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Revision 98.3

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MODEL NO.	FEATURES																									
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MODEL NO.	FEATURES																									
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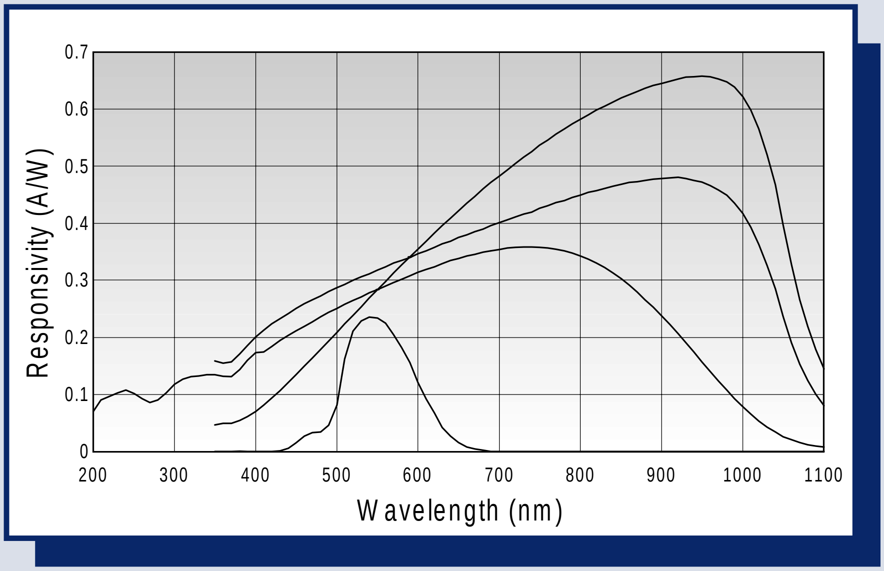
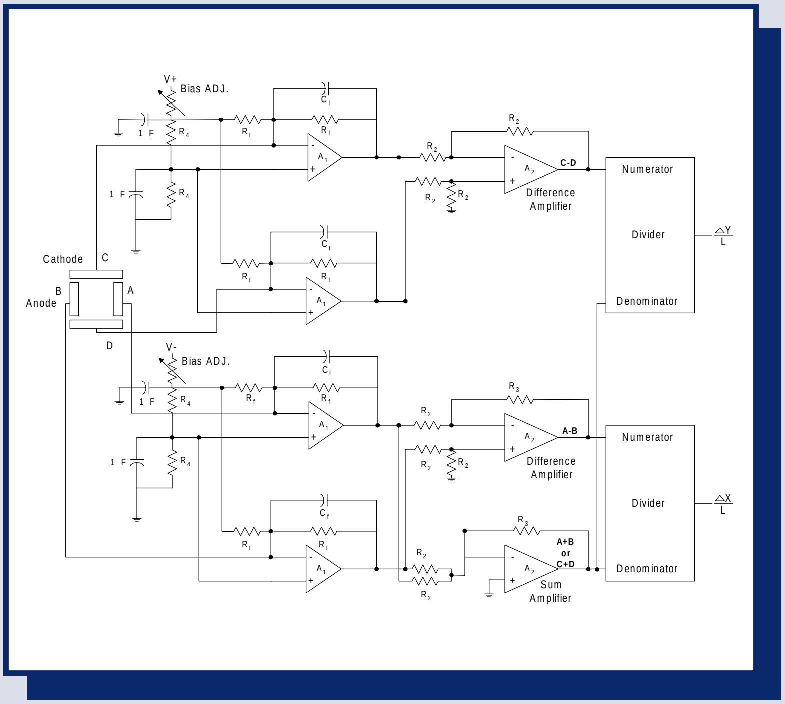
PHOTODIODE CHARACTERSITICS AND APPLICATIONS

INTRODUCTION



- Photovoltaic
- Photoconductive
- Blue Enhanced
- UV-Enhanced
- Suppressd IR
- Soft X-ray Enhanced
- High Energy Particle Enhanced
- Large Active Area High Speed Response
- Fiber Optic
- Avalanche
- Position Sensing

- High Speed Response
- Low Speed Response
- High Light Level
- Low Light Level
- Tetra-Lateral and Duo-Lateral PSDs
- Segmented, Multi-Element Arrays
- CT-Scanning



Silicon photodiodes are semiconductor devices responsive to high-energy particles and photons. Photodiodes operate by absorption of photons or charged particles and generate a flow of current in an external circuit, proportional to the incident power. Photodiodes can be used to detect the presence or absence of minute quantities of light and can be calibrated for extremely accurate measurements from intensities below 1 pW/cm^2 to intensities above 100 mW/cm^2. Silicon photodiodes are utilized in such diverse applications as spectroscopy, photography, analytical instrumentation, optical position sensors, beam alignment, surface characterization, laser range finders, optical communications, and medical imaging instruments.

PLANAR DIFFUSED SILICON PHOTODIODE CONSTRUCTION

Planar diffused silicon photodiodes are simply P-N junction diodes. A P-N junction can be formed by diffusing either a P-type impurity (anode), such as Boron, into a N-type bulk silicon wafer, or a N-type impurity, such as Phosphorous, into a P-type bulk silicon wafer. The diffused area defines the photodiode active area. To form an ohmic contact another impurity diffusion into the backside of the wafer is necessary. The impurity is an N-type for P-type active area and P-type for an N-type active area. The contact pads are deposited on the front active area on defined areas, and on the backside, completely covering the device. The active area is then deposited on with an anti-reflection coating to reduce the reflection of the light for a specific predefined wavelength. The non-active area on the top is covered with a thick layer of silicon oxide. By controlling the thickness of bulk substrate, the speed and responsivity of the photodiode can be controlled. Note that the photodiodes, when biased, must be operated in the reverse bias mode, i.e. a negative voltage applied to anode and positive voltage to cathode.

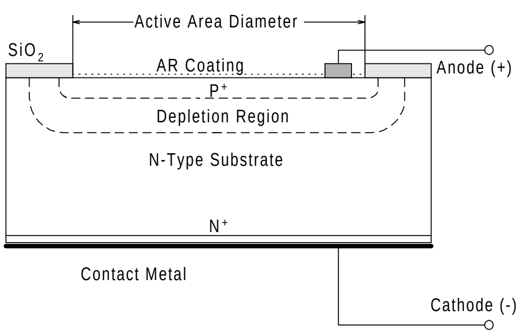


Figure 1. Planar diffused silicon photodiode

PRINCIPLE OF OPERATION

Silicon is a semiconductor with a band gap energy of 1.12 eV at room temperature. This is the gap between the valence band and the conduction band. At absolute zero temperature the valence band is completely filled and the conduction band is vacant. As the temperature increases, the electrons become excited and escalate from the valence band to the conduction band by thermal energy. The electrons can also be escalated to the conduction band by particles or photons with energies greater than 1.12eV, which corresponds to wavelengths shorter than 1100 nm. The resulting electrons in the conduction band are free to conduct current.

Due to concentration gradient, the diffusion of electrons from the N-type region to the P-type region and the diffusion of holes from the P-type region to the N-type region, develops a *built-in voltage* across the junction. The inter-diffusion of electrons and holes between the N and P regions across the junction results in a region with no free carriers. This is the *depletion region*. The built-in voltage across the depletion region results in an electric field with maximum at the junction and no field outside of the depletion region. Any applied reverse bias adds to the built in voltage and results in a wider depletion region. The electron-hole pairs generated by light are swept away by drift in the depletion region and are collected by diffusion from the undepleted region. The current generated is proportional to the incident light or radiation power. The light is absorbed exponentially with distance and is proportional to the absorption coefficient. The absorption coefficient is very high for shorter wavelengths in the UV region and is small for longer wavelengths (Figure 2). Hence, short wavelength photons such as UV, are absorbed in a thin top surface layer while silicon becomes transparent to light wavelengths longer than 1200 nm. Moreover, photons with energies smaller than the band gap are not absorbed at all.

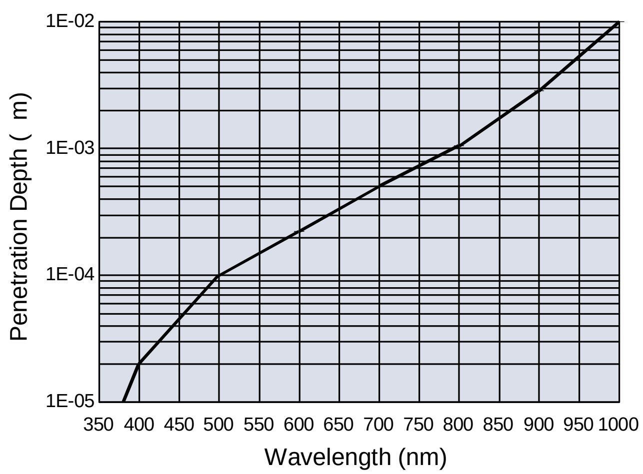


Figure 2. Penetration depth of light into silicon substrate for various wavelengths.

ELECTRICAL CHARACTERISTICS

A silicon photodiode can be represented by a current source in parallel with an ideal diode (Figure. 3). The current source represents the current generated by the incident radiation, and the diode represents

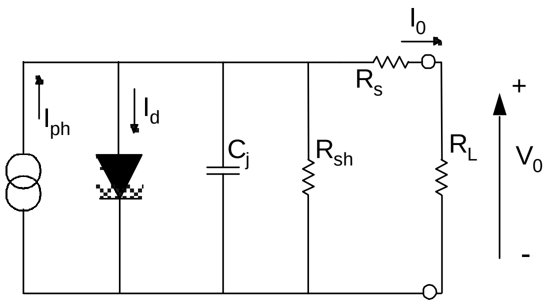


Figure 3. Equivalent Circuit for the silicon photodiode

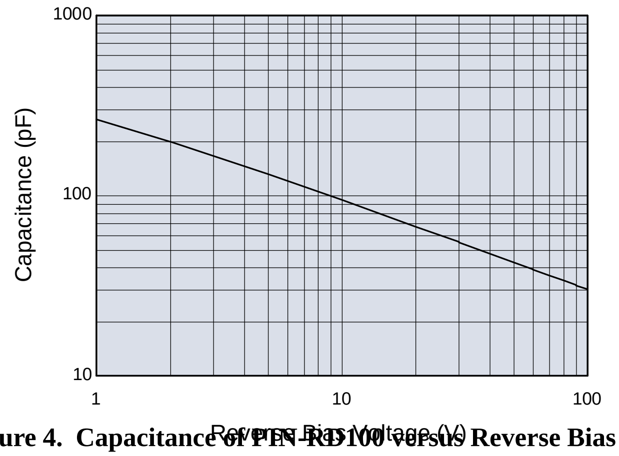


Figure 4. Capacitance of PIN-RD100 versus Reverse Bias Voltage

the p-n junction. In addition, a *junction capacitance* (C_j) and a *shunt resistance* (R_{SH}) are in parallel with the other components. *Series resistance* (R_S) is connected in series with all components in this model.

Shunt Resistance, R_{SH}

Shunt resistance is the slope of the current-voltage curve of the photodiode at the origin, i.e. V=0. Although an ideal photodiode should have a shunt resistance of infinite, actual values range from 10s to 1000s of Mega ohms. Experimentally it is obtained by applying ±10 mV, measuring the current and calculating the resistance. Shunt resistance is used to determine the noise current in the photodiode with no bias (photovoltaic mode). For best photodiode performance the highest shunt resistance is desired.

Series Resistance, R_S

Series resistance of a photodiode arises from the resistance of the contacts and the resistance of the undepleted silicon (Figure 1). It is given by:

$$R_S = \frac{(W_S - W_d)\rho}{A} + R_C \qquad (1)$$

Where W_S is the thickness of the substrate, W_d is the width of the depleted region, A is the diffused area of the junction, ρ is the resistivity of the substrate and R_C is the contact resistance. Series resistance is used to determine the linearity of the photodiode in photovoltaic mode (no bias, V=0). Although an ideal photodiode should have no series resistance, typical values ranging from 10 to 1000 ohm is measured.

Junction Capacitance, C_J

The boundaries of the depletion region act as the plates of a parallel plate capacitor (Figure 1). The junction capacitance is directly proportional to the diffused area and inversely proportional to the width of the depletion region. In addition, higher resistivity substrates have lower junction capacitance. Furthermore, the capacitance is dependent on the reverse bias as follows:

$$C_J = \frac{\varepsilon_{Si}\varepsilon_0 A}{\sqrt{2\varepsilon_{Si}\varepsilon_0 \mu\rho(V_A + V_{bi})}} \qquad (2)$$

where ε_0= 8.854x10^{-14} F/cm, is the permittivity of free space, ε_{Si}=11.9 is the silicon dielectric constant, μ = 1400 cm^2/Vs is the mobility of the electrons at 300 ºK, ρ is the resistivity of the silicon, V_{bi} is the built-in voltage of silicon and V_A is the applied bias. Figure 4 shows the dependence of the capacitance on the applied reverse bias voltage. Junction capacitance is used to determine the speed of the response of the photodiode.

Rise/Fall Time and Frequency Response, t_r / t_f / f_{3dB}

The rise time and fall time of a photodiode is defined as the time for the signal to rise or fall from 10% to 90% or 90% to 10% of the final value respectively. This parameter can be also expressed as frequency response, which is the frequency at which the photodiode output decreases by 3dB. It is roughly approximated by:

$$t_r = \frac{0.35}{f_{3dB}} \qquad (3)$$

There are three factors defining the response time of a photodiode:

1. t_{DRIFT}, the charge collection time of the carriers in the depleted region of the photodiode.
2. $t_{DIFFUSED}$, the charge collection time of the carriers in the undepleted region of the photodiode.
3. t_{RC}, the RC time constant of the diode-circuit combination.

t_{RC} is determined by t_{RC}=2.2 RC, where *R*, is the sum of the diode series resistance and the load resistance ($R_S + R_L$), and *C*, is the sum of the photodiode junction and the stray capacitances (C_j+C_S). Since the junction capacitance (C_j) is dependent on the diffused area of the photodiode and the applied reverse bias (Equation 2), faster rise times are obtained with smaller diffused area photodiodes, and larger applied reverse biases. In addition, stray capacitance can be minimized by using short leads, and careful lay-out of the electronic components. The total rise time is determined by:

$$t_R = \sqrt{t_{DRIFT}^{\;2} + t_{DIFFUSED}^{\;2} + t_{RC}^{\;2}} \qquad (4)$$

Generally, in photovoltaic mode of operation (no bias), rise time is dominated by the diffusion time for diffused areas less than 5 mm^2 and by RC time constant for larger diffused areas for all wavelengths. When operated in photoconductive mode (applied reverse bias), if the photodiode is fully depleted, such as fiber optic series, the dominant factor is the drift time. In non-fully depleted photodiodes, however, all three factors contribute to the response time.

OPTICAL CHARACTERISTICS

Responsivity, R_λ

The responsivity of a silicon photodiode is a measure of the sensitivity to light, and it is defined as the ratio of the photocurrent I_P to the incident light power P at a given wavelength:

$$R_\lambda = \frac{I_P}{P} \qquad (5)$$

In another words, it is a measure of the effectiveness of the conversion of the light power into electrical current. It varies with the wavelength of the incident light (Figure 5) as well as applied reverse bias and temperature.

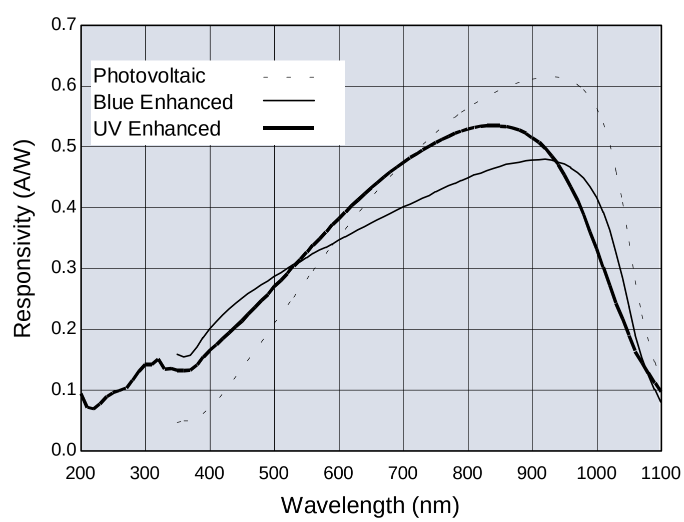


Figure 5. Typical Spectral Responsivity of Several Different Types of Planar Diffused Photodiodes

Responsivity increases *slightly* with applied reverse bias due to improved charge collection efficiency in photodiode. Also there are responsivity variations due to change in temperature as shown in figures 6 and 7. This is due to decrease or increase of the band gap, because of increase or decrease in the temperature respectively. Spectral responsivity may vary from lot to lot and it is dependent on wavelength. However, the relative variations in responsivity can be reduced to less than 1% on a selected basis.

