PB 220

October 2000

Operating Circuit

The recommended operating circuit for most applications is an operational amplifier in a negative-feedback transimpedance configuration. 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. (Figure 1.0).

Because R_D varies significantly with temperature, selection of the proper op-amp will depend on the detector operating temperature as well as the desired bandwidth. The feedback resistor R_F should be at least 10x greater than R_D for best signal-to-noise ratio. Teledyne Judson has preamplifiers for optimum performance with each detector type.

For high frequency applications, the detector may be reverse biased and terminated into a low impedance load. Maximum reverse bias is 1 volt. (See Figure 3.0).

Frequency Response

The feedback resistance R_F, combined with the detector capacitance and dynamic impedance, determines the frequency response of the system. Capacitance and impedance values are provided on the data sheet supplied with each detector.

Recommended Preamplifiers

The PA5, PA6 and PA7 have adjustable gain and low noise. Preamplifiers should be picked by the detector shunt impedance at the optimal operating temperature for a particular application (Table 1). The PA9 should be used where high frequency response and low noise are required. The PA9 may not be suitable for DC applications due to its high input offset voltage.

Preamp Selection vs Shunt Selection Impedance

Detector Shunt Impedance (ohms)	Recommended Op Amp	Teledyne Judson Preamp
1 to 500	LT 1028, Discrete FET	PA-5, PA-9
500 to 2000	OP27, Discrete FET	PA-6, PA-9
2000	OPA111, LF356, Discrete FET	PA-7, PA-9

Table I

Typical J12 Series Operating Circuit

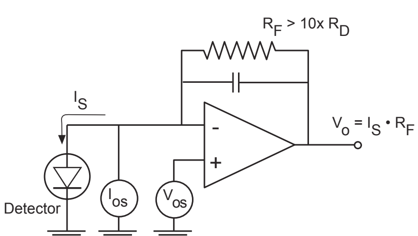


Figure 1.0

Detectivity vs Wavelength for J12 Series

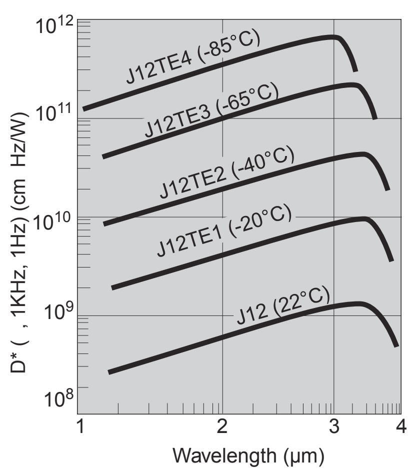


Figure 2.0

High Speed Operating Circuit

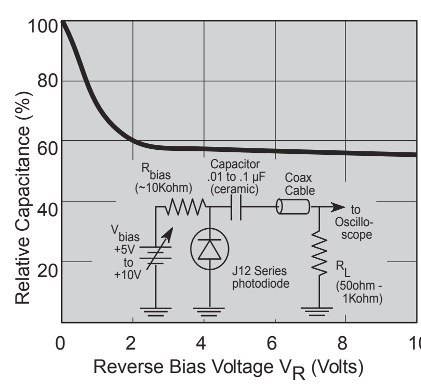


Figure 3.0

221 COMMERCE DRIVE
MONTGOMERYVILLE, PA 18936-9641
PHONE: 215-368-6901
FAX: 215-362-6107
www.teledynejudson.com

Test Conditions
All Teledyne Judson detectors undergo stringent quality control testing before shipment. A test setup (Figure 4.0) is used to check J12 Series detectors for responsivity (R) and detectivity (D*).

