This guide is designed to aid the user in the operation and testing of the infrared detector supplied by Teledyne Judson. Please read carefully before operating the detector. ***See precautions on page 4 before making any connections.***

THEORY OF OPERATION

The J15D series HgCdTe detector is a photoconductive element which undergoes a change in resistance proportional to the incident infrared radiation. This resistance change R_D is converted to a voltage change V by applying a constant bias current I_B through the detector (Figure 1). The optimum bias current depends on the individual detector characteristics such as size and spectral response.

HgCdTe detectors are low impedance devices and require preamplifiers with low voltage noise. The Teledyne Judson model PA-101 voltage preamplifier is recommended for most J15D series detectors (Figure 2).

Each PA-101 preamplifier has built-in bias circuitry, with the bias resistor R_B selected at the factory to provide optimum bias for a particular detector. (R_B is external to the preamp case.) The AC coupling capacitor C blocks the DC bias from the preamplifier, preventing DC saturation. The supply voltage V provides both detector bias and op amp power. The source should be a low-noise DC supply or Gel Cell battery to prevent fluctuations of the bias level.

The low noise PA-101 preamplifier ensures proper performance for subsequent signal-processing with a lock-in amplifier, A-D converter, or oscilloscope.

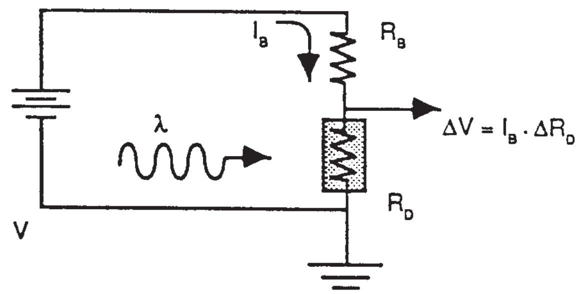


Fig. 1: Photoconductive Detector Operation

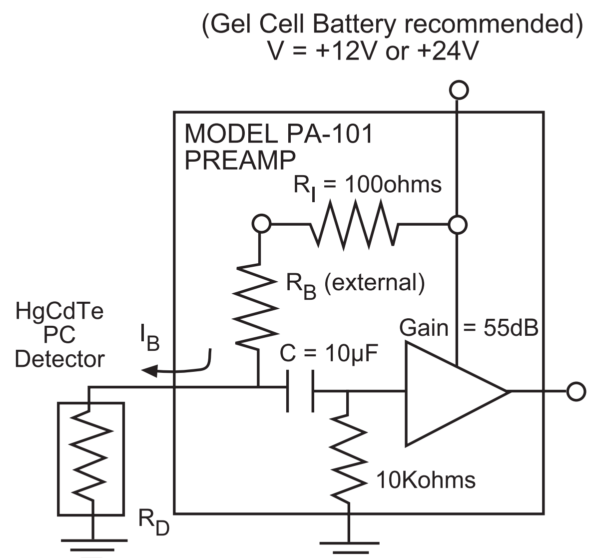


Fig. 2: Suggested Operating Circuit

$$I_B = \frac{V+}{R_B + 100\text{ohms} + R_{DET}}$$

TELEDYNE
JUDSON TECHNOLOGIES
A Teledyne Technologies Company

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

TELEDYNE JUDSON DETECTOR TESTS

All Teledyne Judson detectors undergo stringent quality control testing before shipping. A data sheet showing the test conditions, the specifications to which the detector was tested, and the test results is supplied with each J15D series detector along with a spectral response curve. This section defines the information contained on the data sheet and describes the Teledyne Judson test procedures.

Test Conditions

Figure 3 illustrates the test setup used at Teledyne Judson to determine J15D series detector performance. The following test conditions apply:

Blackbody Temperature

Absolute temperature in degrees Kelvin of the blackbody used as a source for response test. (500°K for J15D series detectors).

Background Temperature

Room temperature in degrees Kelvin providing background radiation.

Detector Temperature

Operating temperature of detector during test, usually 77°K or 87°K for long term measurement with cooler.

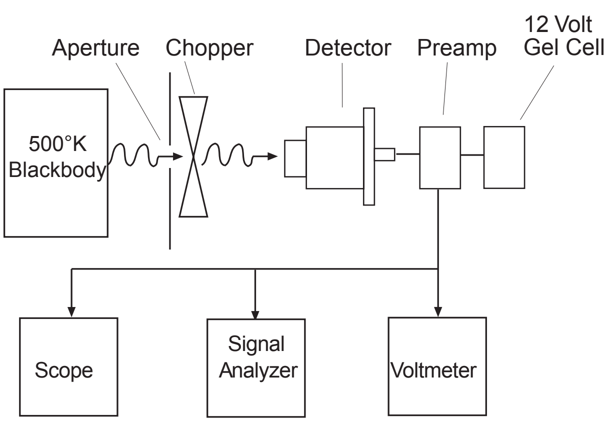


Fig. 3: Detector Test Setup

Flux Density

Actual rms power in watts/cm^2 irradiating the detector surface.Equal to F $(T^4_{BB} - T^4_{CH})$ 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 in degrees Kelvin, A_s is the aperture area and d is the source-to-detector distance.