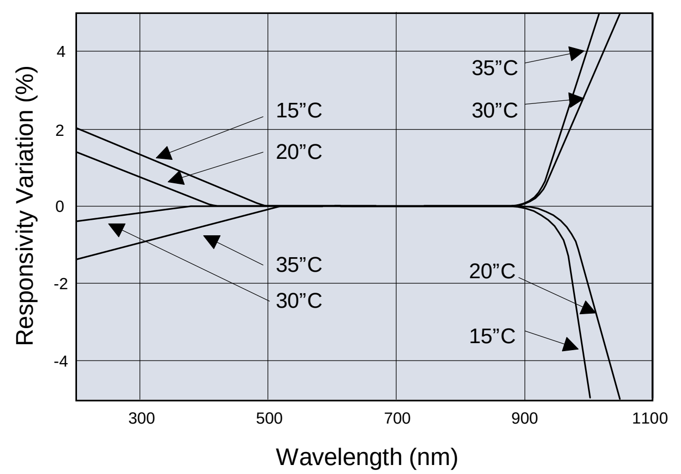


Figure 6. Temperature Dependance of Responsivity

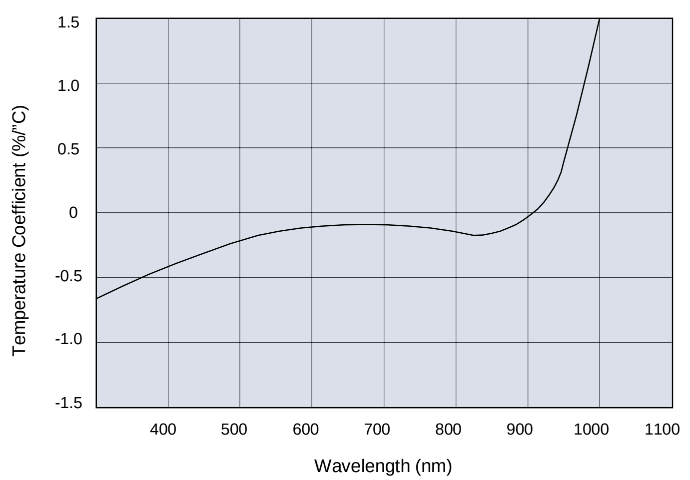


Figure 7. Temperature Coefficient of Silicon Photodiode

Quantum Efficiency, **Q.E.**

Quantum efficiency is defined as the percentage of the incident photons that contribute to photocurrent. It is related to responsivity by:

$$Q.E. = \frac{R_{\lambda\ Observed}}{R_{\lambda\ Ideal}\ (100\%)} = R_\lambda \frac{hc}{\lambda q} = 1.24\times10^3\ \frac{R_\lambda}{\lambda} \qquad (6)$$

where h=6.63 x 10^{-34} J-s, is the Planck constant, c=3 x 10^8 m/s, is the speed of light, q=1.6 x 10^{-19} C, is the electron charge, R_λ is the responsivity in A/W and λ is the wavelength in nm.

Non-Uniformity

Non-Uniformity of response is defined as variations of responsivity observed over the surface of the photodiode active area with a small spot of light. Non-uniformity is inversely proportional to spot size, i.e. larger non-uniformity for smaller spot size.

Non-Linearity

A silicon photodiode is considered linear if the generated photocurrent increases *linearly* with the incident light power. Photocurrent linearity is determined by measuring the small change in photocurrent as a result of a small change in the incident light power as a function of total photocurrent or incident light power. Non-Linearity is the variation of the ratio of the change in photocurrent to the same change in light power, i.e. ΔI/ΔP. In another words, linearity exhibits the consistency of responsivity over a range of light power. Non-linearity of less than ±1% are specified over 6-9 decades for planar diffused photodiodes. The lower limit of the photocurrent linearity is determined by the noise current and the upper limit by the series resistance and the load resistance. As the photocurrent increases, first the non-linearity sets in, gradually increasing with increasing photocurrent, and finally at saturation level, the photocurrent remains constant with increasing incident light power. In general, the change in photocurrent generated for the same change in incident light power, is smaller at higher current levels, when the photodetector exhibits non-linearity. The linearity range can slightly be extended by applying a reverse bias to the photodiode.

I-V CHARACTERISTICS

The current-voltage characteristic of a photodiode with no incident light is similar to a rectifying diode. When the photodiode is forward biased, there is an exponential increase in the current. When a reverse bias is applied, a small reverse saturation current appears. It is related to dark current as:

$$I_D = I_{SAT}\left(e^{\frac{qV_A}{k_BT}} - 1\right) \qquad (7)$$

where I_D is the photodiode dark current, I_{SAT} is the reverse saturation current, q is the electron *charge*, V_A is the applied bias voltage, k_B=1.38 x 10^{-23} J / ºK, is the Boltzmann Constant and T is the absolute temperature (273 ºK= 0 ºC).

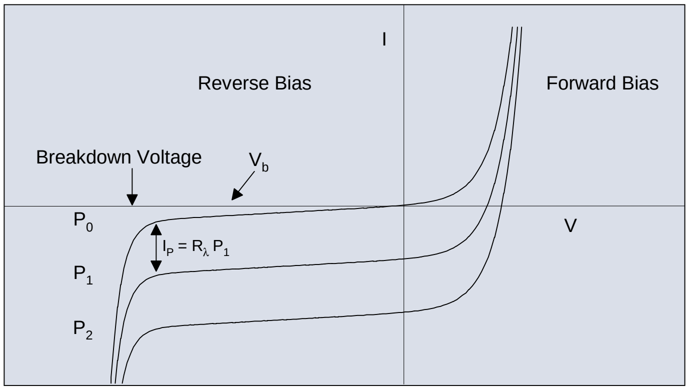


Figure 8. Characteristic IV Curves of a UDT photodiode for PC and PV modes of operation. P_0-P_2 represent different light levels.

This relationship is shown in figure 8. From equation 7, three various states can be defined:

a) V = 0, In this state, the current becomes the reverse saturation current.

b) V = +V, In this state the current increases exponentially. This state is also known as forward bias mode.

c) V = -V, When a reverse bias is applied to the photodiode, the current behaves as shown in figure 8.

Illuminating the photodiode with optical radiation, shifts the I-V curve by the amount of photocurrent (I_p). Thus:

$$I_{TOTAL} = I_{SAT}\left(e^{\frac{qV_A}{k_BT}} - 1\right) + I_P \qquad (8)$$

where I_P is defined as the photocurrent in equation 5.

As the applied reverse bias increases, there is a sharp increase in the photodiode current. The applied reverse bias at this point is referred to as *breakdown voltage*. This is the maximum applied reverse bias, below which, the photodiode should be operated (also known as maximum reverse voltage). Breakdown voltage, varies from one photodiode to another and is usually measured, for small active areas, at a photodiode current of 10 µA.

NOISE

In a photodiode two sources of noise can be identified. Shot noise and Johnson noise:

Shot Noise

Shot noise is related to the statistical fluctuation in both the photocurrent and the dark current. The magnitude of the shot noise is expressed as the root mean square (rms) noise current:

$$I_{sn} = \sqrt{2q\left(I_P + I_D\right)\Delta f} \quad (9)$$

Where q=1.6x10^{-19}C, is the electron charge, I_P is the photogenerated current, I_D is the photodetector dark current and Δf is the noise measurement bandwidth. Shot noise is the dominating source when operating in photoconductive (biased) mode.

Thermal or Johnson Noise

The shunt resistance in a photodetector has a Johnson noise associated with it. This is due to the thermal generation of carriers. The magnitude of the this generated current noise is:

$$I_{jn} = \sqrt{\frac{4k_B T\Delta f}{R_{SH}}} \quad (10)$$

Where k_B=1.38 x 10^{-23} J/ºK, is the Boltzmann Constant, *T*, is the absolute temperature in degrees Kelvin (273 ºK= 0 ºC), Δf is the noise measurement bandwidth and R_{SH} , is the shunt resistance of the photodiode. This type of noise is the dominant current noise in photovoltaic (unbiased) operation mode.

Note: All resistors have a Johnson noise associated with them, including the load resistor. This additional noise current is large and adds to the Johnson noise current caused by the photodetector shunt resistance.

Total Noise

The total noise current generated in a photodetector is determined by:

$$I_{tn} = \sqrt{I_{sn}^{\ 2} + I_{jn}^{\ 2}} \quad (11)$$

Noise Equivalent Power (NEP)

Noise Equivalent Power is the amount of incident light power on a photodetector, which generates a photocurrent equal to the noise current. NEP is defined as:

$$NEP = \frac{I_{tn}}{R_\lambda} \quad (12)$$

Where R_λ is the responsivity in A/W and I_{tn} is the total noise of the photodetector. NEP values can vary from 10^{-11} W/√Hz for large active area photodiodes down to 10^{-15} W /√Hz for small active area photodiodes.

TEMPERATURE EFFECTS

All photodiode characteristics are affected by the change in temperature. They include shunt resistance, dark current, breakdown voltage, responsivity and to a lesser extent other parameters such as junction capacitance.

Shunt Resistance and Dark Current:
There are two major currents in a photodiode contributing to dark current and shunt resistance. *Diffusion current* is the dominating factor in a photovoltaic (unbiased) mode of operation, which determines the shunt resistance. It varies as square of the temperature. In photoconductive mode (reverse biased), however, the *drift current* becomes the dominant current (dark current) and varies directly with temperature. Thus, change in temperature affects the photodetector more in photovoltaic mode than in photoconductive mode of operation.
In photoconductive mode the dark current may approximately double for every 10 ºC increase change in temperature. And in photovoltaic mode, shunt resistance may approximately double for every 6 ºC decrease in temperature. The exact change is dependent on additional parameters such as the applied reverse bias, resistivity of the substrate as well as the thickness of the substrate.

BreakDown Voltage:
For small active area devices, by definition breakdown voltage is defined as the voltage at which the dark current becomes 10µA. Since dark current increases with temperature, therefore, breakdown voltage decreases similarly with increase in temperature.

Responsivity:
Effects of temperature in responsivity are discussed in the "Responsivity" section of these notes.

BIASING

A photodiode signal can be measured as a voltage or a current. Current measurement demonstrates far better linearity, offset, and bandwidth performance. The generated photocurrent is proportional to the incident light power and it requires to be converted to voltage using a transimpedance configuration. The photodiode can be operated with or without an applied reverse bias depending on the application specific requirements. They are referred to as "Photoconductive" (biased) and "Photovoltaic" (unbiased) modes.

Photoconductive Mode (PC)

Application of a reverse bias (*i.e.* cathode positive, anode negative) can greatly improve the speed of response and linearity of the devices. This is due to increase in the depletion region width and consequently decrease in junction capacitance. Applying a reverse bias, however, will increase the dark and noise currents. An example of low light level / high-speed response operated in photoconductive mode is shown in figure 9.

In this configuration the detector is biased to reduce junction capacitance thus reducing noise and rise time (t_r). A two stage amplification is used in this example since a high gain with a wide bandwidth is required. The two stages include a transimpedance pre-amp for current-to-voltage conversion and a non-inverting amplifier for voltage amplification. Gain and bandwidth ($f_{3dB\,MAX}$) are directly determined by R_F, per equations (13) and (14) . The gain of the second stage is approximated by $1+ R_1 / R_2$. A feedback capacitor (C_F) will limit the frequency response and avoids gain peaking.

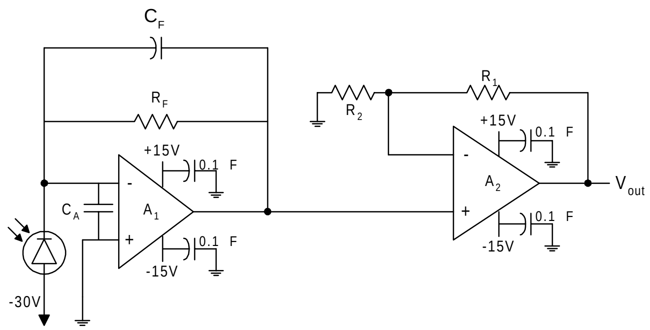


Figure 9. Photoconductive mode of operation circuit example: Low Light Level / Wide Bandwidth

$$f_{3dB\max}(Hz) = \sqrt{\frac{GBP}{2\pi\, R_F\, (C_j + C_F + C_A)}} \qquad (13)$$

Where GBP is the Gain Bandwidth Product of amplifier (A_1) and C_A is the amplifier input capacitance.

$$Gain\left(V\!/\!_W\right) = \frac{V_{OUT}}{I_P} = R_F\left(1 + \frac{R_1}{R_2}\right)R_\lambda \qquad (14)$$

In low speed applications, a large gain, e.g. >10MΩ can be achieved by introducing a large value (R_F) without the need for the second stage.

Typical component used in this configuration are:

Amplifier:	CLC-425, CLC-446, OPA-637, or similar.
R_F:	1 to 10 KΩ Typical, depending on C_j
R_1:	10 to 50 kΩ
R_2:	0.5 to 10 kΩ
C_F:	0.2 to 2 pF

In high speed, high light level measurements, however, a different approach is preferred. The most common example is pulse width measurements of short pulse gas lasers, solid state laser diodes, or any other similar short pulse light source. The photodiode output can be either directly connected to an oscilloscope (Figure 10) or fed to a fast response amplifier. When using an oscilloscope, the bandwidth of the scope can be adjusted to the pulse width of the light source for maximum signal to noise ratio. In this application the bias voltage is large. Two opposing protection diodes should be connected to the input of the oscilloscope across the input and ground.

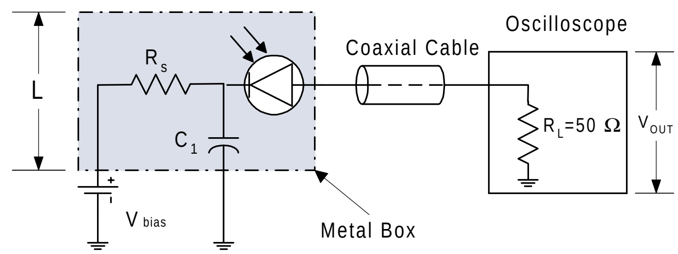


Figure 10. Photoconductive mode of operation circuit example: High Light Level / High Speed Response

To avoid ringing in the output signal, the cable between the detector and the oscilloscope should be short (i.e. < 20cm) and terminated with a 50 ohm load resistor (R_L). The photodiode should be enclosed in a metallic box, if possible, with short leads between the detector and the capacitor, and between the detector and the coaxial cable. The metallic box should be tied through a capacitor (C_1), with lead length (L) less than 2 cm, where $R_L C_1 > 10\,\tau$ (τ is the pulse width in seconds). R_S is chosen such that $R_S < V_{BIAS} / 10\, I_{PDC}$, where I_{PDC} is the DC photocurrent. Bandwidth is defined as 0.35 /τ. A minimum of 10V reverse bias is necessary for this application. Note that a bias larger than the photodiode maximum reverse voltage should not be applied.

Photovoltaic Mode (PV)

The photovoltaic mode of operation (unbiased) is preferred when a photodiode is used in low frequency applications (up to 350 kHz) as well as ultra low light level applications. In addition to offering a simple operational configuration, the photocurrents in this mode have less variations in responsivity with temperature. An example of an ultra low light level / low speed is shown in figure 11.

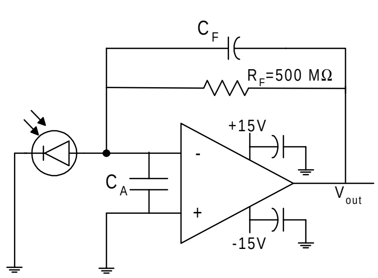


Figure 11. Photovoltaic mode of operation circuit example: Ultra low level light / low speed

In this example, a FET input operational amplifier as well as a large resistance feedback resistor (R_F) is considered. The detector is unbiased to eliminate any additional noise current. The total output is determined by equation (15) and the op-amp noise current is determined by R_F in equation (16):

$$V_{OUT} = I_P \times R_F \qquad (15)$$

$$I_N \left(\frac{A_{rms}}{\sqrt{Hz}}\right) = \sqrt{\frac{4kT}{R_F}} \qquad (16)$$

where k=1.38 x 10^{-23} J/ºK and T is temperature in ºK.

