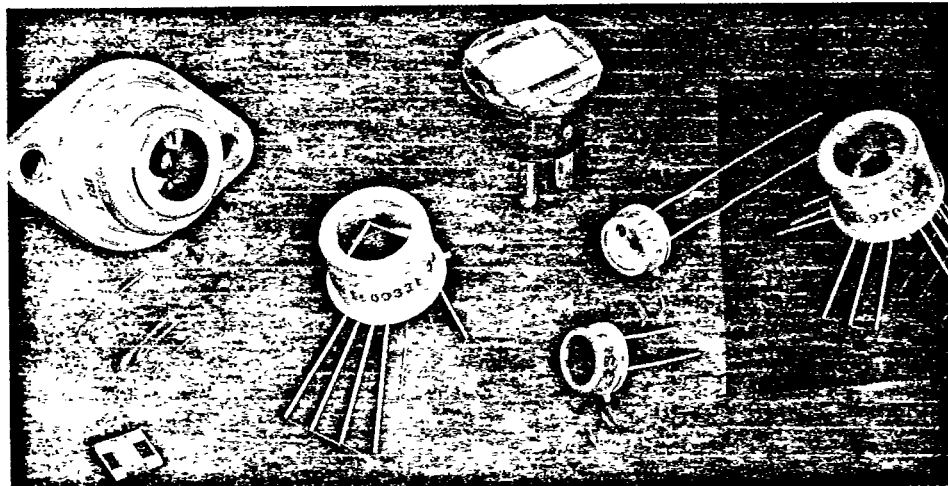


T-41-41

## Lead Sulfide Detectors



### FEATURES

- Spectral Response 1  $\mu\text{m}$  to 3.0  $\mu\text{m}$
- Superior D\*
- Long-Term Stability
- Rugged, Compact
- Fast Delivery, Low Cost

### Description

Infrared Industries, Inc. Lead Sulfide (PbS) detectors are thin film photoconductors which are chemically deposited onto a quartz substrate. Photolithographic techniques are used to define the active areas. Gold electrodes provide noise-free contact between the lead-out wires and the PbS film.

The basic detecting element is the sensitized film on a substrate with two electrical leads attached for connection to the outside world. For many instrumentation applications this basic component is adequate, while for others incasement in packages such as TO style is required. These metal packages, which are similar to other semiconductor devices, are rugged and easily handled in next order assembly operations.

Standard active area sizes are typically one, two, or three mm squares; however, Infrared Industries Inc. can provide sizes ranging from 75 microns x 75 microns to 10 millimeter x 10 millimeter in single element detectors. Table 2 shows active area sizes available from stock and the packages

available. Page 3 shows the mechanical drawings of the stock packages. Infrared Industries, Inc. PbS detectors exhibit excellent stability over a period of many years.

### Performance

As a circuit component, the sensor behaves like a variable resistor when connected to a bias supply. Photons induce changes in conductivity which modulate the current flowing through the detector. Changes in circuit voltage or current are then amplified as required by the application.

Background radiation begins to limit signal-to-noise ratio values below -50 degrees C. The effect becomes more pronounced as the temperature is lowered so that at -196 degrees C (liquid nitrogen) peak detectivity is no greater than the value obtained at -78 degrees C (dry ice). This effect can be partially eliminated by attenuating the background energy with cold apertures and/or cold optical filters to restrict the field-of-view and to observe only those wavelengths of interest.

High performance room temperature

formulations and cooling by thermoelectric methods have become very important since they enable greater detecting capability without the logistical problem of gas supplies. Table 3 shows performance characteristics for stock package TE coolers.

