Mercury Cadmium Telluride Detectors

ISO 9001 Certified
**J15 Mercury Cadmium Telluride Detectors (2 to 26 µm)**

**General**

HgCdTe is a ternary semiconductor compound which exhibits a wavelength cutoff proportional to the alloy composition. The actual detector is composed of a thin layer (10 to 20 µm) of HgCdTe with metalized contact pads defining the active area. Photons with energy greater than the semiconductor band-gap energy excite electrons into the conduction band, thereby increasing the conductivity of the material. The wavelength of peak response depends on the material's band-gap energy and can easily be varied by changing the alloy composition.

In order to sense the change in conductivity, a bias current or voltage is required. Typically, detectors are manufactured in a square or rectangular configuration to maintain a uniform bias current distribution throughout the active region.

**Detector Bias and Operating Circuit**

A basic circuit for operating J15 Series PC HgCdTe detectors is shown in Figure 26-2. These detectors are low impedance devices, typically 10 to 150Ω, and require a low voltage noise preamplifier. A constant bias current is produced in the detector using a low noise DC voltage supply or battery with a current-limiting resistor \( R_B \). An AC coupling capacitor blocks the DC bias voltage from the high gain preamplifier and prevents DC saturation.

For optimum performance, the model PA-101 preamp is recommended for most J15 Series detectors. The PA-101 has built-in bias circuitry and is specially matched to each detector at the factory. The PA-101's low noise, high gain and wide bandwidth ensure proper performance for subsequent signal processing with oscilloscopes, A-D converters, lock-in amplifiers, etc.

**D* and Responsivity vs. Bias**

The responsivity and detectivity of all J15 Series HgCdTe detectors are a function of bias current. Figure 26-3 shows an example of relative responsivity and detectivity for a 1mm J15D14 Series LN\(_2\) cooled detector. At low bias currents, the responsivity increases nearly linearly with bias. At high bias currents, self-heating of the detector eventually causes the responsivity to fail.

The point of maximum responsivity is generally not the recommended bias for the detector. System performance depends on the overall signal-to-noise ratio or detectivity. At low bias current the preamplifier noise or system noise may dominate. At high bias levels the 1/f surface noise often becomes unacceptably high. Each detector is supplied with a data sheet specifying the optimum bias current with the PA-101 preamp. The optimum bias may vary from application to application depending on background radiation levels.

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Germany and other countries: LASER COMPONENTS GmbH, Phone: +49 8142 2864 0, Fax: +49 8142 2864 11, info@lasercomponents.com

Great Britain: LASER COMPONENTS (UK) Ltd., Phone: +44 1245 491 499, Fax: +44 1245 491 801, info@lasercomponents.co.uk

France: LASER COMPONENTS S.A.S., Phone: +33 1 3959 5225, Fax: +33 1 3959 5350, info@lasercomponents.fr
Responsivity vs. Active Size

The voltage responsivity of all J15 Series HgCdTe PC detectors varies significantly with the active size of the element as shown in Fig. 27-1. Responsivity also depends on cutoff wavelength, field of view restriction, operating temperature and bias current. Responsivity for even "identical" detectors may range over a factor of 2 due to variations in material composition. The actual peak and blackbody responsivity data at optimum bias are supplied with each detector.

As with all photon detectors, the optimum system performance is achieved with the smallest size detector capable of collecting the available incident radiation. Focusing optics are highly recommended for reducing radiation spot sizes and thereby improving signal-to-noise performance.

Responsivity and Noise vs. Frequency

The frequency response of HgCdTe detectors is related to the lifetime $\tau$ of the electrons in the HgCdTe crystal, and $\tau$ depends on material composition and operating temperature. Figure 27-2 is an example of responsivity and noise vs. frequency for a J15D12 Series LN$_2$ cooled detector. The actual time constant for each detector type can be found in the specification tables. The 3dB cutoff frequency $f_c$ is given by $f_c = \frac{2}{\tau}$.

All HgCdTe PC detectors exhibit excess low frequency noise which increases approximately as $f^{-1/2}$ below a certain "corner" frequency (typically 1KHz). The optimum detectivity is achieved over a wide range from the corner frequency up to the cutoff frequency $f_c$. The actual responsivity, noise and detectivity data at 10KHz are supplied with each detector.

Linearity and Temperature Effects

Each J15 Series HgCdTe is specially designed for a particular operating temperature range. Responsivity and detectivity will generally increase with decreasing temperature.

HgCdTe PC detectors have a wide dynamic range (see Fig. 27-4). However, a reduction in responsivity may occur at very high incident power levels.

Figure 27-3
Detectivity vs Temperature for J15TE Series HgCdTe

Figure 27-4
Linearity Limitation @ 10.6µm for J15 Series HgCdTe

Germany and other countries: LASER COMPONENTS GmbH, Phone: +49 8142 2864 0, Fax: +49 8142 2864 11, info@lasercomponents.com
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J15D Mercury Cadmium Telluride Detectors (2 to 26 µm)

Description

The J15D Series detectors are Mercury Cadmium Telluride (HgCdTe) photoconductive (PC) detectors designed for operation in the 2 to 26µm wavelength region. The wavelength of peak response depends on the specific alloy composition used.