For stability, select C_F such that

$$\sqrt{\frac{GBP}{2\pi R_F (C_j + C_F + C_A)}} > \frac{1}{2\pi R_F C_F} \qquad (17)$$

Operating bandwidth, after gain peaking compensation is:

$$f_{OP}(Hz) = \frac{1}{2\pi R_F C_F} \qquad (18)$$

Some recommended components for this configuration are:

Amplifier: OP-15, OP-16, OP-17 or similar.
R_f : 500MΩ

These examples or any other configurations for single photodiodes can be applied to any of UDT Sensors' monolithic, common substrate liner array photodiodes. The output of the first stage pre-amplifiers can be connected to a sample and hold circuit and a multiplexer. Figure 12 shows the block diagram for such configuration.

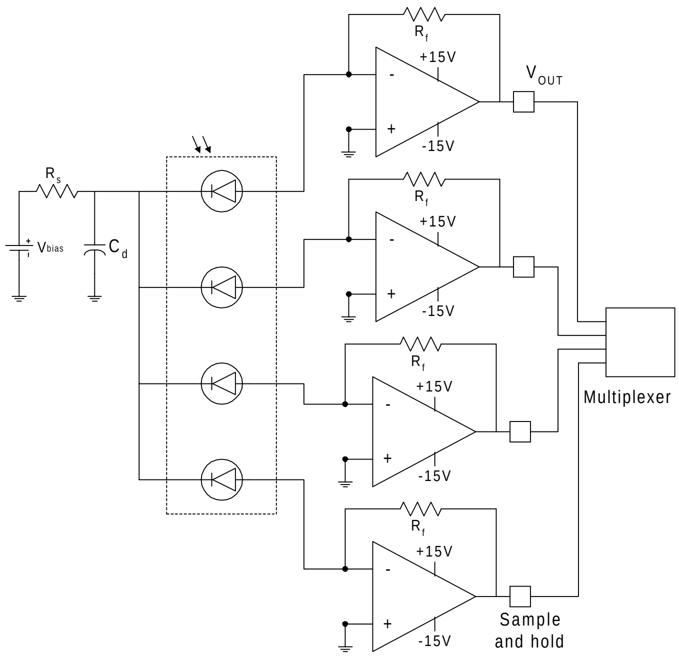


Figure 12. Circuit example for a multi-element, common cathode array

POSITION SENSING DETECTORS

Silicon photodetectors are commonly used for light power measurements in a wide range of applications such as bar-code readers, laser printers, medical imaging, spectroscopy and more. There is another function, however, which utilizes the photodetectors as optical position sensors. They are widely referred to as **P**osition **S**ensing **D**etectors or simply PSD. The applications vary from human eye movement monitoring, 3-D modeling of human motion to laser, light source, and mirrors alignment. They are also widely used in ultra-fast, accurate auto focusing schemes for a variety of optical systems, such as microscopes, machine tool alignment, vibration analysis and more. The position of a beam within fractions of microns can be obtained using PSD's. They are divided into two families: *segmented PSD's* and *lateral effect PSD's*.

Segmented PSD's, are common substrate photodiodes divided into either two or four segments (for one or two-dimensional measurements, respectively), separated by a gap or dead region. A symmetrical optical beam generates equal photocurrents in all segments, if positioned at the center. The relative position is obtained by simply measuring the output current of each segment. They offer position resolution better than 0.1 μm and accuracy higher than lateral effect PSD's due to superior responsivity match between the elements. Since the position resolution is not dependent on the S/N of the system, as it is in lateral effect PSD's, very low light level detection is possible. They exhibit excellent stability over time and temperature and fast response times necessary for pulsed applications. They are however, confined to certain limitations, such as the light spot has to overlap all segments at all times and it can not be smaller than the gap between the segments. It is important to have a uniform intensity distribution of the light spot for correct measurements. They are excellent devices for applications like nulling and beam centering.

Lateral effect PSD's, are continuous single element planar diffused photodiodes with no gaps or dead areas. These types of PSD's provide direct readout of a light spot displacement across the entire active area. This is achieved by providing an analog output directly proportional to both the position and intensity of a light spot present on the detector active area. A light spot present on the active area will generate a photocurrent, which flows from the point of incidence through the resistive layer to the contacts. This photocurrent is inversely proportional to the resistance between the incident light spot and the contact. When the input light spot is exactly at the device center, equal current signals are generated. By moving the light spot over the active area, the amount of current generated at the contacts will determine the exact light spot position at each instant of time. These electrical signals are proportionately related to the light spot position from the center.

The main advantage of lateral-effect diodes is their wide dynamic range. They can measure the light spot position all the way to the edge of the sensor. They are also independent of the light spot profile and intensity distribution that effects the position reading in the segmented diodes. The input light beam may be any size and shape, since the position of the centroid of the light spot is indicated and provides electrical output signals proportional to the displacement from the center. The devices can resolve positions better than 0.5 μm. The resolution is detector / circuit signal to noise ratio dependent.

UDT Sensors manufactures two types of lateral effect PSD's. Duo-Lateral and Tetra-Lateral structures. Both structures are available in one and two-dimensional configurations.

In **duo-lateral PSD's**, there are two resistive layers, one at the top and the other at the bottom of the photodiode. The photocurrent is divided into two parts in each layer. This structure type can resolve light spot movements of less that 0.5 μm and have very small position detection error, all the way almost to the edge of the active area. They also exhibit excellent position linearity over the entire active area.

The **tetra-lateral PSD's**, own a single resistive layer, in which the photocurrent is divided into two or four parts for one or two dimensional sensing respectively. These devices exhibit more position non linearity at distances far away from the center, as well as larger position detection errors compared to duo-lateral types. However, they show smaller dark currents and faster response times compare to duo-lateral PSD's.

Glossary of Terms:

Position Detection Error (PDE) or Position non-linearity is defined as the geometric variation between the actual position and the measured position of the incident light spot. It is measured over 80% of the sensing length for single dimensional PSD's and 64% of the sensing area for two-dimensional PSD's. For all calculations, the zero point is defined as the electrical center. This is the point at which $I_1 = I_2$. The error is calculated using the following equation:

$$PDE\,(\mu m) = \left(\frac{I_2 - I_1}{I_2 + I_1}\right)L - X \qquad (19)$$

Where I_1 and I_2 are the photocurrents at the ends of the PSD, L is the sensing area half-length in μm, and X is the actual displacement of light spot from the electrical center in μm.

Percentage Position Non-linearity is determined by dividing the position detection error by the total length of the sensing area.

Interelectrode Resistance is the resistance between the two end contacts in one axis, measured with illumination.

Position Detection Thermal Drift is the position drift with change of temperature. It is the change in position divided by the total length. It is defined within 80% of length or 64% of the area for two-dimensional PSD's.

Position Resolution is defined as the minimum detectable displacement of a spot of light on the detector active area. The resolution is limited by the signal to noise ratio of the system. It depends on light intensity, detector noise, and electronics bandwidth. Position resolutions in excess of one part in ten million have been achieved with UDT Sensors lateral effect PSD's.

POSITION CALCULATIONS

Segmented PSD's

Figure 13 shows a typical circuit, used with UDT Sensors segmented photodiodes.

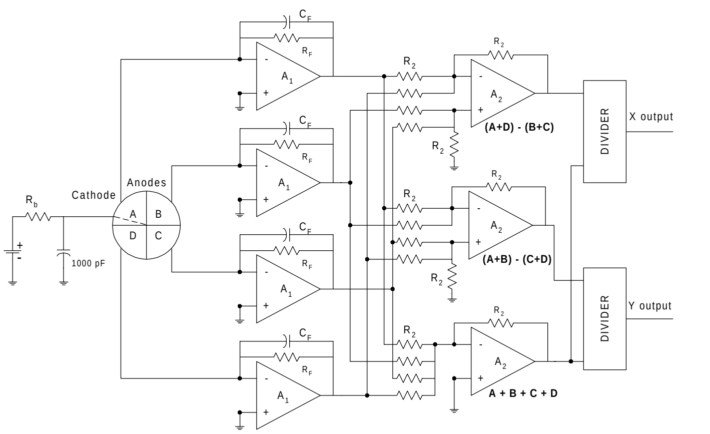


Figure 13. Typical circuit used with segmented photodiodes

The X and Y positions of the light spot with respect to the center on a quadrant photodiode is found by:

$$X = \frac{(A+D)-(B+C)}{A+B+C+D}$$
$$Y = \frac{(A+B)-(C+D)}{A+B+C+D} \qquad (20)$$

Where *A*, *B*, *C*, and *D* are the photocurrents measured by each sector. The recommended components for this circuit are application specific. However, the following components are widely used in most applications:

Amplifiers A_1 and A_2:	OP-37 or similar
Divider:	DIV-100 or similar
R_F and R_2:	10 kΩ to 10 MΩ
C_F:	$1 / (2\pi R_F f)$

The same circuit can be used for one-dimensional (bi-cell) measurments.

Lateral Effect PSD's

The one dimensional lateral effect measurements are the same for duo-lateral and tetra-lateral structures, since they both have two contacts on top with a common contact at the bottom. In tetra-lateral devices, however, the common contact is the anode with two cathodes on top, thus making them a *positive* current generator. In duo-lateral devices there are two anodes on top with a common cathode at the bottom. Figure 14 shows a typical circuit set up used with one-dimensional lateral PSD's.

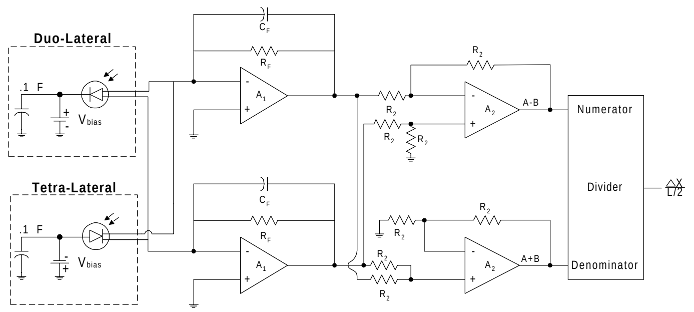


Figure 14. Typical circuit used with one dimensional lateral effect PSD's

In this configuration the outputs from the first stage are summed and subtracted in the second stage and finally divided by the divider in the final stage. The summation, subtraction and the division can be performed by software as well. The position is given as:

$$X = \frac{A-B}{A+B} \qquad (21)$$

The same components as the one used in segmented photodiodes can be used with R_2 varying from 1 kΩ to 100 kΩ.

For high-speed applications, the junctions can be reverse biased with a small gain (R_F). For low frequency applications, however, the photodiode can be left unbiased and the gain (R_F), can be as high as 100 MΩ. The feedback capacitor stabilizes the frequency dependence of the gain and can vary from 1 pF to 10 µF. The gain in the first stage amplifier is $I_P \times R_F$, and the gain of the second stage is unity.

Two Dimensional Duo-lateral PSD's

The two dimensional duo lateral PSD's with two anodes on top and two cathodes on the back surface of the photodiode measure positions in two different directions respectively. They provide a continuous position reading over the entire active area, with accuracy higher than the tetra-lateral PSD's. Figure 15 shows a typical circuit for two-dimensional duo-lateral PSD's.

For high-speed applications, the cathodes are usually forward

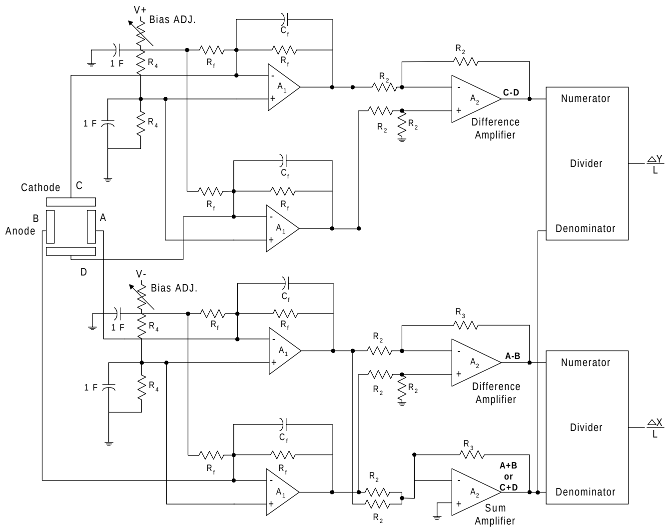


Figure 15. Typical Circuit used with two dimensional duo-lateral PSD's

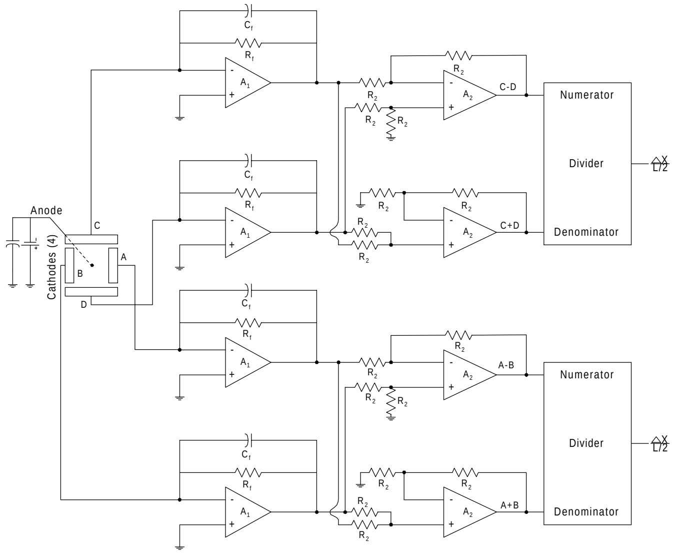


Figure 16. Typical Circuit used with two dimensional tetra-lateral PSD's

biased while the anodes are reverse biased. This extends the bias range that is normally limited by the maximum reverse voltage. Same components as the one-dimensional PSD's are recommended. The output is as following:

$$X = \frac{A-B}{A+B}$$
$$Y = \frac{C-D}{C+D} \qquad (22)$$

Tetra-Lateral PSD's

In a two dimensional tetra-lateral PSD there are four cathodes and one common anode. Similar to other PSD's, the signals from the detector is converted to voltage in the first stage and then summed and subtracted in the second stage and then finally divided in the final stage. This is shown in figure 16.

For high-speed applications, the anode is reverse biased and the feedback resistor (R_F) shall be chosen small. Additional gain can be achieved by additional stages. The recommended components and the output are similar to two-dimensional duo-lateral devices.

APPLICATION NOTES AND READING SOURCES

The following application notes are available for more technical information about specific uses and applications:

1. Silicon photodiodes come into their own
2. Silicon photodiodes - physics and technology
3. Noise and frequency response of silicon photodiode operational amplifier combination
4. Suitability of silicon photodiodes for laser emission measurements
5. Measuring LED outputs accurately
6. Radiometric and photometric concepts based on measurement techniques
7. Silicon photodiode device with 100% external quantum efficiency
8. Lateral-effect photodiodes
9. Techniques for using the position sensitivity of silicon photodetectors to provide remote machine control
10. Practical electro-optics deflection measurements system
11. Non-contact optical position sensing using silicon photodetectors
12. Continuous position sensing series (LSC, SC)
13. Using photodetectors for position sensing
14. High-precision, wide range, dual axis angle monitoring system
15. Real time biomechanical position sensing based on a lateral effect photodiode
16. A new optical transducer to measure damped harmonic motion
17. Quantum efficiency stability of silicon photodiodes
18. Neutron hardness of photodiodes for use in passive rubidium frequency standards
19. The effect of neutron irradiation on silicon photodiodes
20. Stable, high quantum efficiency, UV-enhanced silicon photodiodes by arsenic diffusion
21. Stable, high quantum efficiency silicon photodiodes for vacuum-UV applications
22. Stability and quantum efficiency performance of silicon photodiode detectors in the far ultraviolet
23. Silicon photodiodes with stable, near-theoretical quantum efficiency in the soft X-ray region

For any of the above documents, request them by number and write to:

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FAX:	(310) 644-1727
E-mail:	tech-support@udt.com
Web Site:	www.udt.com

RECOMMENDED SOURCES FOR FURTHER READING:

Graeme, Jerald, Photodiode Amplifiers, McGraw Hill, New York, 1996

Dereniak, E.L., and D.G. Crowe, Optical Radiation Detectors, Wiley, New York, 1984.

Keyes, R.J., Optical and Infrared Detectors, Vol. 19, Topics in Applied Physics, Springer-Verlag, New York, 1980.

