Indium Arsenide Detectors
General

J12 Series detectors are high-quality Indium Arsenide photodiodes for use in the 1 to 3.8 µm wavelength range.

The equivalent circuit is a photon-generated current source $I_{ph}$ with parallel capacitance $C_D$, shunt resistance $R_D$, and series resistance $R_s$ (Fig. 12-1).

The output signal current $I_s$ is defined as:

$$I_s = \frac{I_{ph} R_D}{R_D + R_s + R_{LOAD}}$$

$R_s$ varies as a function of detector temperature (Fig. 12-2). $R_s$ depends on the position of the source light spot on the detector surface; it varies with the distance from the spot to the detector contact ring.

When $R_s$ is small compared to $R_D$, it may be disregarded, but with room temperature InAs the effects of $R_s$ are significant.

Responsivity

The effect of $R_s$ on the apparent response of an InAs detector is illustrated below. At 22°C, $R_s$ and $R_D$ may have the same order of magnitude ($\sim 10^5$). As a result, although incident photons generate carriers uniformly over the detector area, some of the carriers generated near the center of the area may be "shunted away" through $R_s$ and fail to reach the contact ring. This results in a "dip" in response at the center of the detector's active area (Fig. 12-3).

The effect is less pronounced in small-area detectors, which have higher $R_D$ and less surface area. The effect is also reduced or eliminated by cooling the diode, thereby increasing the detector $R_D$.

Temperature Effects

Cooling an InAs photodiode reduces noise and improves detectivity (Fig. 12-4). Cooling also increases shunt resistance $R_s$, as described in the previous section, allowing more of the photocurrent $I_{ph}$ to reach the contact ring. The result is an increase in the diode response (Fig. 12-3).

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.

Figure 12-1  InAs Photodiode Equivalent Circuit

Figure 12-2  Example of InAs Shunt Resistance vs Temperature

Figure 12-3  Example of Response Variation Across 2mm Active Area

Figure 12-4  Detectivity vs Wavelength for J12 Series InAs

Figure 12-5  J12TE Detector Response vs Wavelength & Temperature
Thermoelectric Cooler Operation

Figure 13-1 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 13-2 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.

Operating Circuit

The recommended operating circuit for most applications is an operational amplifier in a negative-feedback transimpedance configuration (Fig. 13-3). 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.

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 (Fig. 13-4). Maximum reverse bias is 1 volt.

Advantages of InAs

Unlike the photoconductors commonly used in the 1-3.8 µm wavelength region, InAs operates in the photovoltaic mode and does not require a bias current for operation. This makes InAs the better choice for DC and low-frequency applications, as it does not exhibit the low-frequency or “1/f” noise characteristic of the photoconductors PbS, PbSe, and HgCdTe (Fig. 13-5).

InAs also offers superior pulse response for applications in monitoring and detecting high-speed pulsed lasers.
J12 Indium Arsenide Detectors (1.0 to 3.8 µm)

Description

The J12 Series Indium Arsenide (InAs) detectors are photovoltaic infrared photodiodes sensitive in the 1.0 to 3.8 µm wavelength region.

Diode sensitivity, speed of response, impedance and peak wavelength can be optimized by operation at the proper temperature. Teledyne Judson offers a variety of convenient packages for room temperature and thermoelectrically cooled operation. Linear arrays, X-Y position sensors and special configurations are also available.

Applications

- Laser Warning Receivers
- Process Control Monitors
- Temperature Sensors
- Pulsed Laser Monitors
- Infrared Spectroscopy
- Power Meters

J12 Series

Room Temperature InAs Detectors

These photodiodes operate at ambient temperatures and are excellent for wide bandwidth (DC to 16MHz) applications such as infrared laser monitors and fast temperature sensors. The devices are available in 0.25 mm, 1 mm or 2 mm 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.

InAs detectors can be reverse-biased to reduce junction capacitance and improve frequency response.

J12TEE1 Series

1-Stage Thermoelectrically Cooled InAs

The J12TE1 Series detectors are high quality temperature stabilized InAs detectors mounted on a one stage thermoelectric cooler. The TE1 series was developed for applications such as temperature monitoring, power meters and infrared spectroscopy where low cost, responsivity, stability and low noise are important issues.

J12TEE2 Series

2-Stage Thermoelectrically Cooled InAs

The J12TE2 Series detectors are high quality InAs photodiodes mounted with thermistors on two-stage thermoelectric coolers and hermetically sealed package. The 8B6 package is standard, with the 66S and HS1 packages available as options.

At the standard operating temperature of -40°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. 13-1 and 13-2 for thermoelectric cooler operating information. Cooler power supplies and temperature controllers are also available.

J12TEE3 Series

3-Stage Thermoelectrically Cooled InAs

The J12TE3 Series detectors are high quality InAs photodiodes mounted in the 66S package which includes a built-in thermistor, three stage thermoelectric cooler and hermetically sealed package.

J12TE3 devices are ideal for critical military, space or industrial applications requiring high detectivity, good uniformity of response and wide bandwidth.