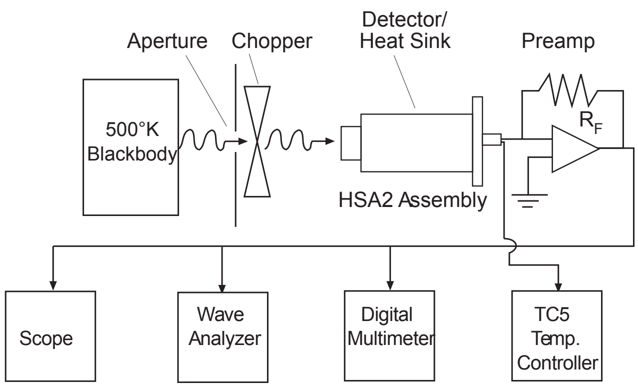


Figure 4.0

A copy of the test data is provided with each detector and includes the following test condition information:

Flux Density (H)
Actual rms total power in watts/cm^2 irradiating the detector surface. Equal to F $T^4_{BB}/A_s/$ d^2 where F is the rms constant of the chopper (0.36), is the Stefan-Boltzman constant, T_{BB} is the blackbody temperature, A_s is the aperture area and d is the source-to-detector distance.

Chopping Frequency
Frequency of chopper for modulating the blackbody source signal.

Blackbody Temperature
Absolute temperature in °K of the blackbody source used for response test.

Background Temperature
Room temperature in °K.

Detector Temperature
Operating temperature of the detector during the test.

Detector Shunt Impedance
Effective dynamic impedance of the detector at operating temperature, measured at 0 volts bias (Figure 5.0).

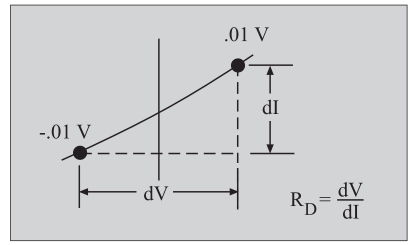


Figure 5.0

Blackbody Responsivity (R_{BB})
Defined as the current produced by a detector in response to the radiant power on the detector (amps/watt) (Figure 6.0). For the test setup, R_{BB} is equal to $V_{out}/(H_{BB}A_D\text{Gain})$ where H_{BB} is the blackbody irradiance in watts/cm^2, A_D is the area of the detector in cm^2, V_{out} is the rms signal voltage at the output of the preamplifier in volts, and Gain is the gain of the preamplifier in volts/amp.

Detector Response to Incoming Photons

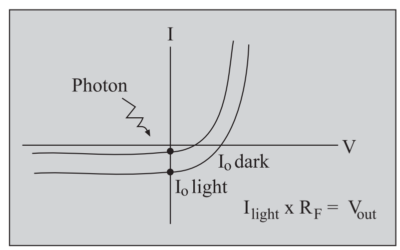


Figure 6.0

Peak Responsivity (R)
Responsivity in amps/watt at the wavelength of peak response. Related to blackbody responsivity by R = R_{BB}G, where the constant G is the ratio of total blackbody power to the power "utilized" by the detector. For InSb detectors without filters, G   5.5 and is determined as follows:

$$G^{-1} = \frac{1}{W_{BB}} \int N(\ ,T_{BB}) \frac{R(\ )}{R(\ _p)} d$$

where N(,T_{BB}) is the irradiance at   in w/cm^2/µ and W_{BB} is the total blackbody irradiance in w/cm^2.

J12TE Detector Response vs Wavelength & Temperature

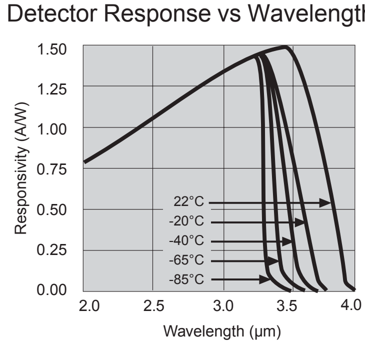
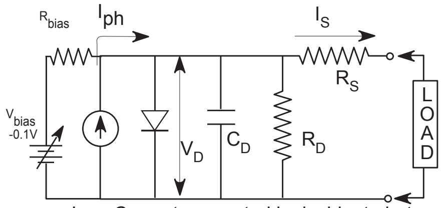