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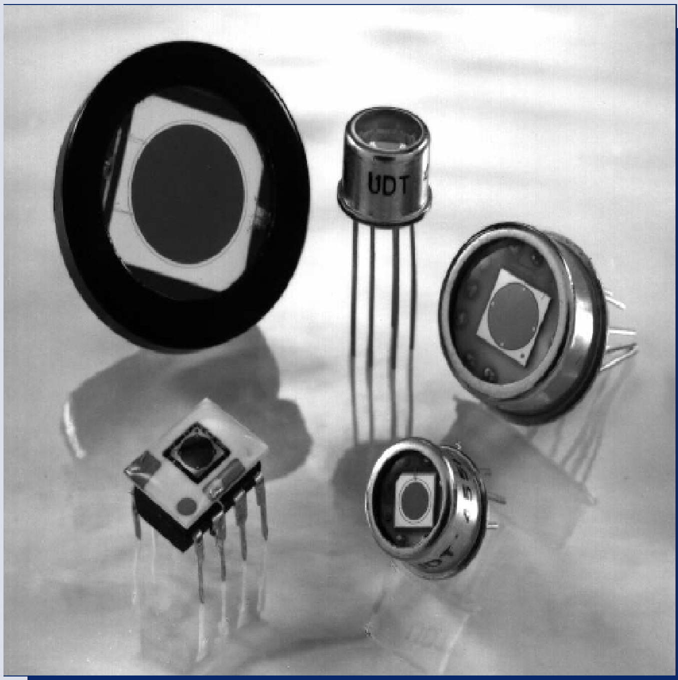
Wolfe, W.L. and G.J. Zissis, The Infrared Handbook, Superintendent of Documents, Washington D.C., 1979.

Standard Photodiodes

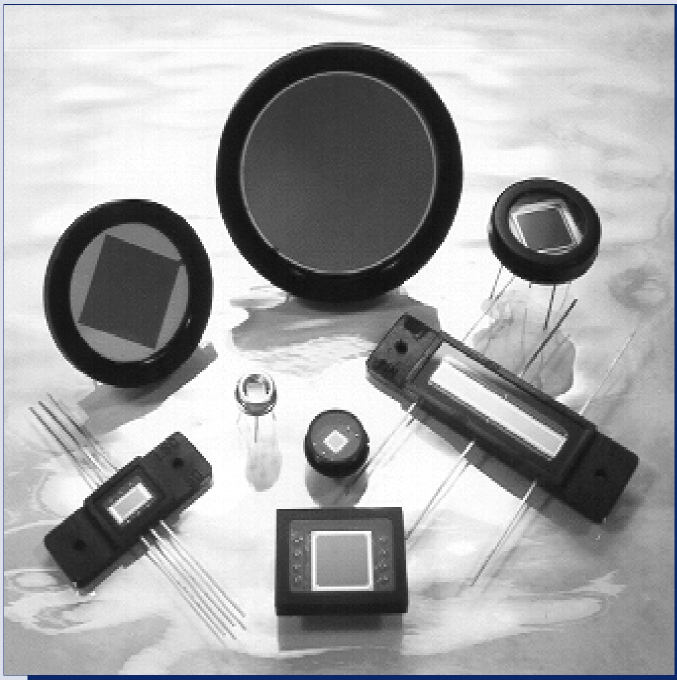
Electro-Optical Specifications and Design Notes

In addition to our wide variety of standard photodiodes appearing in the following pages, a majority of UDT Sensors products include a broad range of custom photodiodes and custom value-added products. Our strong design and engineering group can provide services from concept to final manufactured product.



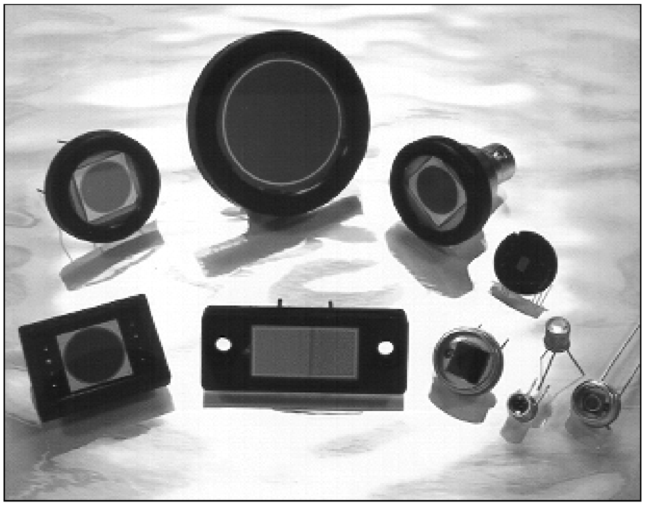
- **High Reliability, Military and Aerospace Detectors per Applicable MIL-STDs.**
- **High Energy Particle Detectors**
- **Detector / Hybrid Combinations (Thick, Thin and Combifilm Ceramics)**
- **Detector / Filter Combinations**
- **Detector / Emitter Combinations**
- **Detector / PCB Combinations**
- **Detector / Scintillator Crystal Combinations**

- **Color Temperature Detectors**
- **Low Cost Plastic molded Detectors**
- **Opto Switches and Interrupters**
- **Detector / Thermo-Electric Cooler Combinations**
- **Suface Mount Packages**
- **Custom Position Sensing Detectors**
- **Multi-Element Array (1D and 2D Configurations)**



Photoconductive Series

Planar Diffused Silicon Photodiodes



Applications

- Pulse Detectors
- Optical Communications
- Bar Code Readers
- Optical Remote Control
- Medical Equipment
- High Speed Photometry

Features

- High Speed Response
- Low Capacitance
- Low Dark Current
- Wide Dynamic Range
- High Responsivity

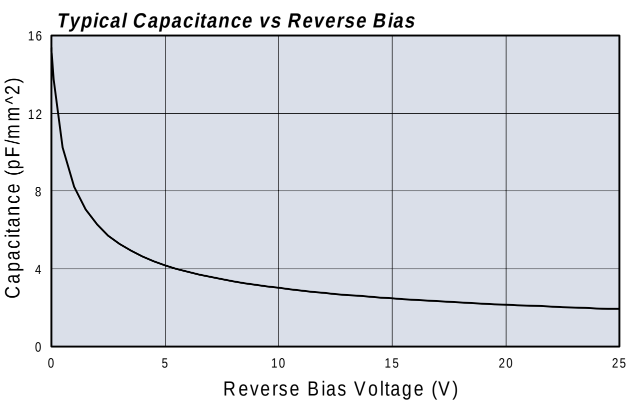
The Photoconductive Detector Series are suitable for high speed and high sensitivity applications. The spectral range extends from 350 to 1100 nm, making these photodiodes ideal for visible and near IR applications, including such AC applications as detection of pulsed LASER sources, LEDs, or chopped light.

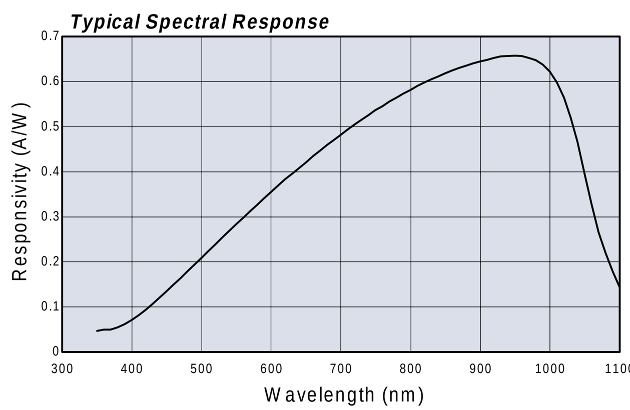
To achieve high speeds, these detectors should be reverse biased. Typical response times from 10 ns to 250 ns can be achieved with a 10V reverse bias, for example. When a reverse bias is applied, capacitance decreases (as seen in the figure below) corresponding directly to an increase in speed.

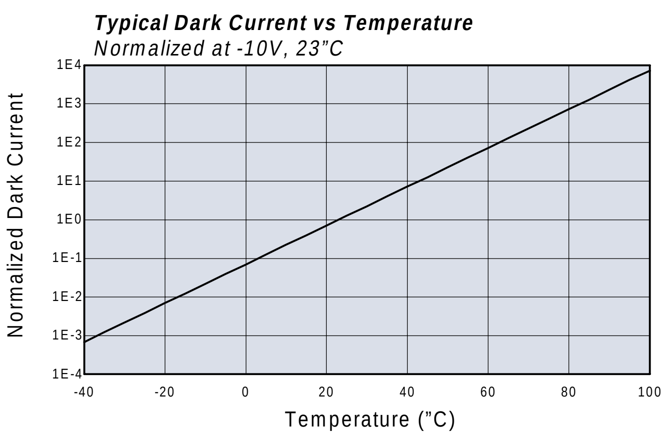
As indicated in the specification table, the reverse bias should not exceed 30 volts. Higher bias voltages will result in permanent damage to the detector.

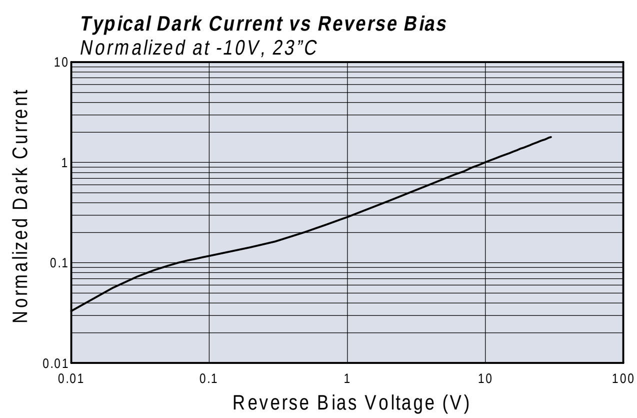
Since a reverse bias generates additional dark current, the noise in the device will also increase with applied bias. For lower noise detectors, the Photovoltaic Series should be considered.

Refer to the *Photoconductive Mode (PC)* paragraph in the "Photodiode Characteristics" section of this catalog for detailed information on electronics set up.







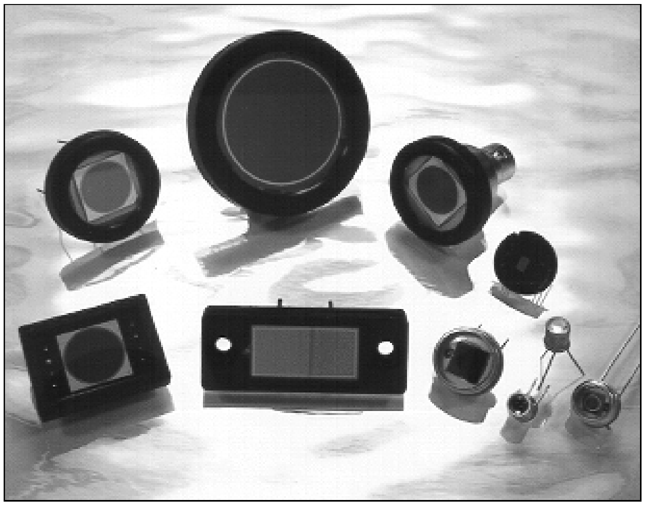


Model No.	Active Area: Area (mm^2)	Active Area: Dimension (mm)	Responsivity (A/W) 400 nm min	400 nm typ	632 nm min	632 nm typ	970 nm min	970 nm typ	Capacitance (pF) 0 V typ	Capacitance (pF) -10 V typ	Dark Current (nA) -10 V typ	Dark Current (nA) -10 V max	NEP (W/√Hz) -10V 970 nm typ	Reverse Voltage (V) max	Rise Time (ns) -10 V 632 nm 50 Ω typ	Temp Range (°C) Operating	Temp Range (°C) Storage	Package Style ¶
D SERIES, METAL PACKAGE																		
PIN-020A	.20	0.51 ϕ	.07	.12	.33	.40	.60	.65	4	1	.01	.15	2.8 e -15	30	26	-40 ~ +100	-55 ~ +125	1 / TO-18
PIN-040A	.81	1.02 ϕ							8	2	.05	.50	6.2 e -15		24			
PIN-2DI	1.1	.81 x 1.37							25	5	.10	1.0	8.7 e -15		13			4 / TO-18
PIN-3CDI	3.2	1.27 x 2.54							45	12	.15	2	1.1 e -14					
PIN-3CD																		7 / TO-18
PIN-5DI	5.1	2.54 ϕ							85	15	.25	3	1.4 e -14		12			2 / TO-5
PIN-5D																		5 / TO-5
PIN-13DI	13	3.6 sq							225	40	.35	6	1.6 e -14		14			2 / TO-5
PIN-13D																		5 / TO-5
PIN-6DI	16.4	4.57 ϕ							330	60	.5	10	1.9 e -14		17			3 / TO-8
PIN-6D																		6 / TO-8
PIN-44DI	44	6.6 sq							700	130	1	15	2.8 e -14		24			3 / TO-8
PIN-44D																		6 / TO-8
PIN-10DI	100	11.28 ϕ							1500	300	2	25	3.9 e -14		43	-10 ~ +60	-20 ~ +70	10 / Lo-Prof
PIN-10D																		11 / BNC
PIN-25D	613	27.9 ϕ							9500	1800	15	1000	1.1 e -13		250			12 / BNC
D SERIES, PLASTIC PACKAGE §																		
FIL-3C	3.2	1.27 x 2.54	.08	.12	.33	.40	.60	.65	45	12	.15	2	1.1 e- 14	30	13	-10 ~ +60	-20 ~ +70	14 / Plastic
FIL-5C	5.1	2.54 ϕ							85	15	.25	3	1.4 e- 14		12			
FIL-20C	16.4	4.57 ϕ							330	60	.5	10	1.9 e- 14		17			
FIL-44C	44	6.6 sq							700	130	1	15	2.8 e- 14		24			15 / Plastic
FIL-100C	100	11.28 ϕ							1500	300	2	25	3.9 e- 14		43			
PIN-220D	200	10 x 20							3200	600	5	100	6.2 e -14		75			26 / Plastic

The I suffix on the model number is indicative of the photodiode chip being isolated from the package by an additional pin connected to the case.
§ The photodiode chips in FIL series are isolated in a low profile plastic package. They have a large field of view as well as in line pins.
¶ For mechanical drawings please refer to pages 59 thru 71.

PHOTOVOLTAIC SERIES

PLANAR DIFFUSED SILICON PHOTODIODES



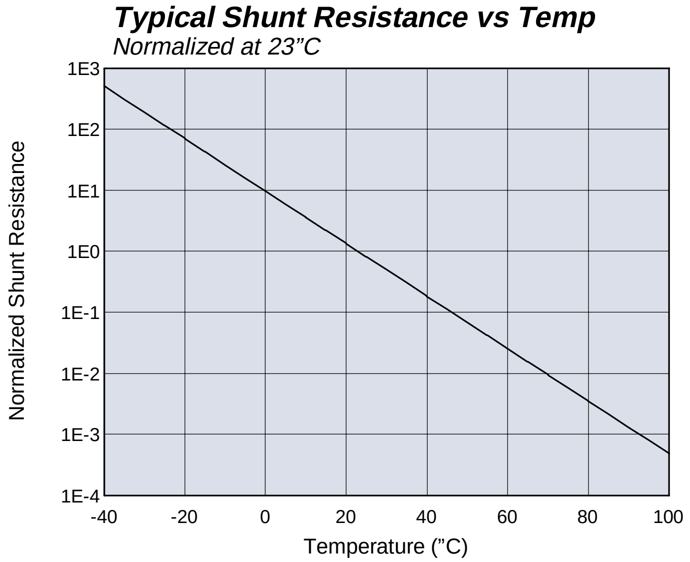
APPLICATIONS	FEATURES
• Colorimeters	• Ultra Low Noise
• Photometers	• High Shunt Resistance
• Spectroscopy Equipment	• Wide Dynamic Range
• Fluorescence	• Blue Enhanced

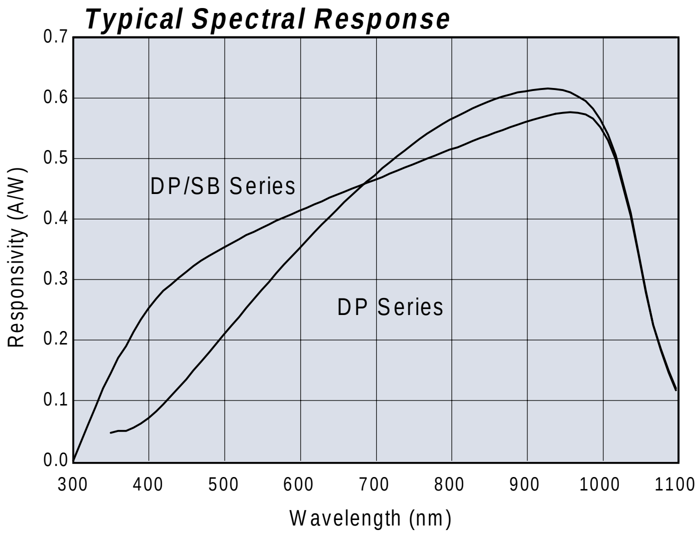
The Photovoltaic Detector series is utilized for applications requiring high sensitivity and moderate response speeds, with an additional sensitivity in the visible-blue region for the blue enhanced series. The spectral response ranges from 350 to 1100 nm, making the regular photovoltaic devices ideal for visible and near IR applications. For additional sensitivity in the 350 nm to 550 nm region, the blue enhanced devices are more suitable.