### Biasing Circuits

Since PbS is passive until energized, a bias is used. There are three basic methods for biasing. Figure 1: (a) biasing with a matched series load resistor to a constant voltage source; (b) constant current biasing with a low impedance current sensitive termination; (c) constant voltage operation, with a low resistance (relative to the detector) current sensitive termination. The circuit in Figure 1(a) will yield good results and is quite simple; a series circuit with a low impedance voltage supply, a resistor, and the detector. The input of the preamplifier is connected across the detector terminals to allow grounding of one detector lead. The load resistor adds a noise generator which, in some instances, prevents sensor-limited performance and must be considered in the design.

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The constant current configuration (Figure 1b), uses a low impedance current sensitive termination and provides an output signal that is a direct function of the PbS sensor's output independent of its dark resistance value. The power dissipated in the sensor is a direct function of its dark resistance, which decreases with increasing temperature. Thus, the  $I^2R$  heating effect of this configuration will not result in thermal runaway.

Furthermore, there will be a tendency for this bias approach to stabilize

sensor temperature. The constant current approach results in linear performance of the amplifier's input circuit. The constant current method of Figure 1b uses the inverting terminal of an operational amplifier as the current sensitive point. The main disadvantage of current mode biasing is the perfect tracking of variations caused by small detector temperature changes. This can be corrected by introducing temperature compensation elements to the constant current,  $I_{bias}$ .

The constant voltage technique (Figure 1c), has some advantages. Constant voltage across the sensor terminals provides excellent thermal compensation; that is, a more constant output when variations in sensor temperature occur. The circuit of (Figure 1c) is good for small active area sensors since only small  $V_{bias}$  values can be used with operational amplifiers. It is suggested that amplifiers having operational voltages of  $\pm 22.5$  volts be used instead of the traditional  $\pm 15$  volts. The  $V_{bias}$  value can then be as high as 12 volts.

**TABLE I STOCK DETECTOR PERFORMANCE CHART PbS**

PARAMETER	OPERATING CONDITIONS	SERIES NUMBER				UNITS
		1000	2000	2600C*	2700C*	
Ambient Temperature.	Package 298°K	298	298	298	298	°K
Element Temperature	Package 298°K	298	253	243	203	°K
		25°C	-20°C	-30°C	-70°C	
D* (D-Star) Typical	500°K, 750Hz, 1Hz	6.5 x10E8	1.5x10E9	2.7x10E9	8x10E9	cmHz 1/2w-1
D* (D-Star) Typical	pk,750Hz,1Hz	6.5 x10E10	1.5x10E11	2.5x10E11	3x10E11	cmHz 1/2w-1
Spectral Response		1-3	1-3.2	1-3.3	1-3.8	Micron
Resistance (Dark)		.5-1.5	.8 - 8.0	1-10	0.4-50	Megohms
Time Constant		200-250	500-1000	700-1200	2500-3500	µSec
Responsivity (Minimum)	pk,750Hz,1Hz 1mm x 1mm 2mm x 2mm 3mm x 3mm		400000	600000		Volts/Watt
			200000	300000		
			80000	120000		
Package Type		Plate TO Type	TO Type	TO Type	TO Type	

D\* MAY BE UP TO 30% LESS THAN STATED VALUE UNLESS SPECIFIED BY CUSTOMER ORDER.

**TABLE II STOCK DETECTORS**

ELEMENT SIZE (mm's)	SIZE NO.	SERIES NUMBER				
		1000	2000	2600C*	2700C*	2900C*
		PACKAGE NUMBER				
1 x 1	3	Plate 0303	TO-5 2303	TO-37 2637C TO-8 2638C	TO-37 2737C	TO-3(S) 2933C
2 x 2	5	Plate 0305	TO-5 2305	TO-37 2657C TO-8 2658C	TO-37 2757C	TO-3(S) 2953C
3 x 3	6	Plate 0306	TO-5 2306	TO-37 2667C TO-8 2668C	TO-37 2767C	TO-3(S) 2963C
10 X 10	11	Plate 1311	n/a	n/a	n/a	n/a