Figure 7.0

Calculating Detector Response Uniformity

Detector 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

Output signal current from detector I_s is defined as:

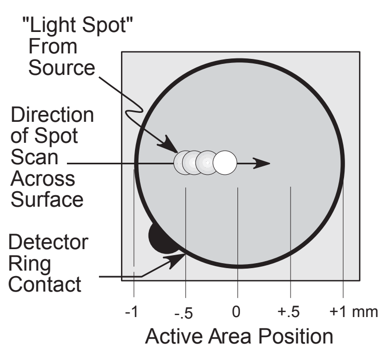
$$I_{signal} = I_{photon}\left(\frac{\text{Detector shunt ( ) - Detector series ( )}}{\text{Detector shunt ( )}}\right)$$

For J12-5AP-R02M

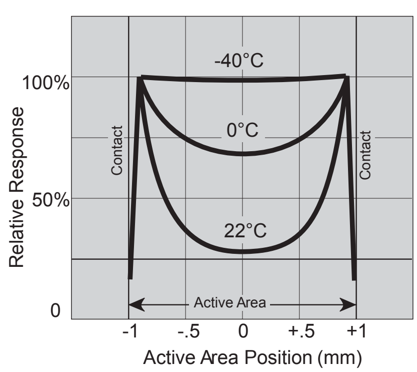
$$I_{signal} = 1.25A/W\left(\frac{10-6}{10}\right) = .5A/W$$

For J12TE2-8B6-R02M

$$I_{signal} = 1.25A/W\left(\frac{200-6}{200}\right) = 1.21A/W$$



Series resistance is approx. 0   at contact. Total series resistance is approx. 5 - 10 , approx. 6 nominal. Therefore, response uniformity is a fucntion of the voltage divider in the equivalent circuit R_D and R_S.



For a J12-5AP-R02M:

$$\frac{R_D - R_S}{R_D} = \frac{10-6}{10} = \frac{4}{10} = \text{40\% response at center}$$

For a J12-5SP-R02M:

$$\frac{R_D - R_S}{R_D} = \frac{100-6}{100} = \frac{94}{100} = \text{94\% response at center}$$

• High ratio of Detector Shunt Impedance to series resistance = high uniformity.

J12 Series Detector Noise

• Noise due to shunt impedance or noise current Johnson (thermal) noise

$$i_{nt} = \sqrt{\frac{4KT\ f}{R_{sh}}}$$

where R_{sh} = detector shunt resistance or feedback resistance whichever is lower.

K = Boltzmans Constant (1.38 x 10^{-23} joules/°K)
T = Operating Temperature (°K)
 f = Noise Equivalent Bandwidth (Hertz)
R_{sh} = Shunt Resistance (ohms)

• Noise due to Capacitance at a frequency
For a photovoltaic detector junction capacitance can dominate noise at high frequency.

i_n = (Preamp voltage noise floor) (2 fC_D)

Temperature Effects

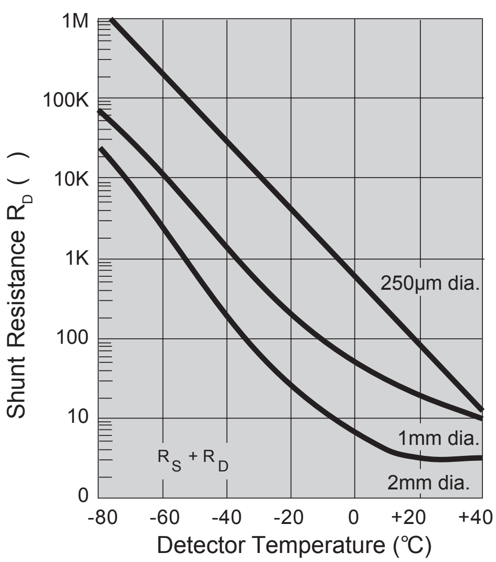
Cooling an InAs photodiode reduces noise and improves detectivity.