These detectors have high shunt resistance and low noise, and exhibit long term stability. Unbiased operation of these detectors offers stability under wide temperature variations in DC or low speed applications. For high light levels (greater than $10mW/cm^2$), the Photoconductive Series detectors should be considered for better linearity.

These detectors are not designed to be reverse biased! Very slight improvement in response time may be obtained with a slight bias. Applying a reverse bias of more than a few volts (>3V) will permanently damage the detectors. If faster response times are required, the Photoconductive Series should be considered.

Refer to the *Photovoltaic Mode (PV)* paragraph in the "Photodiode Characteristics" section of this catalog for detailed information on electronics set up.





DP Series, Metal Package

Model No.	Active Area: Area (mm²)	Active Area: Dimension (mm)	Responsivity (A/W) 400 nm min	400 nm typ	632 nm min	632 nm typ	970 nm min	970 nm typ	Capacitance (pF) 0 V typ	Shunt Resistance (MΩ) -10 mV min	-10 mV typ	NEP (W/√Hz) 0V 970 nm typ	Rise Time (ns) 0 V 632 nm 50 Ω typ	Temp Range (°C) Operating	Temp Range (°C) Storage	Package Style ¶
PIN-2DPI	1.1	.81 x 1.37							150	1000	10000	2.1 e -15	30			4 / TO-18
PIN-125DPL	1.6	1.27 sq.							160							8 / TO-18
PIN-3CDPI	3.2	1.27 x 2.54							320	750	5000	3.0 e -15	50			4 / TO-18
PIN-3CDP																7 / TO-18
PIN-5DPI	5.1	2.54 ϕ							500	500	4000	3.4 e -15	60			2 / TO-5
PIN-5DP																5 / TO-5
PIN-13DPI	13	3.6 sq							1200	350	3500	3.6 e -15	150	-40 ~ +100	-55 ~ +125	2 / TO-5
PIN-13DP																5 / TO-5
PIN-6DPI	16.4	4.57 ϕ	.07	.12	.33	.40	.55	.60	2000	200	3000	3.9 e -15	220			3 / TO-8
PIN-6DP																6 / TO-8
PIN-44DPI	44	6.6 sq							4300	100	2000	4.8 e -15	475			3 / TO-8
PIN-44DP																6 / TO-8
PIN-10DPI	100	11.28 ϕ							9800	50	1000	6.8 e -15	1000	-10 ~ +60	-20 ~ +70	10 / Lo-Prof
PIN-10DP																11 / BNC
PIN-25DP	613	27.9 ϕ							60000	2	50	3.0 e -14	6600			12 / BNC

DP Series, Plastic Package §

Model No.	Area (mm²)	Dimension (mm)	400 nm min	400 nm typ	632 nm min	632 nm typ	970 nm min	970 nm typ	Capacitance (pF) typ	Shunt min	Shunt typ	NEP typ	Rise Time typ	Operating	Storage	Package Style ¶
FIL-3V	3.2	1.27 x 2.54							320	750	5000	3.0 e -15	20			
FIL-5V	5.1	2.54 ϕ							500	500	4000	3.4 e -15	60			14 / Plastic
FIL-20V	16.4	4.57 ϕ	.08	.12	.33	.40	.55	.60	2000	200	3000	3.9 e -15	220	-10 ~ +60	-20 ~ +70	
FIL-44V	44	6.6 sq							4300	100	2000	4.8 e -15	475			
FIL-100V	100	11.28 ϕ							9800	50	1000	6.8 e -15	1000			15 / Plastic
PIN-220DP	200	10 x 20							20000	15	300	1.2 e -14	2200			26 / Plastic

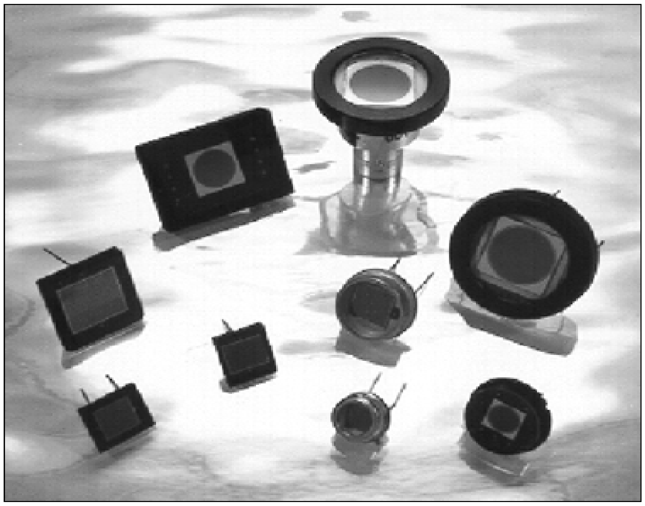
Super Blue Enhanced DP/SB Series (All Specifications @ λ = 410nm, V_{BIAS} = 0V, R_L = 50Ω)

Model No.	Active Area/Dimension mm²	mm	Responsivity (A/W) Min	Typ	Capacitance (pF) Typ	Rsh (MΩ) Min	NEP (W/√Hz) Typ	Operat. Current (mA) Max	Rise Time (ns) Typ			Pakcage Style ¶
PIN-5DP/SB	5.1	2.54 ϕ			450	150	5.2 e -14	2.0	0.2			5 / TO-5
PNI-10DP/SB	100	11.28 ϕ	0.15	0.20	8800	10	2.0 e -13	10.0	2.0	-10 ~ +60	-20 ~ +70	10 / LoProf
PIN-10DPI/SB												11 / BNC
PIN-220DP/SB	200	10 x 20			17000	5	2.9 e -13	10.0	4.0			26 / Plastic

The I suffix on the model number is indicative of the photodiode chip being isolated from the package by an additional pin connected to the case.
§ The photodiode chips in FIL series are isolated in a low profile plastic package. The have a large field of view as well as in line pins.
¶ For mechanical drawings please refer to pages 59 thru 71.
Operating Temperature: -40 to +100 °C, Storage Temperature: -55 to +125 °C.

UV ENHANCED SERIES

INVERSION LAYERS AND PLANAR DIFFUSED SILICON PHOTODIODES



APPLICATIONS

- Pollution Monitoring
- Medical Instrumentation
- UV Exposure Meters
- Spectroscopy
- Water Purification
- Fluorescence

FEATURES

- Inversion series:
  100% Internal QE
- Ultra High R_{SH}
- Planar Diffused Series:
  IR Suppressed
  High Speed Response
  High Stability
- Excellent UV response

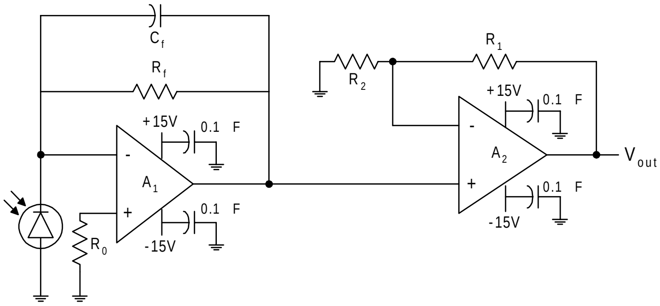
UDT Sensors offers two distinct families of UV enhanced silicon photodiodes. Inversion channel series and planar diffused series. Both families of devices are especially designed for low noise detection in the UV region of electromagnetic spectrum.

Inversion layer structure UV enhanced photodiodes exhibit 100% internal quantum efficiency and are well suited for low intensity light measurements. They have high shunt resistance, low noise and high breakdown voltages. The response uniformity across the surface and quantum efficiency improves with 5 to 10 volts applied reverse bias. In photovoltaic mode (unbiased), the capacitance is higher than diffused devices but decreases rapidly with an applied reverse bias. Photocurrent non-linearity sets in at lower photocurrents for inversion layer devices compared to the diffused ones. They represent highly stable responsivity under temperature changes up to 700 nm.

Planar diffused structure UV enhanced photodiodes show significant advantages over inversion layer devices, such as lower capacitance and higher response time. These devices exhibit linearity of photocurrent up to higher light input power compared to inversion layer devices.

They have relatively lower responsivities and quantum efficiencies compared to inversion layer devices. There are two types of planar diffused UV enhanced photodiodes available: UVD and UVE. Both series have almost similar electro-optical characteristics, except in the UVE series, where the near IR responses of the devices are suppressed. This is especially desirable if blocking the near IR region of the spectrum is necessary. UVD devices peak at 970 nm and UVE devices at 720 nm (see graph). Both series may be biased for lower capacitance, faster response and wider dynamic range. Or they may be operated in the photovoltaic (unbiased) mode for applications requiring low drift with temperature variations. The UVE devices have a higher shunt resistance than their counterparts of UVD devices, but have a higher capacitance.

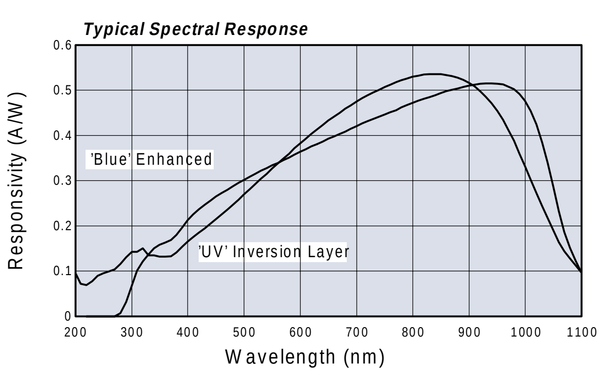
These detectors are ideal for coupling to an OP-AMP in the current mode configuration as shown below.

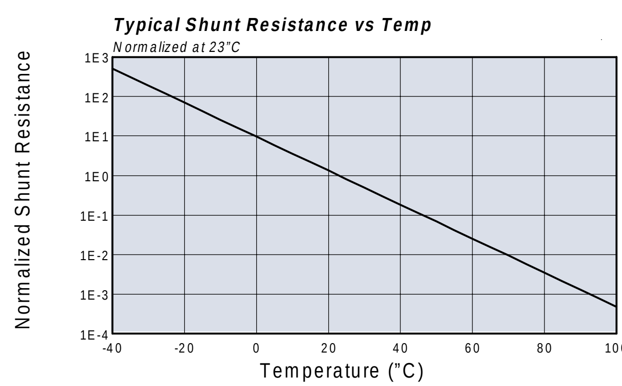


For further details, refer to the “Photodiode Characteristics” section of the catalog.

Model No.	Active Area		Responsivity (A/W)		Capacitance (pF)	Shunt Resistance (MΩ)		NEP (W/√Hz)	Reverse Voltage (V)	Rise Time (μs)	Operating Current (mA)	Temp Range (°C)		Package Style ¶
	Area (mm²)	Dimension (mm)	254 nm		0 V	-10 mV		0V 254 nm		0 V 254 nm 50 Ω	0 V	Operating	Storage	
			min	typ	typ	min	typ	typ	max	typ	max			
UV ENHANCED SERIES, METAL PACKAGE														
UV-001	0.8	1.0 ϕ			60	250	500	6.4 e -14		0.2				
UV-005	5.1	2.54 ϕ			300	80	200	1.0 e -13		0.9				5 / TO-5
UV-015	15	3.05 x 3.81			800	30	100	1.4 e -13		2.0		-20 ~ +60	-55 ~ +80	
UV-20	20	5.08 ϕ			1000	25	50	2.0 e -13		2.0				6 / TO-8
UV-35	35	6.60 x 5.33	.09	.14	1600	20	30	1.7 e -13	5	3.0	0.1			
UV-50														11 / BNC
UV-50L	50	7.87 ϕ			2500	10	20	2.6 e -13		3.5		-10 ~ +60	-20 ~ +70	10 / LoProf
UV-100														11 / BNC
UV-100L	100	11.28 ϕ			4500	5	10	4.5 e -13		5.9				10 / LoProf
UV ENHANCED SERIES, PLASTIC PACKAGE §														
FIL-UV005	5.1	2.54 ϕ			300	50	100	9.2 e -14		0.9				14 / Plastic
FIL-UV20	20	5.08 ϕ			1000	20	50	1.3 e -13		2.0				
UV-35P	35	6.60 x 5.33	.09	.14	1600	15	30	1.7 e -13	5	3.0	0.1	-10 ~ +60	-20 ~ +70	24 / Plastic
FIL-UV50	50	7.87 ϕ			2500	10	20	2.1 e -13		3.5				15 / Plastic
FIL-UV100	100	11.28 ϕ			4500	5	10	2.9 e -13		5.9				

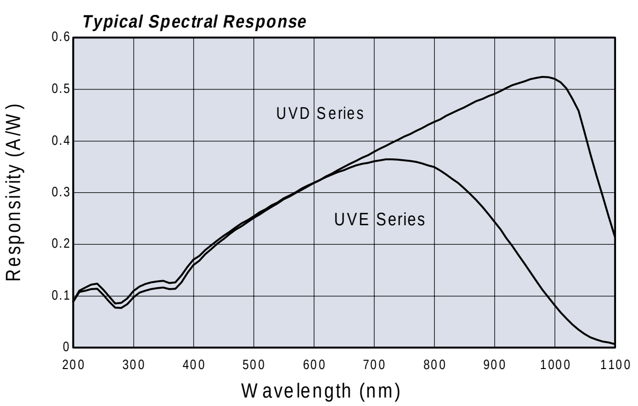
The I or L suffix on the model number is indicative of the photodiode chip being isolated from the package by an additional pin connected to the case.
§ The photodiode chips in FIL series are isolated in a low profile plastic package. The have a large field of view as well as in line pins.
¶ For mechanical drawings please refer to pages 59 thru 71.

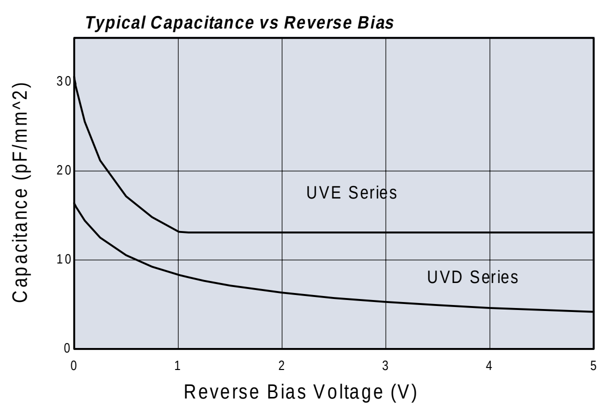


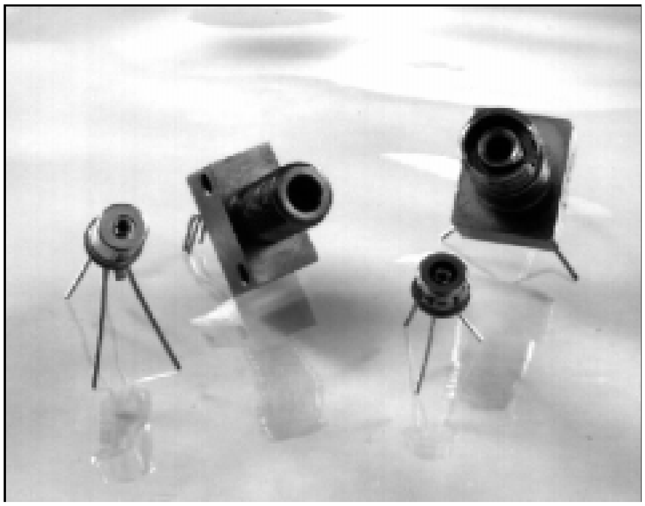


Model No.	Active Area		Peak Wavelength (nm)	Responsivity (A/W)			Capacitance (pF)	Shunt Resistance (GΩ)		NEP (W/√Hz)	Reverse Voltage (V)	Rise Time (µs)	Temp Range (°C)		Package Style ¶
	Area (mm^2)	Dimension (mm)		254 nm	633 nm	930 nm	0 V	-10 mV		0V 254 nm		0 V 254 nm 50 Ω	Operating	Storage	
				typ	typ	typ	typ	min	typ	typ	max	typ			
UVE SERIES METAL PACKAGE															
UV-005E	5.7	2.4 sq	720	0.10	0.33	0.17	200	0.50	10	1.3 e -14	5	0.15	-20 ~ +60	-55 ~ +80	5 / TO-5
UV-013E	13	3.6 sq					400	0.40	5	1.8 e -14		0.30			
UV-035E	34	5.8 sq					1000	0.20	1	4.1 e -14		0.80			6 / TO-8
UVE SERIES CERAMIC PACKAGE															
UV-005EC	5.7	2.4 sq	720	0.10	0.33	0.17	200	0.50	10	1.3 e -15	5	0.15	-20 ~ +60	-20 ~ +80	24/Ceramic
UV-035EC	34	5.8 sq					1000	0.20	1	4.1 e -14		0.80			
UV-100EC	100	10 sq					2500	0.10	0.50	5.8 e -14		1.00			
UVD SERIES METAL PACKAGE															
UV-005D	5.7	2.4 sq	970	0.10	0.33	0.50	100	0.30	4	2.0 e -14	5	0.10	-20 ~ +60	-55 ~ +80	5 / TO-5
UV-013D	13	3.6 sq					225	0.20	2	2.8 e -14		0.20			
UV-035D	34	5.8 sq					550	0.10	0.50	5.6 e -14		0.40			6 / TO-8
UVD SERIES CERAMIC PACKAGE															
UV-005DC	5.7	2.4 sq	970	0.10	0.33	0.50	100	0.30	4	2.0 e -14	5	0.10	-20 ~ +60	-20 ~ +80	24/Ceramic
UV-035DC	34	5.8 sq					550	0.10	0.5	5.6 e -14		0.20			
UV-100DC	100	10 sq					1750	0.04	0.20	9.1 e -14		1.00			

¶ For mechanical drawings please refer to pages 59 thru 71.