J12TEE4 Series

4-Stage Thermoelectrically Cooled InAs

The J12TE4 Series detectors are high quality InAs photodiodes mounted in the 3CN package which includes a built-in thermistor, four stage thermoelectric cooler and hermetically sealed package.
<table>
<thead>
<tr>
<th>Model Number</th>
<th>Part Number</th>
<th>Active Size (dia.) (mm)</th>
<th>Operating Temperature</th>
<th>Cutoff Wave-length @ co (50%) (µm)</th>
<th>Responsivity @ p (A/W)</th>
<th>Shunt Resistance R_D @ V_A = 10mV</th>
<th>Maximum NEP @ peak and 1KHz (pW/Hz^1/2)</th>
<th>Minimum D* @ peak and 1KHz (Jones) (cm^2Hz^1/2(W))</th>
<th>Capacitance C_D @ V_A = 0V</th>
<th>Optional Packages and Accessories</th>
</tr>
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<tr>
<td>J12-18C-R250U</td>
<td>420002</td>
<td>0.25</td>
<td>22°C</td>
<td>3.60</td>
<td>1.5</td>
<td>2.00</td>
<td>300</td>
<td>6.0</td>
<td>3.7E9</td>
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<td>1.00</td>
<td>25°C</td>
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<td>1.0</td>
<td>15</td>
<td>25</td>
<td>33</td>
<td>2.7E9</td>
<td>400</td>
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<tr>
<td>J12-5AP-R02M</td>
<td>420011</td>
<td>2.00</td>
<td>-40°C</td>
<td>3.45</td>
<td>1.5</td>
<td>12.2</td>
<td>24.2</td>
<td>0.69</td>
<td>3.2E10</td>
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<td>0.25</td>
<td>-20°C</td>
<td>3.50</td>
<td>1.5</td>
<td>2.00</td>
<td>300</td>
<td>5.6</td>
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<td>1.5</td>
<td>1.2K</td>
<td>2.4K</td>
<td>2.2</td>
<td>4.1E10</td>
<td>1600</td>
</tr>
<tr>
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<td>2.00</td>
<td>-65°C</td>
<td>3.40</td>
<td>1.5</td>
<td>160K</td>
<td>320K</td>
<td>0.18</td>
<td>1.2E11</td>
<td>50</td>
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<td>10K</td>
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<td>0.18</td>
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<td>50</td>
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<td>10K</td>
<td>1.0</td>
<td>1.3E11</td>
<td>800</td>
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<td>3.30</td>
<td>1.5</td>
<td>2.5K</td>
<td>5K</td>
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<td>13K</td>
<td>0.84</td>
<td>2.1E11</td>
<td>1600</td>
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**Optional Packages and Accessories**
- HS1, CM21
- HS Amp, HS1, CM21, CM Amp

**Models and Specifications**
- **Part Number**: 420002, 420003, 420011, 420088, 420061, 420065, 420083, 420061, 420065, 420088, 420061, 420065, 420083, 420061, 420065, 420088, 420061, 420065, 420088, 420061, 420065, 420088, 420061, 420065, 420088, 420061, 420065, 420088, 420061, 420065, 420088, 420061, 420065, 420088, 420061, 420065, 420088
- **Active Size (dia.) (mm)**: 0.25, 1.00, 2.00
- **Operating Temperature**: 22°C, 25°C, -40°C, -65°C, -85°C
- **Cutoff Wave-length @ co (50%) (µm)**: 3.60, 3.50, 3.45, 3.40, 3.30
- **Responsivity @ p (A/W)**: 1.5, 1.5, 1.5, 1.5, 1.5
- **Shunt Resistance R_D @ V_A = 10mV**: 2.00, 200, 300, 2000, 3000
- **Maximum NEP @ peak and 1KHz (pW/Hz^1/2)**: 6.0, 1.8, 0.69, 0.18, 0.11
- **Minimum D* @ peak and 1KHz (Jones) (cm^2Hz^1/2(W))**: 3.7E9, 1.3E10, 3.2E10, 1.2E11, 2.1E11
- **Capacitance C_D @ V_A = 0V**: 50, 50, 50, 50, 50
- **Optional Packages and Accessories**: HS1, CM21, HS Amp, HS1, CM21, CM Amp

**Dimensions and Markings**
- **Detector Plane**: 0.32 mm
- **Side View**: 0.28 mm
- **Background Pins**: 0.5 mm
- **Thermistor (+)**: 0.76 mm
- **Thermistor (-)**: 0.56 mm
- **6 pins on .200" bolt circle**: 0.37 mm
- **Cooler (+)**: 0.147 dia. 2 holes
- **Cooler (-)**: 0.147 dia. 2 holes
- **Sapphire Window**: 0.435 mm
- **Sealant**: 0.50 mm
- **Detector (+)**: 0.96 mm
- **Detector (-)**: 0.69 mm
- **Thermistor pins**: 0.96 mm

**Color Codes**
- **Thermistor**: Yellow, White, Green, Black, Red, Clear, Yellow
In addition to our Indium Arsenide product line, Teledyne Judson Technologies offers a wide range of high performance standard, custom and space qualified detector products and accessories.

- Germanium detectors and arrays
- Indium Gallium Arsenide detectors and arrays
- Indium Antimonide detectors and arrays
- Mercury Cadmium Telluride detectors and arrays
- Lead Selenide detectors and arrays
- Lead Sulfide detectors and arrays
- Dewars, backfill and vacuum packages
- Thermoelectric, Joule Thomson and closed cycle linear and rotary coolers
- Preamplifiers
- Temperature controllers and readout electronics

Please contact us for more information on these products at 215-368-6900 or on the web at www.teledynejudson.com.