Cooling also increases shunt resistance R_D allowing more of the photocurrent I_{ph} to reach the contact ring. The result is an increase in the diode response.

For high-power applications such as pulsed laser detection, cooling is generally not necessary. For sensitive, low-power applications such as temperature measurements, the InAs detector should be cooled or at least temperature-stabilized.

Stabilizing the temperature near 22°C room temperature will not improve performance, but will prevent changes in detector response due to ambient temperature drift.

Shunt Resistance vs Temperature



Thermoelectric Cooler Operation

Figure 8.0 shows typical power requirements for the TE1, TE2 and TE3 coolers. The built-in thermistor can be used to monitor or control the temperature. Figure 10.0 shows typical thermistor resistance vs. temperature values. Sensitivity, cutoff wavelength and response uniformity are all functions of temperature. Detector temperature should be optimized for a particular application.

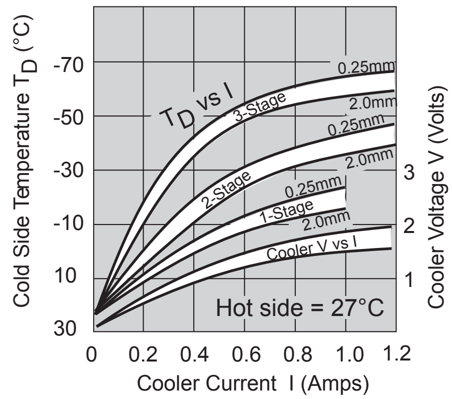


Figure 8.0

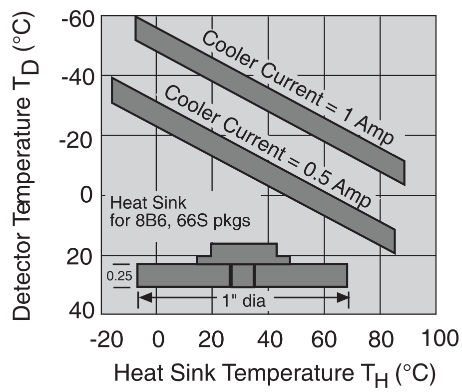
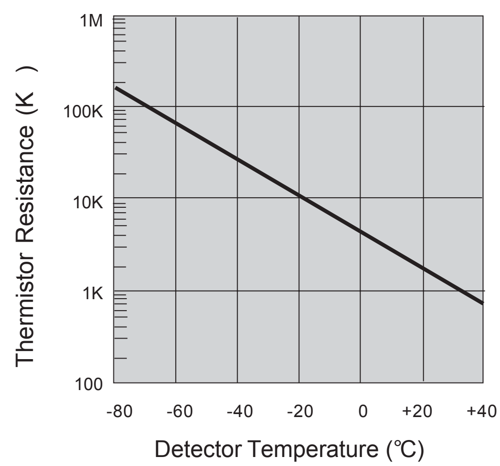


Figure 9.0



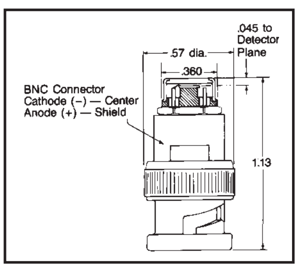
Detector Temperature	Thermistor Value (K) Min.	Typ.	Max.
22°C		1.3	
-40°C	15.0	30.0	40.0
-65°C	60.0	85.0	100.0

Figure 10.0

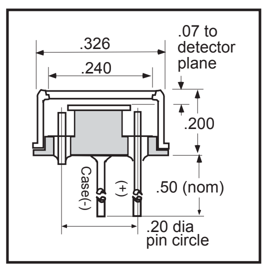
J12 SERIES
INAS DETECTORS
Operating Instructions