APPLICATIONS	FEATURES
• Fiber Optic Communication Links	• Speeds in sub ns
• Video Systems	• High gain
• Laser Monitoring Systems	• Low dark current
• Computers and Peripherals	• Low capacitance
• Industrial Controls	• TO-46 metal can With lensed cap
• Guidance Systems	
• FDDI Local Area Networks	
• High Speed Optical Communications	

UDT Sensors offers a variety of fiber optic detectors. They include:

Fiber Optic Series-Silicon: are several families of small active area silicon photodiodes divided into High Responsivity Series (HR), High Speed Series (HS) and Ultra High Speed (UHS) series.

Fiber Optic Series-Silicon / Hybrid: is a 90 MHz integrated silicon photodetector / transimpedance amplifier hybrid with a single power supply and linear differential output voltage for applications such as Ethernet and token ring systems. This detector is available with a micro lens cap.

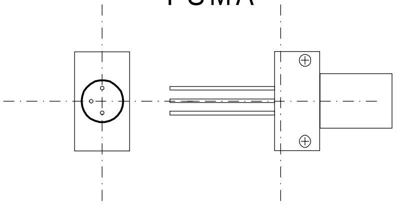
Fiber Optic Series-Silicon APD: is a small active area Silicon Avalanche Photodiode with gains up to a few hundred with a typical reverse bias of only 325 V. It provides high gain bandwidth product and high responsivity compared to detector/transimpedance amplifier combination.

Fiber Optic Series-Silicon BPX-65: is a 1 x 1 mm active area high speed silicon photodetector for high modulation bandwidth applications where a large active area is needed.

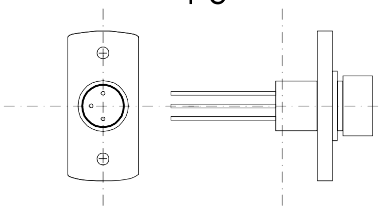
Fiber Optic Series-InGaAs: devices are high speed InGaAs detectors exhibiting a spectral range of 850 to 1700 nm. These detectors are specifically designed for NIR optical communication, providing high responsivity, low capacitance and high speed. They are available with micro lens cap.

All of the above detectors and /or hybrids are also available with a spherical micro lens cap to enhance fiber optic coupling efficiency. They can also be provided with any of the standard receptacles such as SMA, ST, FC, etc., for direct optical fiber coupling.

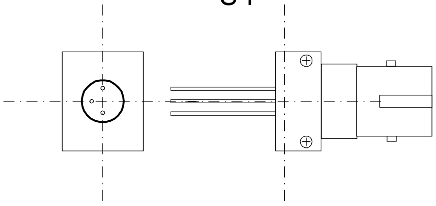
FSMA



FC

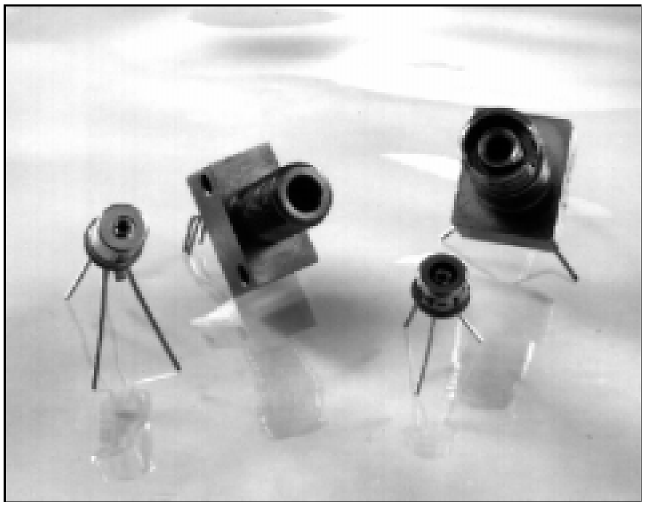


ST



HIGH SPEED SILICON SERIES

FIBER OPTIC PHOTODIODES



APPLICATIONS	FEATURES
• Fiber Optic Communication Links	• Sub ns Response
• Video Systems	• Low Dark Current
• Computers and Peripherals	• Low Capacitance
• Industrial Control	• TO-46 Package
• Guidance Systems	• w/ FO Receptacle
• Laser Monitoring	• w/ Lensed Cap

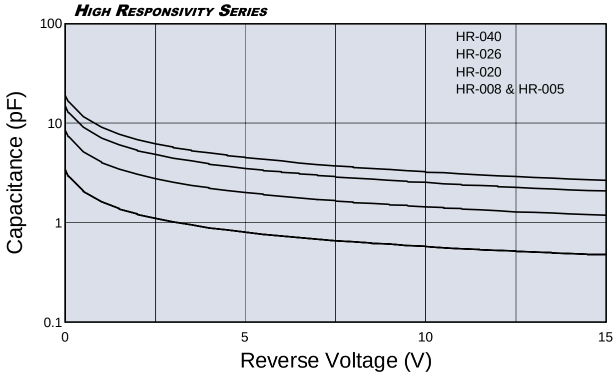
UDT Sensors Silicon Fiber Optic detector series consist of three families of small active area photodiodes with High Responsivity (HR Series), High Speed (HS Series) and Ultra High Speed (UHS Series) properties.

The spectral range for these devices are from 350 nm to 1100 nm. The responsivity and response time are optimized such that the HR series exhibit a peak responsivity of 0.50 A/W at 800 nm and typical response times of a few hundred pico seconds at -5V, while the HS series have a peak responsivity of 0.40 A/W at 750 nm and typical response times less than 500 ps at -3V.

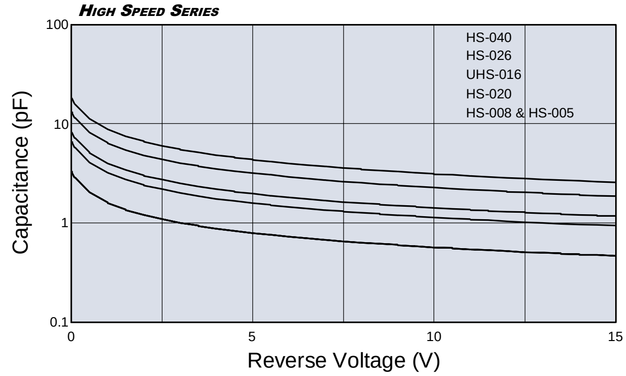
UDT Sensors' Ultra High Speed (UHS) detector demonstrates state of the art detector technology, achieving response times less than 300ps at -3V reverse bias.

Note that for all high-speed photodetectors, a reverse bias is required to achieve the fastest response times. However, the reverse bias should be limited to maximum reverse voltage specified to avoid damage to the detector. Output signals can be measured directly with an oscilloscope or coupled to high frequency amplifiers as shown in figure 10 of the Photodiode Characteristics section of the catalog.

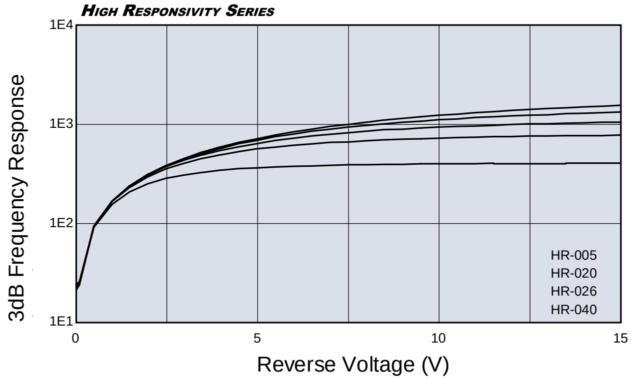
Typical Capacitance vs Reverse Bias
HIGH RESPONSIVITY SERIES



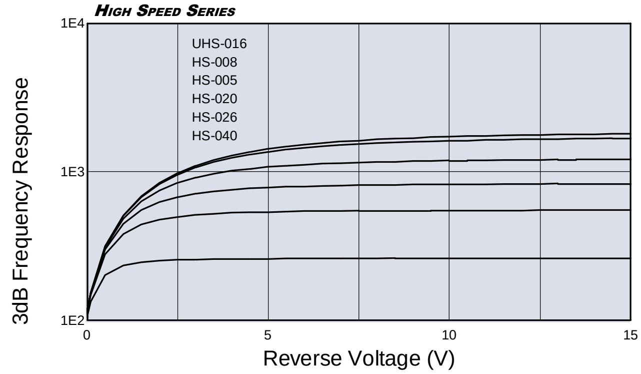
Typical Capacitance vs Reverse Bias
HIGH SPEED SERIES



Frequency Response vs Reverse Bias
HIGH RESPONSIVITY SERIES



Frequency Response vs Reverse Bias
HIGH SPEED SERIES



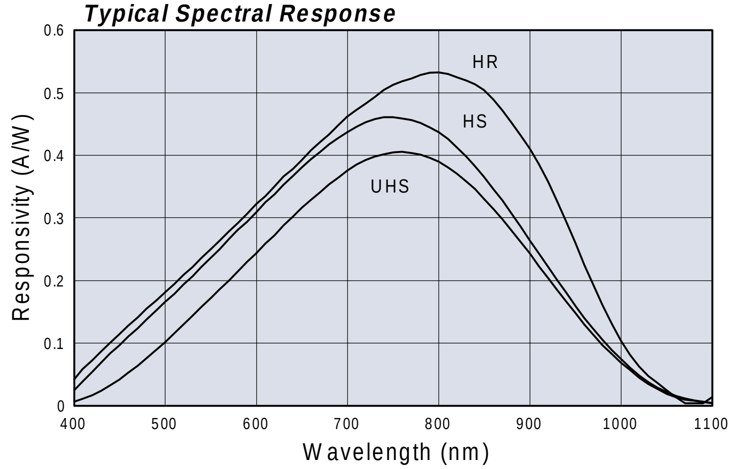
Model No.	Active Area: Area (mm^2)	Active Area: Dimension (mm)	Peak Wavelength (nm)	Responsivity (A/W) 830 nm min	Responsivity (A/W) 830 nm typ	Capacitance (pF) typ	Dark Current (nA) typ	Dark Current (nA) max	NEP (W/√Hz) 830 nm typ	Reverse Voltage (V) max	Rise Time § (ns) 830 nm 50 Ω typ	Rise Time § (ns) 830 nm 50 Ω max	Temp Range (℃) Operating	Temp Range (℃) Storage	Package Style ¶
HIGH SPEED SERIES (V_{BIAS}=-3 V)															
PIN-HS005 PIN-HS005L*	.01	0.127 ϕ	750	.35*	.40*	1.0	0.01	0.30	4.5 e-15	15	0.30	0.40	-40 ~ +100	-55 ~ +125	9 / TO-18
PIN-HS008 PIN-HS008L*	.04	0.203 sq				1.0	0.01	0.30	4.5 e-15		0.30	0.40			
PIN-HS020 PIN-HS020L*	.20	0.508 ϕ				2.5	0.02	0.50	6.3 e-15		0.40	0.50			
PIN-HS026 PIN-HS026L*	.34	0.660 ϕ				4.0	0.035	0.80	8.4 e-15		0.45	0.65			
PIN-HS040 PIN-HS040L*	.77	0.991 ϕ				5.5	0.05	1.50	1.0 e-14		0.65	0.90			
HIGH RESPONSIVITY SERIES (V_{BIAS}=-5 V)															
PIN-HR005 PIN-HR005L*	.01	0.127 ϕ	800	.45*	.50*	0.8	0.03	0.80	1.6 e -14	15	0.60	1.0			
PIN-HR008 PIN-HR008L*	.04	0.203 sq				0.8	0.03	0.80	1.6 e -14		0.60	1.0			
PIN-HR020 PIN-HR020L*	.20	0.508 ϕ				2.0	0.06	1.00	8.8 e-15		0.80	1.2			
PIN-HR026 PIN-HR026L*	.34	0.660 ϕ				3.5	0.085	1.50	1.0 e-14		0.90	1.4			
PIN-HR040 PIN-HR040L*	.77	0.991 ϕ				4.5	0.30	2.00	1.9 e-14		1.0	1.6			
ULTRA HIGH SPEED (V_{BIAS}=-3 V)															
PIN-UHS016 PIN-UHS016L*	.13	0.406 ϕ	750	.30*	.35*	2.0	0.020	0.50	7.2 e-15	15	0.25	0.30			

* Responsivtiy measured with a flat glass window. Refer to the specific family of devices for applied reverse bias.

¶ For mechanical drawings please refer to pages 59 thru 71.

Chip centering within – 0.005 inches w.r.t. the OD of header.

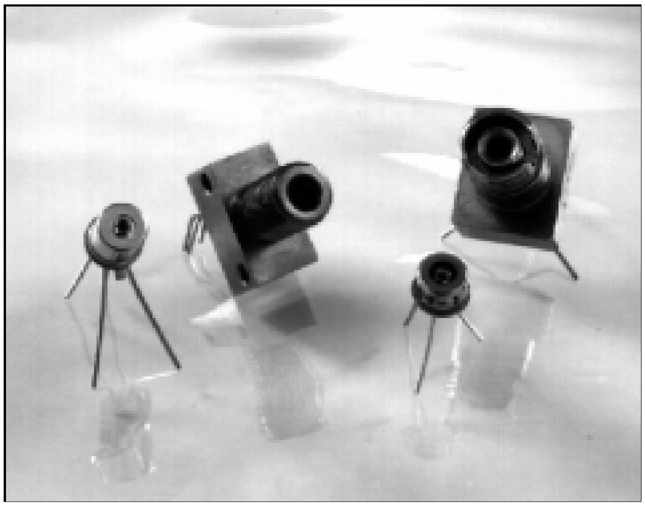
Typical Spectral Response



PRECAUTION: These devices are sensitive to electrostatic discharge (ESD). Use proper handling and testing procedures.

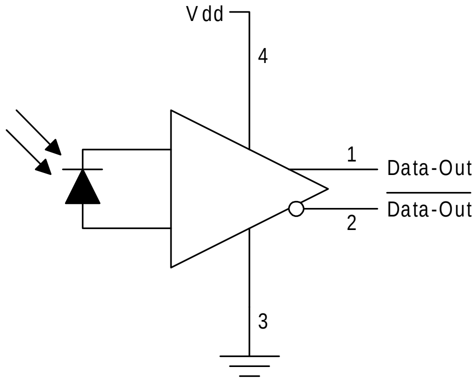
PIN-H90M

Fiber Optic Hybrid Photodiode



Applications	Features
• Ethernet and Token Ring Systems	• High Speed CMOS op-amp
• Fiber Based 10Base-FL	• High Sensitivity
• FOIRL	• Differential output
• WDM in 750-900 nm range	• Single +5V supply

The PIN-H90M is an integrated silicon photodetector and transimpedance amplifier hybrid mounted in a lensed TO-46 metal package, suitable for fiber optic coupling with any of standard fiber optic receptacles such as ST, SMA and FC. Fiber sizes from 50µm to 100µm can be accommodated when mounted in any the above receptacles. The device is capable of handling a bandwidth of 45 MHz minimum and operates from a single +5V supply. Furthermore, it provides a linear, differential output biased around a nominal 2.5V.