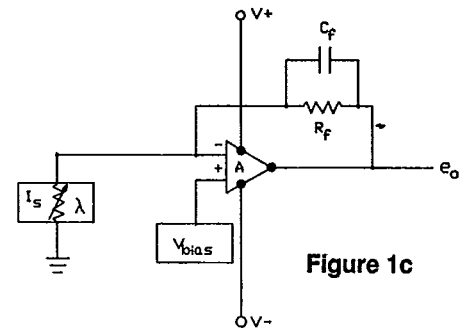
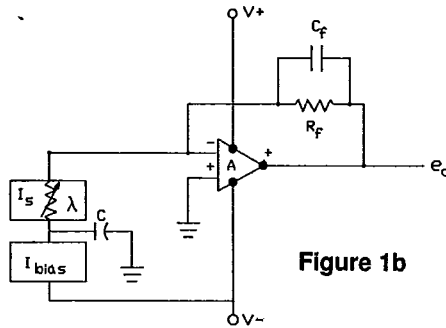
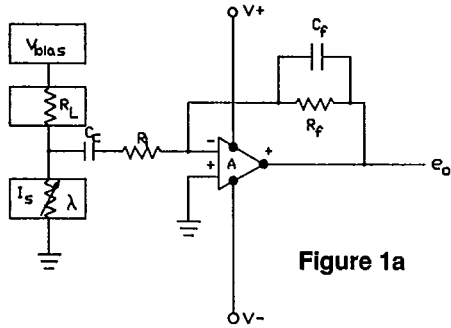
"C" AT THE END OF SERIES NUMBER DENOTES CALIBRATED THERMISTOR.

TABLE III THERMO-ELECTRIC COOLERS (TYPICAL)

Cooler Type	Delta T Max (°C) dry N <sub>2</sub>	Q max (watts) (amps)	I max (volts)	V max
Single stage	64	1.01	2.0	0.8
Two stage	88	0.35	1.7	0.9
Three stage	101	0.72	1.4	3.6

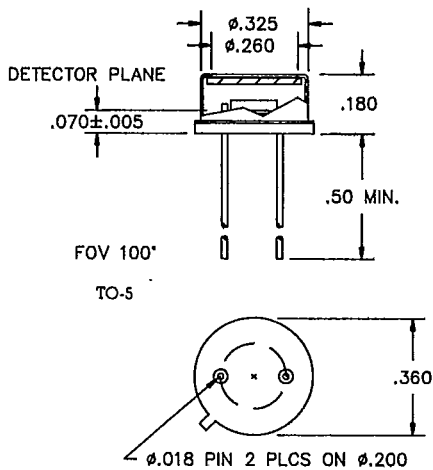
Thermoelectric coolers are solid state, vibration free, noise free heat pumps. "Q" max is the net heat load which completely suppresses ΔT at the maximum applied power (I max @ V max). Example: The three stage cooler produces 101° CΔT in dry nitrogen @ 1.4 amps @ 3.6 volts. It will take 0.72 watts to completely suppress that ΔT to zero. This suppression is linear so that 10% of Q max (0.072) applied to the cold plate would suppress ΔT 10% thus producing 90.9° CΔT for that heat load condition. "Q" is dependent on detector size, leads, thermistors, etc. Consult the factory. TE Cooler data is based on hot side temperature of 27°C.

COMMON CIRCUITS FOR LEAD SULFIDE

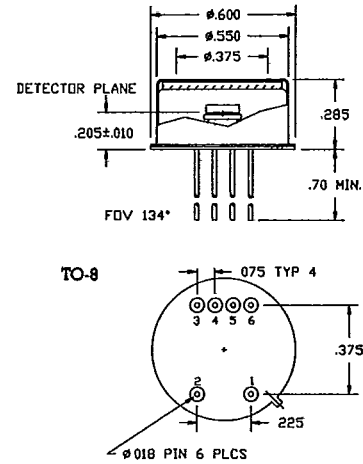
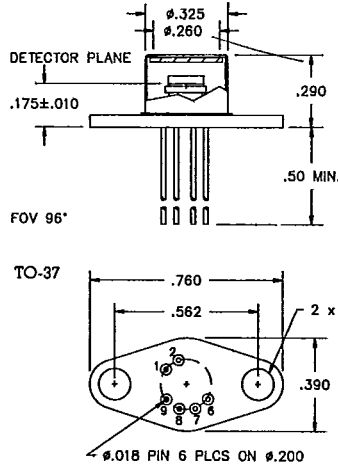