Model Number	Part Number	Active Size (dia.) (mm)	Operating Temperature	Cutoff Wavelength @ λco (50%) (µm)	Responsivity @ λp (A/W)	Shunt Resistance R_D @ V_R = 10mV Min. (ohms)	Shunt Resistance R_D @ V_R = 10mV Typ. (ohms)	Maximum NEP @ λpeak and 1KHz ($pW/Hz^{1/2}$)	Minimum D* @ λpeak and 1KHz (Jones) ($cmHz^{1/2}W^{-1}$)	Capacitance C_D @ V_R = 0V (pF)	Optional Packages and Accessories
J12 Series Room Temperature InAs											
J12-18C-R250U	420002	0.25	22°C	3.60	1.5	200	300	6.0	3.7E9	50	LD2
J12-18C-R01M	420003	1.00			1.0	15	25	33	2.7E9	400	
J12-5AP-R02M	420011	2.00			0.8	5	10	71	2.5E9	1600	
J12TE1 Series One-Stage Thermoelectrically Cooled InAs											
J12TE1-37S-R250U	420088	0.25	-20°C	3.50	1.5	2000	3000	1.8	1.3E10	50	HS1, CM21
J12TE1-37S-R01M	420061	1.00			1.5	200	300	5.6	1.6E10	400	
J12TE1-37S-R02M	420065	2.00			1.25	50	90	13	1.3E10	1600	
J12TE2 Series Two-Stage Thermoelectrically Cooled InAs											
J12TE2-66D-R250U	420083	0.25	-40°C	3.45	1.5	12K	24K	.69	3.2E10	50	HS Amp, HS1, CM21, CM Amp
J12TE2-66D-R01M	420041	1.00				1.2K	2.4K	2.2	4.1E10	400	
J12TE2-66D-R02M	420089	2.00				300	500	4.4	4.1E10	1600	
J12TE3 Series Three-Stage Thermoelectrically Cooled InAs											
J12TE3-66D-R250U	420081	0.25	-65°C	3.40	1.5	160K	320K	.18	1.2E11	50	HS Amp, HS1, CM21, CM Amp
J12TE3-66D-R01M	420056	1.00				10K	20K	.71	1.2E11	400	
J12TE3-66D-R1.5M	420063	1.50				5K	10K	1.0	1.3E11	800	
J12TE3-66D-R02M	420098	2.00				2.5K	5K	1.4	1.2E11	1600	
J12TE4 Series Four-Stage Thermoelectrically Cooled InAs											
J12TE4-3CN-R250U		0.25	-85°C	3.30	1.5	400K	800K	.11	2.1E11	50	HS Amp, HS1, CM21, CM Amp
J12TE4-3CN-R01M	420093	1.00				25K	50K	.43	2.1E11	400	
J12TE4-3CN-R02M-B		2.00				6.5K	13K	.84	2.1E11	1600	

