom order. Our sales and engineering staff is available to assist customers in the design and specification of arrays for any application.

Configurations

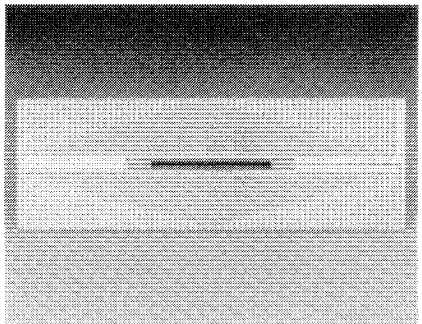
Judson can provide a wide range of detector array configurations. Both discreet and monolithic linear arrays can be readily fabricated in Ge, InAs, InSb, and HgCdTe materials. The accompanying table shows recommended guidelines for each detector type in relation to maximum number of elements, minimum element size, and minimum spacing between elements. Elements can be any size or shape for Ge, InAs, or InSb detector arrays. Elements should be square or rectangular for HgCdTe. The arrays may be linear, staggered linear, cross shaped, quadrant, etc. Simple mosaic patterns are possible, (i.e. 3 x 3), but larger mosaics are not recommended due to lead out problems.

Presently, all arrays from Judson are parallel output format with a single output lead for each element of the array. Parallel format generally requires a separate preamplifier for each channel of the array. Self-scanning Ge arrays using EG&G Reticon multiplexers are now under development.

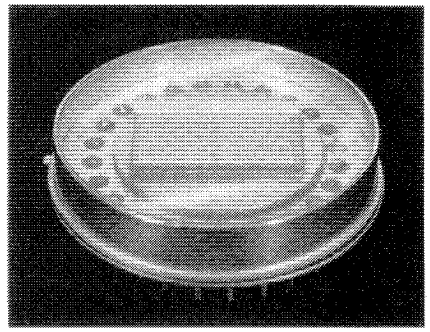
Specifications and Packages

Specifications for the individual elements of the array will be similar to those listed in the brochure for the respective single element detector type. Detector arrays which require cooling must have appropriate packaging. Custom packages or cooling systems can be engineered for specific applications. Standard multipin packages include:

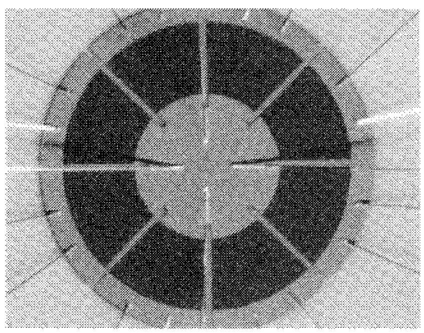
- Metal dewars (up to 32 pins)
- Two-stage TE cooled (up to 16 pins)
- Four-stage TE cooled (up to 32 pins)
- Cryostat glass dewars (up to 12 pins)



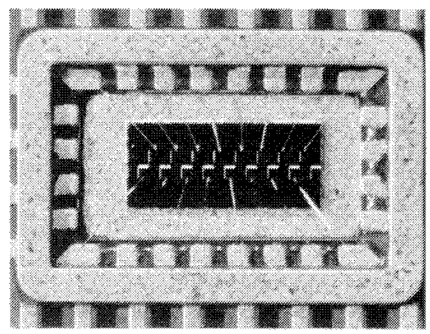
128 Element Germanium Array



Room Temperature InAs Array



Eight Element HgCdTe Circular Array



InSb Staggered Linear Array

Custom Array Configurations

Material Type	Maximum # Elements	Smallest Element Size (Microns)	Minimum Element Spacing (Microns)
Ge	128	50	50
InAs	36	100	50
InSb	32	100	50
HgCdTe	32	25	25