STOCK PACKAGES

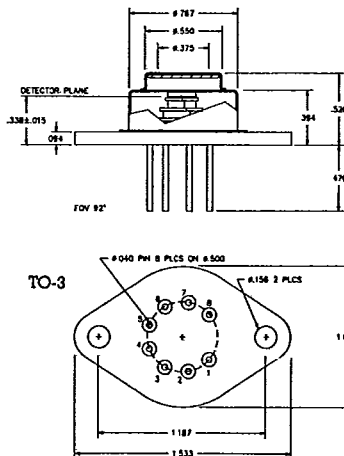
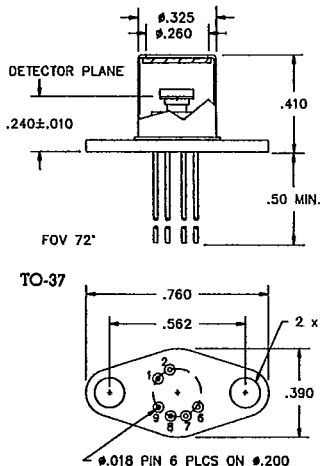
HERMETIC SEAL, UNCOOLED (2000)



HERMETIC SEAL, 1 STAGE, TE COOLED (2600) BELOW PIN CONFIGURATIONS HAVE CAL THERMISTOR



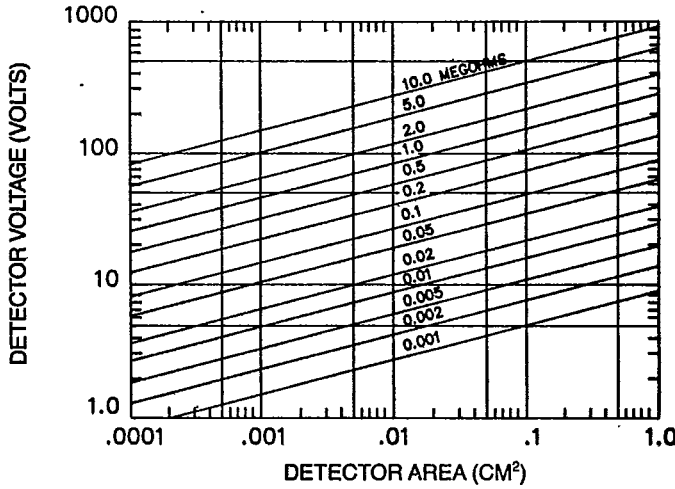
HERMETIC SEAL, 2 STAGE/3 STAGE, TE COOLERS (2700/2900)