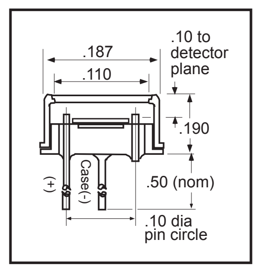
• LD2



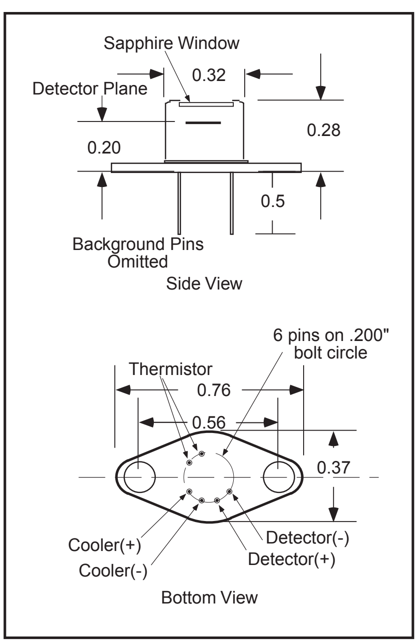
• 5AP



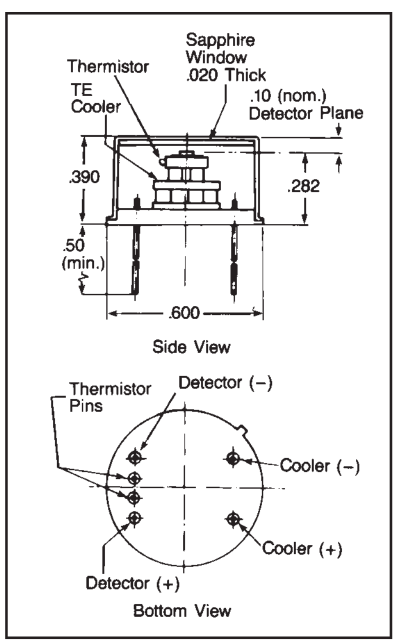
• 18C



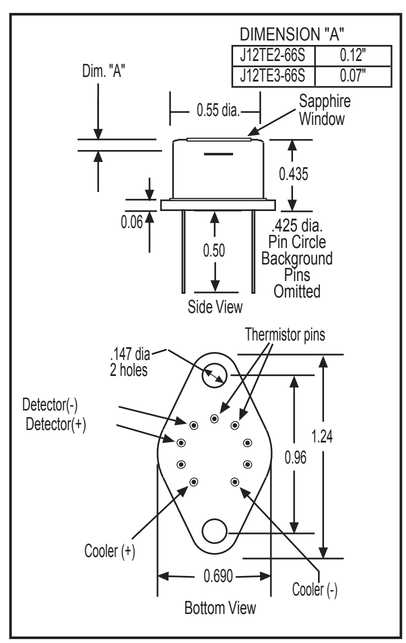
• 37S



• 8B6



• 66S



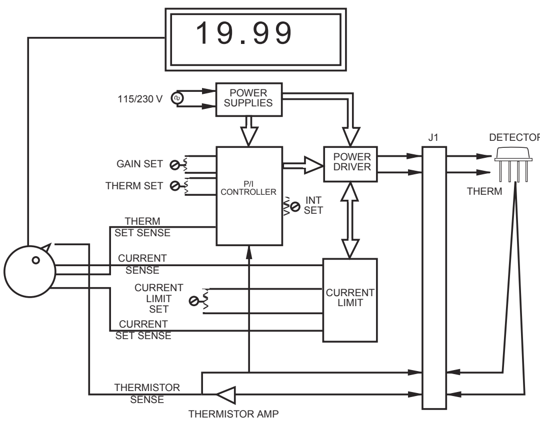
TELEDYNE
JUDSON TECHNOLOGIES
A Teledyne Technologies Company

Temperature Controllers

The Teledyne Judson Model TC5 power supply and temperature controller provides convenient cooler operation at a range of fixed temperatures. The built-in thermistor is used to stabilize the detector temperature.

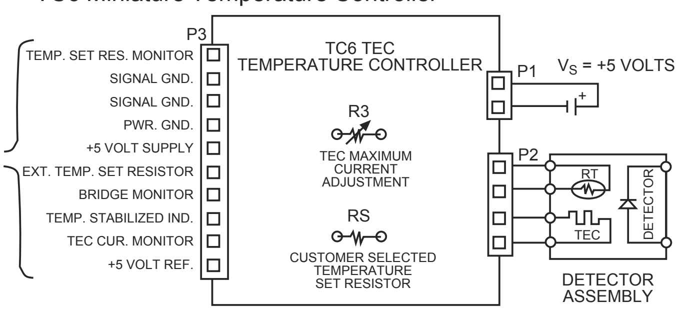
To operate without automatic temperature control, use a 2.5V power supply. Beginning with a fixed voltage and low current, gradually increase the current as the detector cools. The thermistor can be used to monitor the detector temperature if desired.