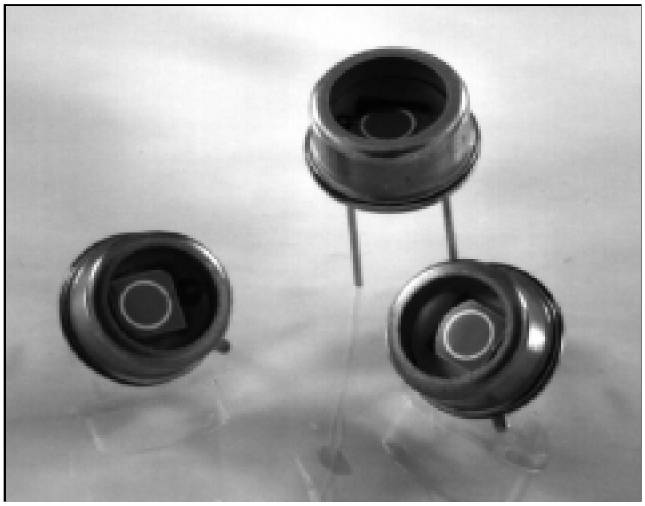
PARAMETER	SYMBOL	UNIT	CONDITION	MINIMUM	TYPICAL	MAXIMUM
Absolute Maximum Ratings						
Operating Temperature Range	TOP	”C	---	-40	---	+85
Storage Temperature Range	TST	”C	---	-50	---	+85
Lead Soldering Temperature	TSLD	”C	10 sec	---	---	+260
Package Style ¶	TO-18 with Micro Lens Cap					

¶ For mechanical drawings please refer to pages 59 thru 71, figure 16.

PARAMETER	SYMBOL	UNIT	CONDITION	MINIMUM	TYPICAL	MAXIMUM
OPERATING CONDITIONS						
Power Supply	V+	V	---	4.75	5.0	5.25
Spectral Range	λ_{RANGE}	nm	---	750	800	950
Resistive Load	R_L	Ω	---	400	---	---
Capacitive Load	C_L	pF	---	---	---	10
Power Supply Current	I_{DD}	mA	R_L=infinity	---	15	20
OPTICAL CHARACTERISTICS						
Peak Linear Input Power	P_{LIN}	dBm	---	---	---	-13
Saturation Input Power	P_{SAT}	dBm	---	---	---	-6
DC Output Voltage	V_{ODC}	V	---	2	2.5	3
Differential Output Voltage Swing	V_{OSG}	V	---	---	1	---
Output Sink / Source Current	I_{OUT}	mA	---	4	---	---
Output Impedance	Z_O	Ω	---	---	50	---
DYNAMIC CHARACTERISTICS						
Bandwidth	fc	MHz	---	45	90	---
Output Rise/Fall Times	t_R, t_F	ns	---	---	4	6
Pulse Width Distortion	PWD	ns	PW=10ns 50% duty cycle 50% amplitude	---	0.5	2.5
Overshoot	---	%	---	---	---	3
NOISE						
Equivalent Optical Noise Input	P_{NO}	dBm	DC-50MHz	---	-43	-41
Equivalent Optical Noise Voltage	V_{NO}	mV	---	---	---	0.5
TRANSFER CHARACTERISTICS						
Responsivity	R_λ	mV/µW	Single Ended	9.0	12.0	15.0
			Differential	18.0	24.0	30.0
Power Supply Rejection Ratio	PSRR	dB	Single Ended	---	20	---
			Differential	---	30	---

PIN-APD032

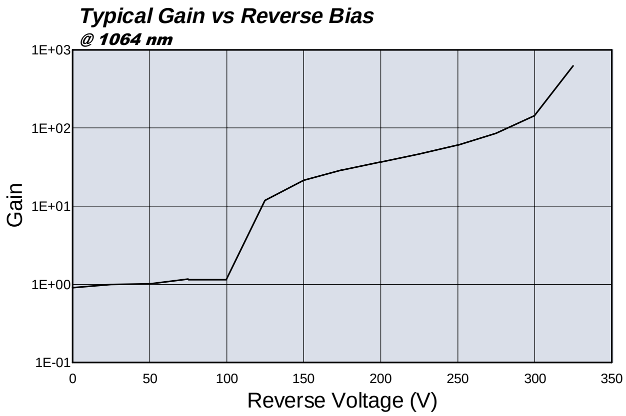
Fiber Optic Avalanche Photodiode

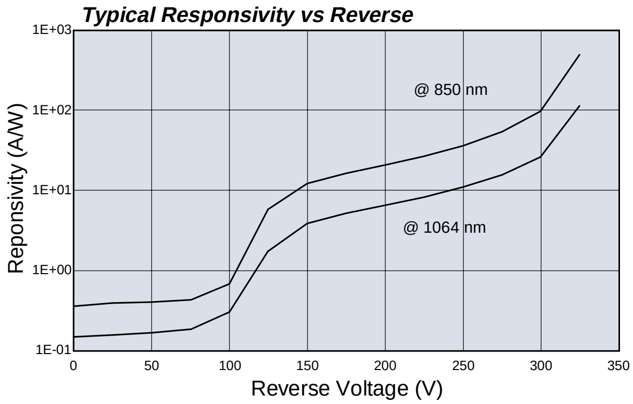


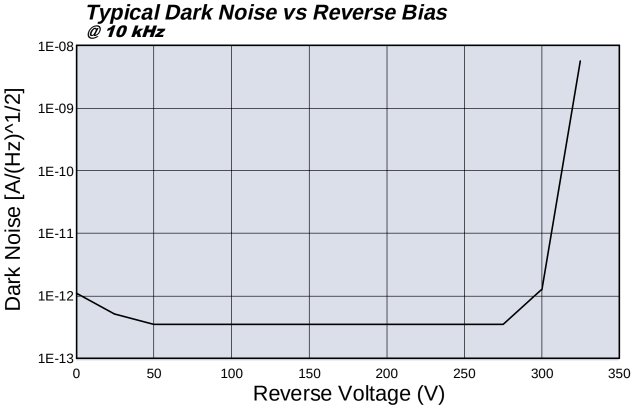
Applications	Features
• Pulse Detectors	• Very High Sensitivity / QE
• Optical Communications	• Low Noise
• Bar Code Reader	• Fast Response time
• Optical Remote Control	• Low Bias Voltage
• Medical Equipment	
• High Speed Photometry	

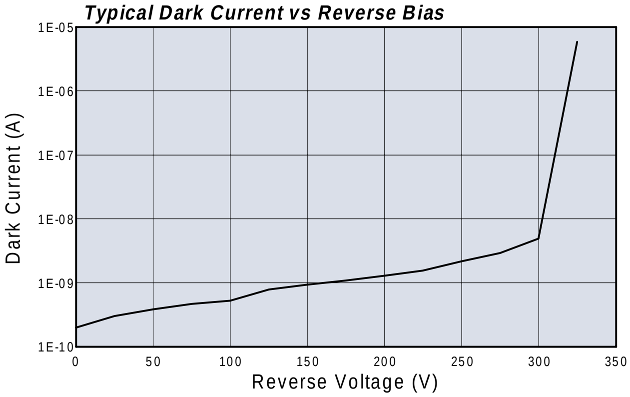
There are a few applications where a normal photodiode becomes Johnson noise limited when used with a low impedance load resistor for fast response. Silicon Avalanche Photodiodes (APD) make use of internal multiplication, to achieve gain due to impact ionization. The result is high responsivity as well as high gain bandwidth product with superior sensitivity compared to regular PIN photodiode/amplifier combinations for high bandwidth applications. Silicon is especially suited for making good avalanche photodiodes, as the ionization coefficient for electrons is much higher than for holes.

PIN-APD032 is manufactured using a double implanted "reach through" structure, which is the optimum structure for good gain and temperature stability combined with low noise and dark current.



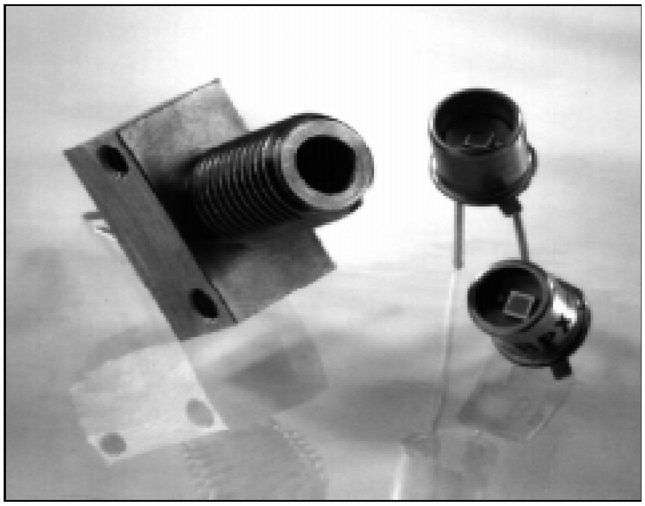






PARAMETER	UNIT	CONDITION	MINIMUM	TYPICAL	MAXIMUM
Active Area	mm^2	---	---	0.5	---
Active Area Diamater	mm	---	---	0.8	---
Operational Voltage	V	Gain=120	---	275	---
Responsivity	A/W	850 nm	45	75	---
		1064 nm	10	20	---
Dark Current	nA	Gain=120	---	3	10
Capacitance	pF	---	---	2	4
Series Resistance	Ω	---	---	---	15
Temperature Coeff. * Const. Responsivity	V/"C	---	---	2.2 *	---
Noise Current	$pA/Hz^{1/2}$	f=10 kHz, Δf=1.0 Hz	---	0.5	2
Rise Time	ns	50 Ω, 900 nm	---	2.0	3.0
Breakdown Voltage	V	---	300	375	---
Operating Temperature	"C		-40	---	+70
Storage Temperature	"C	---	-60	---	+100
Package Style ¶	Isolated 3 pin TO-5				

¶ For mechanical drawings please refer to pages 59 thru 71, figure 2.
* Measured between 0º - 40º C



Applications

- Fiber Optic Communications
- Laser Warning Systems
- Encoders

Features

- TO-18 Flat Glass Pkg
- High Speed
- 1 X 1 mm active area

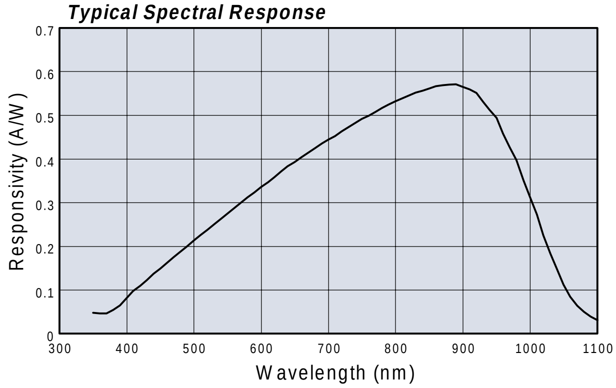
BPX65 is a high speed 1 x 1 mm active area photodiode designed for applications with high modulation bandwidth including fiber optics. A TO-18 with a flat window houses this low dark current device. It is also available with a micro lens cap as well as standard fiber optic receptacles such as SMA, FC and ST, for fiber coupling enhancement and higher efficiency.

Typical Electro-Optical Specification at T_A=23°C

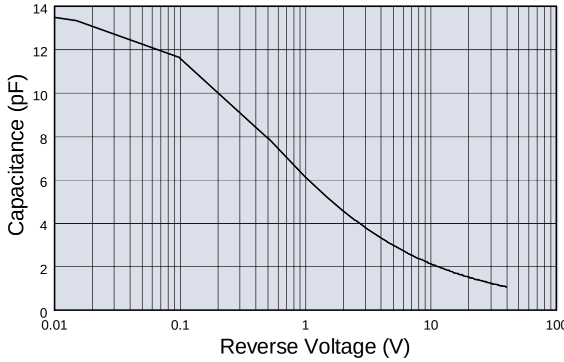
Model No.	Active Area		Peak Wavelength (nm)	Responsivity (A/W)		Capacitance (pF) 1 MHZ		Dark Current (nA)		NEP (W/√Hz)	Reverse Voltage (V)	Rise Time (ns)		Temp Range (°C)		Package Style ¶
	Area (mm^2)	Dimension (mm)		peak		-20 V 1 MHZ		-20 V		-20V 970 nm		-20 V 830 nm 50 Ω		Operating	Storage	
				min	typ	typ	max	typ	max	typ	max	typ	Max			
BPX65	1.0	1.0 sq	900	0.50	0.55	3.0	4	0.50	5.0	2.3 e-14	50	2.0	3.0	-25 ~ +85	-40 ~ +100	8/TO-18

¶ For mechanical drawings please refer to pages 57 thru 67.

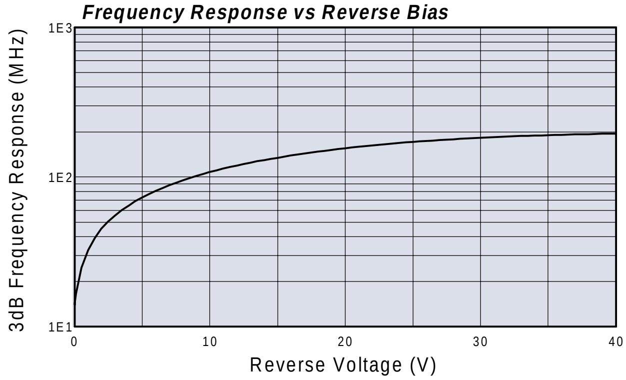
Typical Spectral Response



Typical Capacitance vs Reverse
f = 1 MHz

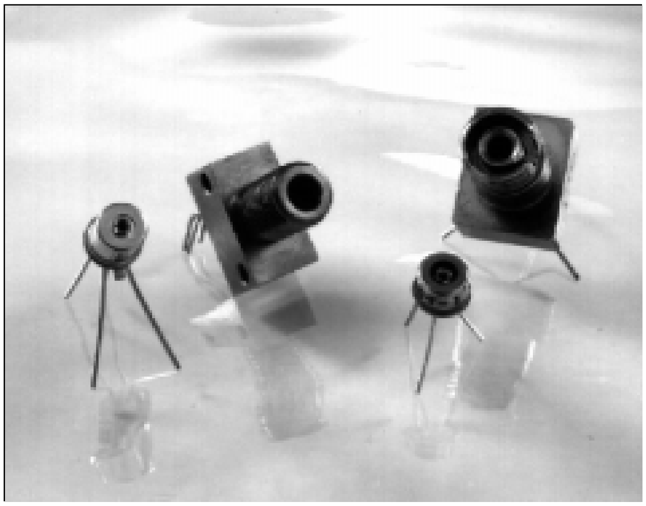


Frequency Response vs Reverse Bias



HIGH SPEED INGAAS SERIES

FIBER OPTIC PHOTODIODES



APPLICATIONS	FEATURES
• High Speed LAN	• High Speed Response
• FDDI Local Area Networks	• Very Low Capacitance
• High-Speed CATV, Telecom	• Micro Lens Cap

The InGaAs detectors exhibit a spectral response range from 900 nm to 1700nm. These detectors are specifically designed for optical communication applications, providing high responsivity, low capacitance and high speed. They are provided with a spherical lens to enhance coupling efficiency. The detectors are also available with any of the standard receptacles such as SMA, ST and FC for direct optical fiber coupling.

Applying reverse bias is required to achieve the fastest response. The reverse bias should be limited to maximum reverse voltage as specified in the table below, to avoid damage to the detector. Detector output can be coupled to high frequency amplifiers or measured directly with an oscilloscope as shown in figure 10 in the Photodiode Characteristics section of this catalog.