TECHNICAL DATA SHEET

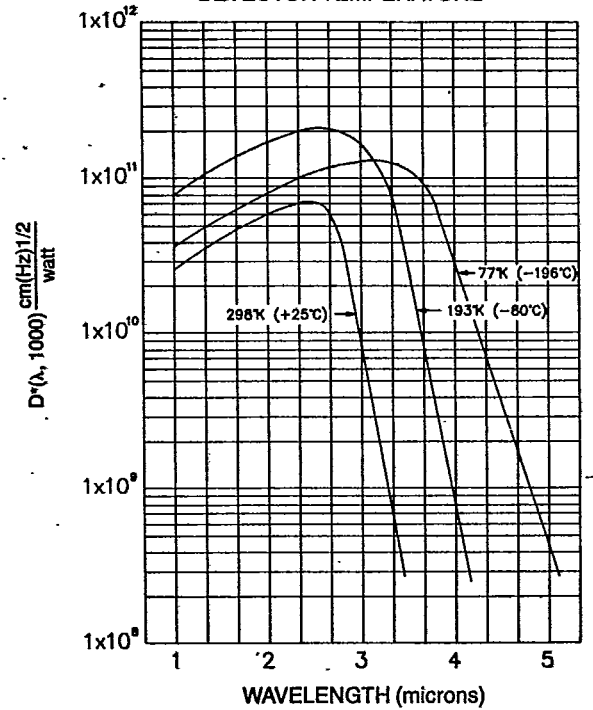
TYPICAL PERFORMANCE CURVES (2π STERADIAN FOV, 298°K BACKGROUND)

RECOMMENDED MAXIMUM DETECTOR VOLTAGE VS. DETECTOR AREA AND RESISTANCE FOR DETECTOR TEMPERATURE OF 298°K (+25°C)

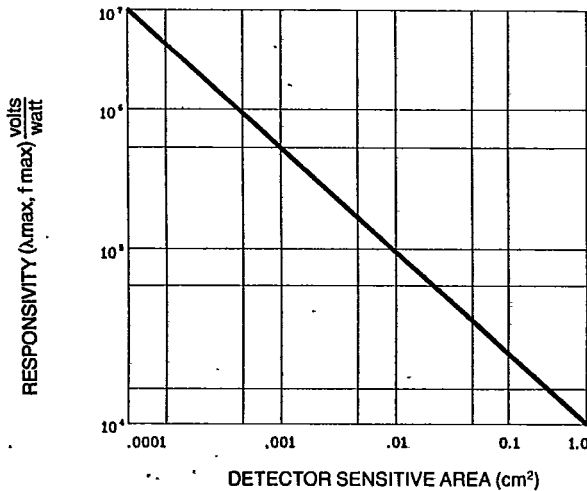


NOTES: 1. DETECTOR VOLTAGE IS VOLTAGE ACROSS DETECTOR TERMINALS.  
2. USE FACTOR OF TWO LESS TO MAINTAIN OPTIMUM D\*

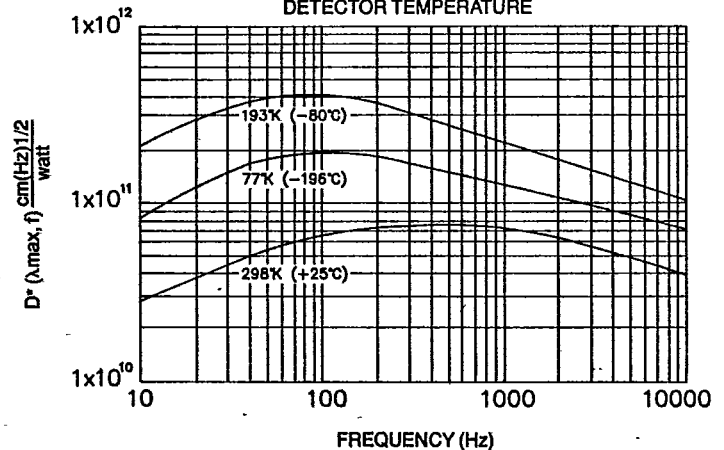
DETECTIVITY AT A FREQUENCY OF 1000 Hz VS. WAVELENGTH AS A FUNCTION OF DETECTOR TEMPERATURE



TYPICAL PEAK RESPONSIVITY VS. AREA FOR DETECTOR TEMPERATURE OF 298°K (+25°C)



DETECTIVITY VS. FREQUENCY AS A FUNCTION OF DETECTOR TEMPERATURE



Custom detectors are available.

Infrared Industries, Inc. also manufactures bias supplies, preamplifiers, TE controllers, and test equipment which can be used in conjunction with lead sulfide detectors.