Chopping Frequency

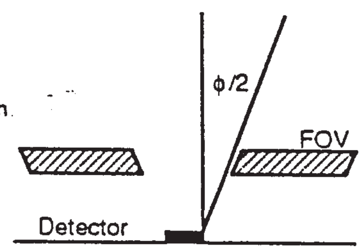
Frequency of the mechanical chopper for modulating the blackbody source signal.

Field of View

Equal to 60° unless otherwise specified by the customer. FOV is defined as two times the half angle /2 from the edge of the detector (Figure 4). Objects at larger angles are obscured. This <u>cold</u> field stop reduces background radiation on the detector and may give improved detectivity. Theoretical dependence is:

D* ( ) = D* (180°) /SIN (/2).

Fig 4: Field of View Definition



Maximum Allowable Current

Maximum bias current that may be applied to the detector before damaging the element. ***The detector should <u>not</u> be operated near this level.*** See bias voltage and bias current in the next section, "Test Results".

Test Results

The main parameters used to describe J15D-MCC1 detector performance are responsivity, detectivity, cutoff wavelength and cooler power. These are determined as follows:

Bias Voltage, Bias Current

The bias current listed on the data sheet is the current at which optimum detector performance is achieved. The Teledyne Judson preamplifier PA-101 has this bias built in when purchased with a detector. This bias current produces a bias voltage across the detector element. (Note this is not the same as the supply voltage.)

Blackbody Responsivity (R_{BB})

R_{BB} is the response of the detector to incident blackbody radiation (V/W). In the test setup of Figure 3, the blackbody response is determined as

$R_{BB} = V_O / (H_{BB} \cdot A_D \cdot \text{Gain})$ where

V_o = rms signal voltage at output of preamp

H_{BB} = Blackbody irradiance in watts/cm^2

A_D = Area of detector in cm^2

Gain = Gain of preamplifier (500 for PA-101)

Peak Responsivity (R)

Response to radiation at the detector's peak wavelength $_p$. This is related to blackbody responsivity by R = $R_{BB} \cdot$ G, where the constant G is the ratio of total blackbody power to the actual power "utilized" by the detector. G can be determined as follows:

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

where N(, T_{BB}) is the irradiance at in W/cm^2/m and W_{BB} is the total blackbody irradiance in W/cm^2. The value of G is dependant on the spectral response of the detector and is listed on the data sheet.

Noise

Rms noise voltage V_n measured at a specified frequency. The noise bandwidth is normalized to 1 Hz.

Peak Detectivity (D *)

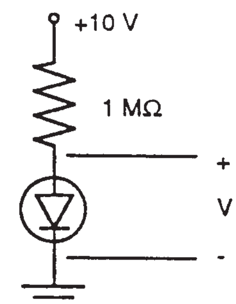
Detectivity at the wavelength of peak response. Defined as:

$$D^* = \frac{\sqrt{A_D}\, R}{\text{Noise}} \quad \text{cm Hz}^{(1/2)}\text{W}^{-1}$$

Silicon Temperature Sensor Checked

A silicon diode temperature sensor is mounted alongside some J15D series detectors to verify proper operating temperature. The voltage measured between the sensor anode (+) and ground (-) should be 0.6 V maximum at room temperature and 1V minimum at 77°K for the suggested test circuit shown in Figure 5.

Fig. 5: Silicon Diode Temperature Sensor



Temperature vs Sensor Voltage Plot

Cutoff Wavelength

The spectral response of the detector is measured using a Fourier Transform Infrared Spectrometer, giving a plot of detector response vs. wavelength. The cutoff wavelength is defined as the wavelength where the detector response drops to 50% (or 20%) of the peak response.

Detector Resistance

Resistance at operating temperature, with the detector viewing normal room temperature background radiation.

Dewar Heat Load

The LN_2 boil-off rate is measured with a flow meter to determine the rate at which N_2 evaporates from the dewar. This boil-off rate is used to estimate the heat load of the dewar.

PRECAUTIONS

- The detector should be cooled to its operating temperature (usually 77^0 K) before power is applied.

- Do not operate the detector at higher bias currents than suggested in the test data.

- Do not drop the detector package or subject the package to shock and vibrations.

- **Make all circuit connections before applying power to the circuit.** Power must be turned off before disconnecting the detector from the circuit.

- Do not use an ohmmeter across the detector. Standard ohmmeters may apply excess current through the detector.

- The detector is sensitive to electrostatic discharge. Operator should be grounded using wrist straps or other grounding precautions before making electrical connections to the dewar or preamplifier.

REFERENCES

The references below provided complete descriptions of infrared applications and measurement techniques:

R.C. Jones, D. Goodwin, and G. Pullan, “Standard Procedure for Testing Infrared Detectors and for Describing Their Performance,” Office of Director of Defense Research and Engineering, Washington, DC. September 12, 1960.

R.A. Smith, F.E. Jones, and R.P. Chasmar, The Detection and Measurement of Infrared Radiation, London:Oxford University Press, 1957.

P.W. Kruse, L.D. McGlaughlin, and R.B. McQuistan, Elements of Infrared Technology, New York: Wiley, 1962.

W.L. Wolfe, ed., Handbook of Military Infrared Technology, Office of Naval Research. Department of the Navy, Washington, DC, 1965.

R.D. Hudson, Jr. Infrared Systems Engineering, New York: Wiley, 1969.

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