TELEDYNE
JUDSON TECHNOLOGIES
A Teledyne Technologies Company

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TYPICAL OPERATING CIRCUITS

High Detectivity Circuit

J10D series InSb detectors are photovoltaic and generate a current proportional to the intensity of the photons absorbed. For maximum detectivity these detectors are operated at zero volt bias. Figure 1 shows the recommended operating circuit, using a low-noise FET op amp in a negative feedback, current mode configuration. The signal current (I_s) times the feedback resistor (R_F) results in the output voltage (V_O). The properties of the op amp ensure that the detector remains near zero volt bias.

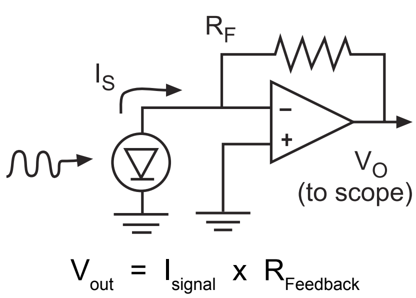

Fig. 1: Recommended Operating Circuit

Selection of the feedback resistance R_F is determined by the system requirements as follows:

Op Amp Saturation

Photovoltaic detectors generate a DC short circuit current due to background radiation. To avoid op amp saturation, the product I_{SC} times R_F must be less than the maximum DC output capability of the op amp. Recommended level is less than 5 volts.

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

Recommended preamplifiers are the Teledyne Judson models PA-9 and PA-7. The PA-9 is an ultra-low noise preamp with a fixed RF matched to the detector for optimum detectivity, gain and bandwidth. The PA-7 has adjustable gain and lower bandwidth. Refer to preamplifier product bulletin #216 (PA-7) or #218 (PA-9) for more information on the frequency response of a particular detector/preamplifier combination.

High Speed Circuit

Frequency response can be improved by using the circuit shown in Figure 2, where the load resistance R_L is small compared to the detector dynamic impedance. However, the small load resistor generates Johnson Thermal Noise, which may be larger than the detector noise, so that overall detectivity is reduced.

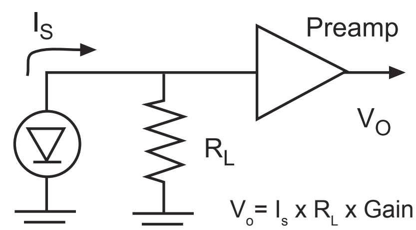

Fig 2: High Speed Operating Circuit

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TELEDYNE JUDSON DETECTOR TESTS

Test Conditions

All Teledyne Judson detectors undergo stringent quality control testing before shipment. The test setup of Figure 3 is used to check J10D series detectors for responsivity (R) and detectivity (D*).

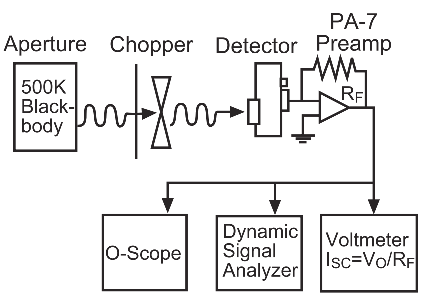

Fig 3: Detector Test Setup

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

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.

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), s 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.

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

D*( ) =D* (180°) /SIN (/2)

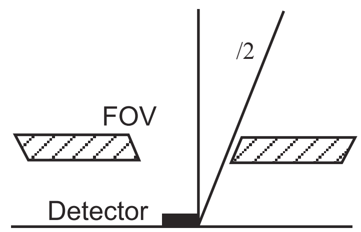

Fig 4: Field of View Definition

Filter
The center wavelength and bandpass of the cold filter (if any) mounted in the dewar. Must be specified by customer when ordering. Cold filters improve D* by reducing the background radiation reaching the detector.

Electrical Test Measurements

The following parameters are measured to verify proper detector performance:

Open Circuit Voltage (V_{OC})

DC voltage generated by the detector at operating temperature into a high impedance load. Measured with a digital voltmeter.

Short Circuit Current (I_{SC})

Current generated by the detector into a shorted load while viewing background radiation only.

Noise

Rms noise current at 1 KHz normalized to a 1 Hz bandwidth. InSb detector noise is dominated by shot noise; current generated by the detector looking at a 300°K background.

$$\overline{i^2} = 2qI \quad f$$

where I is the total current, q is the electric charge and f is noise bandwidth.

Blackbody Responsivity (R_{BB})

Defined as the current produced by a detector in response to the radiant power on the detector (amps/watt). For the test setup of Figure 3, R_{BB} is equal to V_{out} / (H_{BB} A_D 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.

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:

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

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.

Peak Detectivity (D *)

Detectivity at the wavelength of peak response. Defined as:

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

Detector Shunt Impedance

Effective dynamic impedance of the detector at operating temperature, measured near zero bias. NOT measured with a standard ohmmeter.

Junction Capacitance

Capacitance of the detector at zero bias.

Additional Information

LN_2 boil-off rate is measured with a flow meter to determine the rate at which coolant evaporates from the dewar. The boil-off rate is used to calculate the LN_2 hold time of the dewar.

SUGGESTED METHODS FOR USER TESTING

Preliminary Inspection

- Read precaution instructions on page 4 of this bulletin.
- Examine the detector for visible signs of damage.
- Carefully cool the detector to operating temperature by filling with liquid nitrogen.

Measuring V_{oc}

Measure the open circuit voltage V_{oc} using a digital voltmeter. ***Do not use an ohmmeter.*** The current generated by an ohmmeter may destroy the detector. The detector should be viewing a room temperature background (approximately 295°K). Generally, if the V_{OC} measured is within ±10 mV of the value specified on the data sheet, you can be confident that the detector is operating properly.

Further Testing

Further testing can be done if problems are suspected or if the user wishes to verify the test data supplied. Place the detector in view of a modulated source of known irradiation, ideally a 500°K blackbody. Assemble the circuitry shown in Figure 3. Recommended preamps are Teledyne Judson models PA-7 or PA-9.Turn power on only after all connections have been made. Measure the signal to compute responsivity as described above. Measure the noise to compute D*. (Note that noise due to the user preamp may differ from noise due to the factory test set preamp.)

Malfunctioning Detector

If the detector is not cooling or the data measured is not consistent with the test data sheet provided, contact the factory for assistance.

PRECAUTIONS

- The detector dewar is fully evacuated at time of shipping. Do not attempt to remove the window, or the plug in the pump-out port on the side of the dewar. (For detectors packaged in glass dewars with JTC cryostat systems, see Product Bulletin #219.)

- The detector should be cooled to its operating temperature (usually ~77°K) before power is applied to the system. Use the funnel provided and avoid spilling coolant around the pump-out port or window areas. When the detector reaches 77°K, a spout of cold gas will erupt from the fill port. Do not look into the fill port until this eruption is past.

- **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.

- Operation at 0 volt bias is recommended (see Figure 1). Maximum reverse bias is -200 mV. Do not allow a current more than ten times the short circuit current to flow through the junction.

- Ultraviolet and visible radiation can convert the surface of an exposed n-type material to p-type, enlarging the junction area. This effect, called “flashing”, will increase the effective area of the detector, lower the impedance, increase the signals, and cause excessive crosstalk. To prevent flashing, protect the detector element from direct UV or visible light, particularly fluorescent light. The flashing effect is most pronounced if the detector is exposed while cooled, and can generally be reversed by warming the detector to room temperature and recooling. **Extended exposure or exposure to high intensity light, even at room temperature, may result in permanent damage.**

- Do not drop the detector package or subject the package to shock, vibrations or temperatures above 70°C.

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