Typical Setup with TC5
Automatic Temperature Control



Package pin configurations:
See Product Outline Drawing supplied with detector.
Caution: Observe cooler polarity and max. power rating.

TC6 Miniature Temperature Controller



FEATURES

- Precise Temperature Control
- Temperature Set with a Single Resistor
- Operates with Most TEC Cooled Detectors
- LED Temperature Stabilization
- Maximum TEC Current Adjustable to 2 Amps
- Detailed Instruction Manuat Provided
- Temperature Stability to ±0.02°C
- Single +5 Volt Power Supply Operation
- Thermistor Bridge Monitor
- TEC Current Monitor
- Small Size

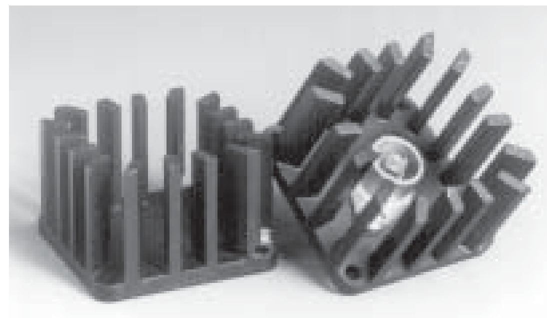
CAUTION:
Max. current for the TE2, TE3 and TE4 is 1.3 ampere.
Max. current for the TE1 is 1.0 ampere. When using a one stage cooler, a series resistor needs to be installed with the TC to limit the max. current to 1.0 ampere.

Heat Sinking the Thermoelectric Cooler

Teledyne Judson thermoelectric coolers dissipate up to 5 watts of power. Heat sinking is necessary to dissipate this power. Teledyne Judson offers the following heat sinks to accomplish this task.

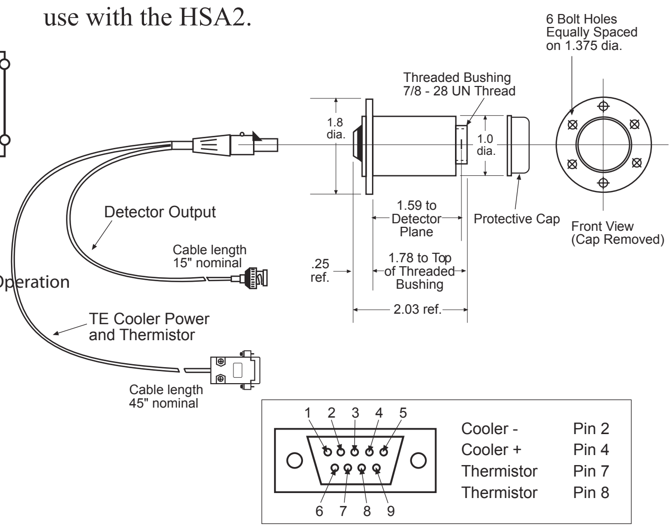
HS1 Heat Sink for Teledyne Judson 66S/66G Packages

The HS1 heat sink is available for Teledyne Judson Ge, InAs and HgCdTe TE cooled detectors mounted in the 66S and 66G packages. The heat sink is designed to provide easy heat sinking to the customer's bench top or optical system.



HSA2 Heat Sink Assembly for Teledyne Judson Thermoelectrically Cooled Detectors

The HSA2 two-stage thermoelectric cooler and heat sink assembly is available for Teledyne Judson TE cooled detectors. The assembly consists of the specified detector, a thermistor and a two-stage thermoelectric cooler mounted in a hermetic package with heat sink and detachable cables. The Model TC5 temperature controller is specifically designed for use with the HSA2.



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