All J15D Series detectors are designed for cryogenic operation at 77°K. Judson’s superior technology and careful device selection can provide background limited (BLIP) detectors with state-of-the-art performance.

Applications

- Thermal Imaging
- CO₂ Laser Detection
- FTIR Spectroscopy
- Missile Guidance
- Night Vision

Figure 28-1
Example of Detectivity for J15D Series HgCdTe

J15D5 Series

HgCdTe PC Detectors (2 to 5 µm)

The J15D5 Series HgCdTe detectors peak at 5µm and are recommended for thermal imaging or infrared tracking applications which require liquid nitrogen cooled PC detectors.

Excellent performance in the 3 to 5 µm wavelength region can also be obtained from ourJ15TE2, J15TE3 and J15TE4 Series thermoelectrically cooled HgCdTe detectors.

J15D12 Series

HgCdTe PC Detectors (2 to 12 µm)

The J15D12 Series HgCdTe detectors peak at 11µm with a cutoff wavelength greater than 12 µm. The devices offer optimum performance in the 8 to 12µm wavelength region with high responsivity, near-BLIP performance and fast response time. Applications include thermography, CO₂ laser detection and missile guidance.

Minimum and typical detectivities for all standard sizes with a 60° FOV cold stop are listed in the adjoining specification table. Cold stops for reduced FOV’s are provided at no extra cost and may improve detectivity since detector performance is often background limited. Custom cold filters may also improve detectively by eliminating radiation in unwanted wavelength regions.

The detector is mounted in the M204 or the M205 metal dewar with ZnSe window. A wide variety of glass and metal dewar options are available, including dewars for Joule-Thomson cryostat and closed-cycle cooling. The LC1 and RC2 cooler systems allow for operation of J15D12 detectors without bulk liquid nitrogen.

All Judson HgCdTe PC detectors are fully passivated and can be provided on a dewar mount or a miniature flat pack for mounting by the customer.

The J15D12 Series detectors can be manufactured in a wide variety of special configurations including linear arrays, quad cells and two-color sandwich devices.

J15Dxx Series

HgCdTe PC Detectors for FTIR Spectroscopy (2 to 26 µm)

The J15D14, J15D16, J15D22 and J15D24 Series HgCdTe detectors are specifically designed for use in conventional or Fourier Transform Infrared (FTIR) Spectroscopy. The J15D14 series offers the highest sensitivity for “narrow band” use (750 to 5000 cm⁻¹). The 1 mm active size is recommended for conventional sampling, and the 0.1 and 0.25 mm active sizes are best for microscope applications.

The J15D16 Series offers extended wavelength coverage for “midband” applications (600 to 5000 cm⁻¹) while still maintaining excellent detectivity. The J15D22 Series or J15D24 Series are the detectors of choice for general “wide band” spectroscopy (425 to 5000 cm⁻¹). They have much higher sensitivity and speed than alternative pyroelectric devices.

J15D Series detectors are mounted in the standard M204 or M205 metal dewars. A variety of alternative dewars designed to fit most FTIR manufacturers’ instruments are available as options.

Standard window materials for FTIR detectors are ZnSe for narrow band and midband, and KRS-5 for wide band. All windows have “wedged” surfaces to prevent unwanted interference effects. Detectivity performance data and a spectral response curve are provided with each detector.
## Typical Specifications J15D Series HgCdTe @ 77°K, 60°FOV

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Part No.</th>
<th>Active Size (square)</th>
<th>Cutoff Wavelength $\lambda_{co}$ (20%) (µm)</th>
<th>Peak Wavelength $\lambda_{peak}$ (µm)</th>
<th>Peak $D^*$ @ 10KHz (cm Hz$^{1/2}$ W$^{-1}$)</th>
<th>Typical Responsivity @ $\lambda_{peak}$ (V/W)</th>
<th>Time Constant $\tau$ (µsec)</th>
<th>Typical Resistance $R_{DET}$ (Ω)</th>
<th>Typical Bias Current $I_b$ (mA)</th>
<th>Packages</th>
<th>Standard Options</th>
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</thead>
<tbody>
<tr>
<td>J15D5-M204-S050U-60</td>
<td>450546</td>
<td>1</td>
<td>5x10$^{-10}$</td>
<td>8x10$^{-10}$</td>
<td>2x10$^3$</td>
<td>5</td>
<td>800</td>
<td>$-0.10$</td>
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<tr>
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<td>2</td>
<td>2x10$^{-10}$</td>
<td>2.5x10$^{-10}$</td>
<td>500</td>
<td>0.5</td>
<td>100</td>
<td>0.5</td>
<td></td>
<td>M204</td>
<td>See Catalog</td>
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<td>J15Dxx Series HgCdTe for FTIR Spectroscopy (2-26 µm)</td>
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