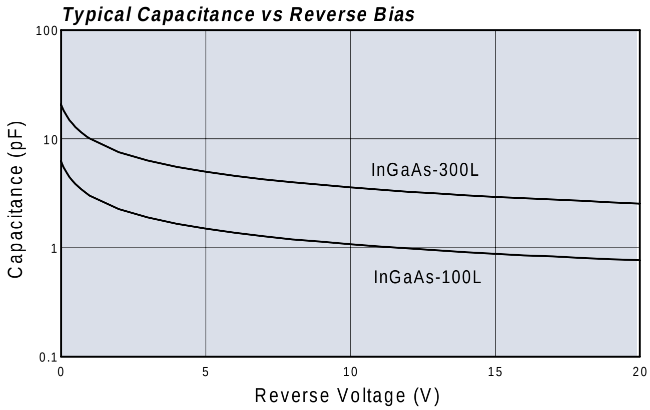
InGaAs SERIES

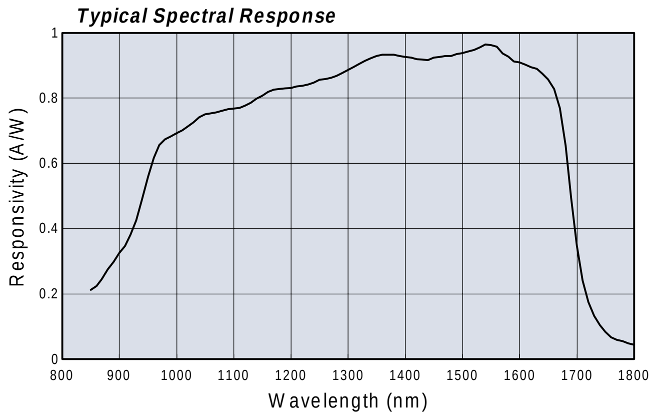
TYPICAL ELECTRO-OPTICAL SPECIFICATION AT TA=23°C

Model No.	Active Area		Responsivity (A/W)		Capacitance (pF)		Dark Current (nA)		Rise/Fall Time (ns)	Reverse Voltage (V)	Reverse Current (mA)	Forward Current (mA)	Temp Range (°C)		Package Style ¶
	Area (mm^2)	Dimension (mm)	1300 nm		-5 V 1 MHz		-10 V		-5 V 1300 nm 50 Ω				Operating	Storage	
			min	typ	typ	max	typ	max	max	max	max	max			
InGaAs-100L	.008	.10 ϕ	0.8	0.9	1.5	2.0	0.05	1.0	0.5	20	1	5	-40 ~ +100	-55 ~ +125	16 / TO-18
InGaAs-300L	.071	.30 ϕ			5.0	7.0	0.1	1.0	4	20	1	5			

Responsivity measured with a 8.7/125 fiber for InGaAs-100L and 62.5/125 fiber for InGaAs-300L. ¶ For mechanical drawings please refer to pages 57 thru 67.

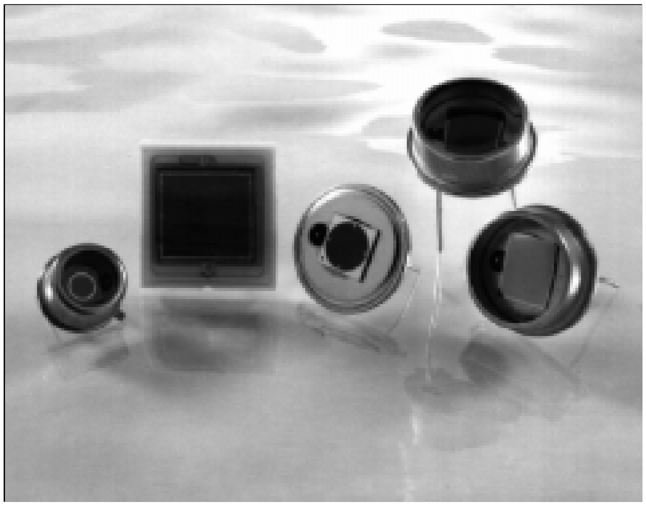
PRECAUTION: These devices are sensitive to electrostatic discharge (ESD). Use proper handling and testing procedure.





Soft X-ray, Far UV Enhanced Series

Inversion Layer Silicon Photodiodes



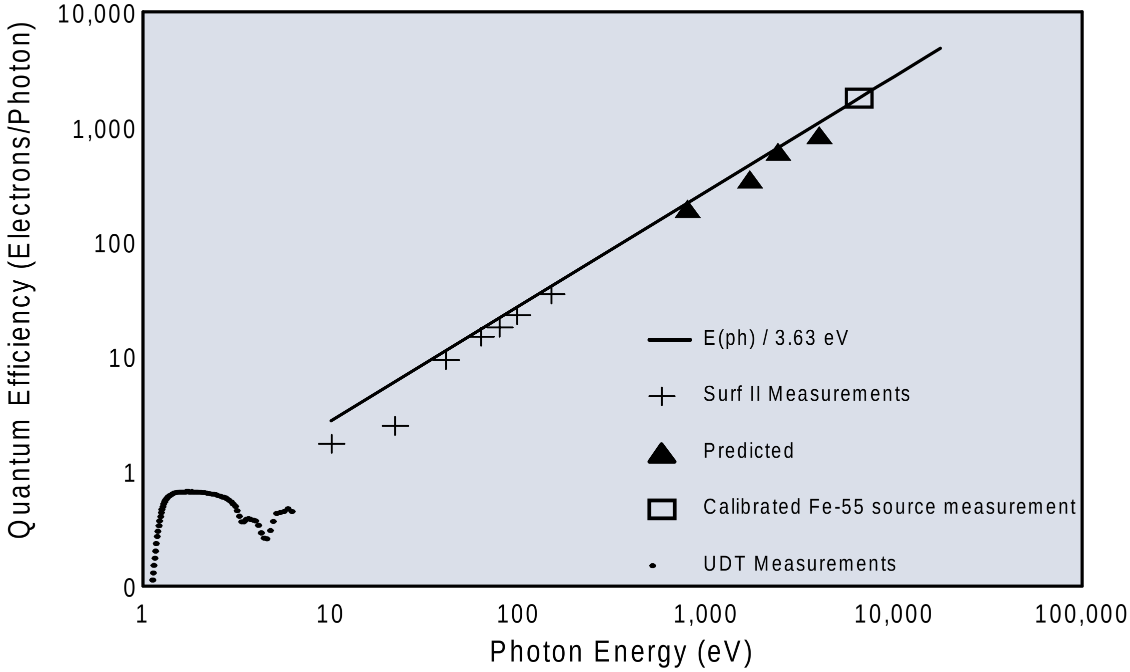
Applications	Features
• Electron Detection	• Direct Detection
• Medical Instrumentation	• No Bias Needed
• Dosimetry	• High Quantum Efficiency
• Radiation Monitoring	• Low Noise
• X-ray Spectroscopy	• High Vacuum Compatible
• Charged Particle Detection	• Cryogenically Compatible
	• 0.070 nm to 1100 nm Wavelength Range

UDT Sensors' 1990 R&D 100 award winning X-UV detector series are a unique class of silicon photodiodes designed for additional sensitivity in the X-Ray region of the electromagnetic spectrum without use of any scintillator crystals or screens. Over a wide range of sensitivity from 200 nm to 0.07 nm (6 eV to 17,600 eV), one electron-hole pair is created per 3.63eV of incident energy which corresponds to extremely high stable quantum efficiencies predicted by Eph/3.63eV (See graph below). For measurement of radiation energies above 17.6 keV, refer to the "Fully Depleted High Speed and High Energy Radiation Detectors" section.

A reverse bias can be applied to reduce the capacitance and increase speed of response. In the unbiased mode, these detectors can be used for applications requiring low noise and low drift. These detectors are also excellent choices for detecting light wavelengths between 350 to 1100 nm.

The detectors can be coupled to a charge sensitive preamplifier or low-noise op-amp as shown in the circuit on the opposite page.

Typical Quantum Efficiency



Model No.	Active Area		Capacitance (nF)		Shunt Resistance (MΩ)		NEP (W/√Hz)		Temp Range (ºC)		Package Style ¶
	Area (mm^2)	Dimension (mm)	0 V		-10 mV		0V 200 nm		Operating	Storage	
			typ	max	min	typ	typ	max			
XUV SERIES METAL PACKAGE											
XUV-005	5	2.565 ϕ	0.3	0.5	200	2000	2.9 e -15	9.1 e -15	-20 ~ +60	-20 ~ +80	21 / TO-5
XUV-020	20	5.00 ϕ	1.2	1.6	50	500	5.8 e -15	1.8 e -14			22 / TO-8
XUV-035	35	6.78 x 5.59	2	3	30	300	7.4 e -15	2.3 e -14			
XUV-100	100	11.33 ϕ	6	8	10	100	1.3 e -14	4.1 e -14			27 / BNC
XUV SERIES CERAMIC PACKAGE											
XUV-50C	50	0.316 ϕ	2	3	20	200	9.1 e -15	2.9 e -14	-20 ~ +60	-20 ~ +80	24 / Ceramic
XUV-100C	100	0.396 sq	6	8	10	100	1.3 e -14	4.1 e -14			

¶ For mechanical drawings please refer to pages 59 thru 71.
All XUV devices are supplied with removable windows.

In this circuit example, the pre-amplifier is a FET input op-amp or a commercial charge sensitive preamplifier. They can be followed by one or more amplification stages, if necessary. The counting efficiency is directly proportional to the incident radiation power. The reverse bias voltage must be selected so that the best signal-to-noise ratio is achieved.

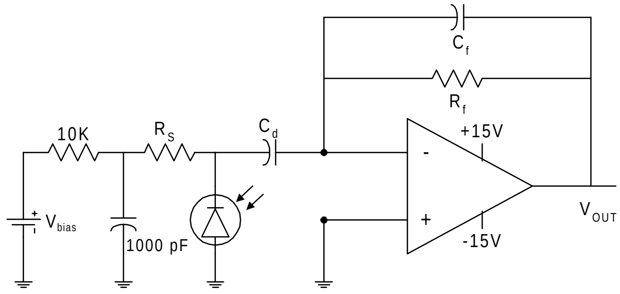
For low noise applications, all components should be enclosed in a metal box. Also, the bias supply should be either simple batteries or a very low ripple DC supply.

Amplifier: OPA-637, OP-27 or similar

R_f: 10 MΩ to 10GΩ
R_s: 1 MΩ; Smaller for High Counting Rates
C_f: 1pF
C_d: 1pF to 10 μF

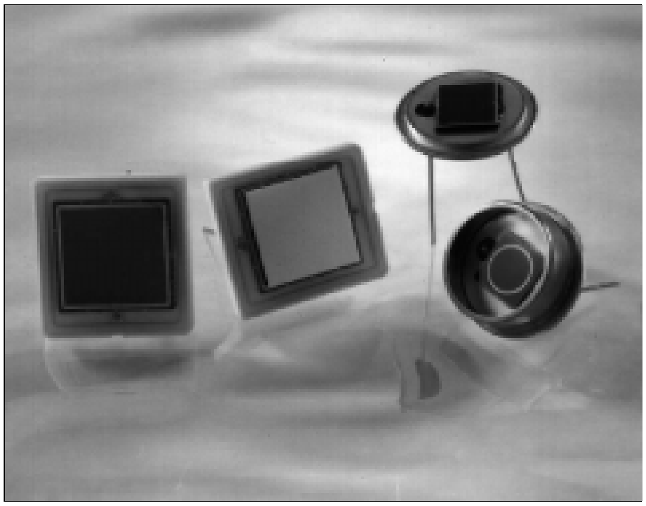
OUTPUT $V_{out} = Q / C_f$

Q, is the Charge Created by One Photon or One Particle



Fully Depleted Series

Large Active Area Silicon Photodiodes



	Applications	Features
High Speed Detectors	• Laser Guided Missiles • Laser Warning • Laser Range Finder • Laser Alignment • Control Systems	• Large Active Area • Fully Depleteable • Fast Response • Ultra Low Dark Current • Low Capacitance
Radiation Detectors	• Electron Detection • Medical Instrumentation • High Energy Spectroscopy • Charged Particle Detection • High Energy Physics • Nuclear Physics	• Large Active Area • Scintillator Mountable • Fully Depleteable • Ultra Low Dark Current • Low Capacitance • High Breakdown Voltage

The **Large Active Area High Speed Detectors** can be fully depleted to achieve the lowest possible junction capacitance for fast response times. They may be operated at a higher reverse voltage, up to the maximum allowable value, for achieving even faster response times in nano seconds. The high reverse bias at this point, increases the effective electric field across the junction, hence increasing the charge collection time in the depleted region. Note that this is achieved without the sacrifice for the high responsivity as well as active area.

The **Large Active Area Radiation Detectors** can also be fully depleted for applications measuring high energy X-rays, γ-rays as well as high energy particles such as electrons, alpha rays and heavy ions. These types of radiation can be measured with two different methods. Indirect and direct.

Indirect High Energy Radiation Measurement:

In this method, the detectors are coupled to a scintillator crystal for converting high energy radiation into a detectable visible wavelength. The devices are mounted on a ceramic and covered with a clear layer of an epoxy resin for an excellent optical coupling to the scintillator. This method is widely used in detection of high energy gamma rays and electrons. This is where the X-UV devices fail to measure energies higher than 17.6 keV. The type and size of the scintillator can be selected based on radiation type and magnitude.

Direct High Energy Radiation Measurement:

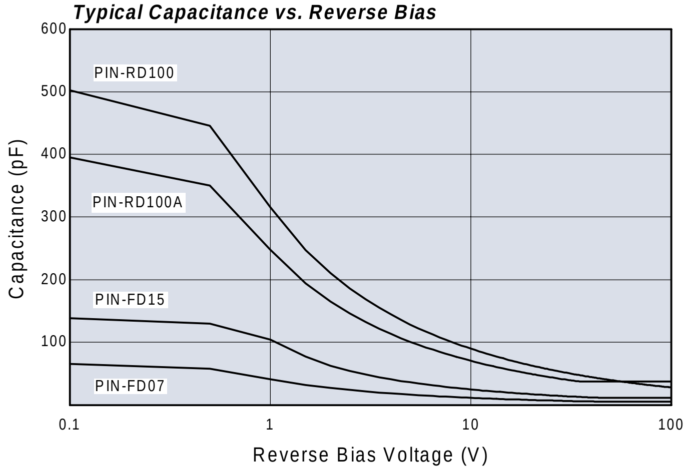
Both PIN-RD100 and PIN-RD100A, can also be used without any epoxy resin or glass window for direct measurement of high energy radiation such as alpha rays and heavy ions. The radiation exhibits loss of energy along a linear line deep into the silicon after incident on the active area.

The amount of loss and the penetration depth is determined by the type and magnitude of the radiation. In order to measure completely the amount of radiation, the depletion layer should be deep enough to cover the whole track from the incident point to the stop point. This requires a high bias application to fully deplete the detector. In spite of the large active area as well as high bias voltage applications, the devices exhibit super low dark currents, low capacitances and low series resistances.

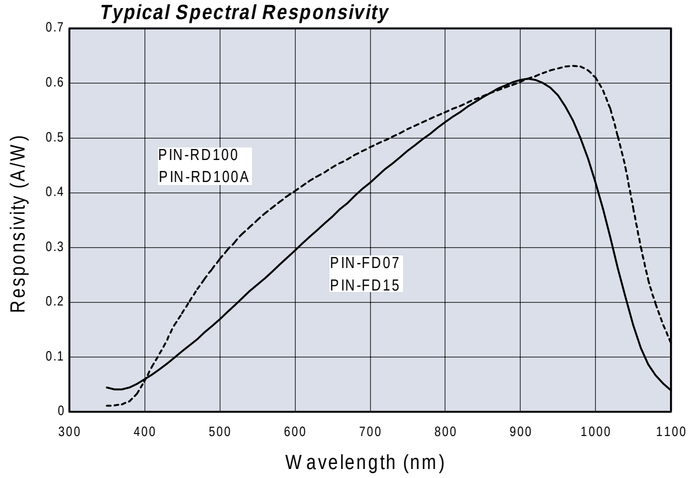
In addition to their use in high energy particle detection, the PIN-RD100 and PIN-RD100A are also excellent choices for detection in the range between 350 to 1100 nm in applications where a large active area and high speed is desired.

These detectors can be coupled to a charge sensitive preamplifier or low-noise op-amp as shown in the opposite page. The configuration for indirect measurement is also shown with a scintillator crystal.

Typical Capacitance vs. Reverse Bias



Typical Spectral Responsivity



Model No.	Active Area: Area (mm^2)	Active Area: Dimension (mm)	Peak Wavelength (nm) typ	Responsivity (A/W) 900 nm typ	Depletion Voltage (V) typ	Dark Current (nA) -100 V typ	Dark Current (nA) -100 V max	Capacitance (pF) -100 V typ	Capacitance (pF) -100 V max	Rise Time (ns) 900 nm -100 V 50 Ω typ	NEP (W/√Hz) 900 nm -100V typ	Reverse Voltage (V) 10 µA max	Temp Range (ºC) Operating	Temp Range (ºC) Storage	Package Style ¶
LARGE ACTIVE AREA, HIGH SPEED															
PIN-FD07	7.1	3.00 ϕ	900	0.55	48	0.2	5.0	8.0	9.0	1.5	1.2 e-14	135	-40 ~ +100	-55 ~ +125	25 / TO-8
PIN-FD15	14.9	4.35 ϕ		0.58	55	1.0	30	14	16	3.0	2.5 e-14	140			

Model No.	Active Area: Area (mm^2)	Active Area: Dimension (mm)	Peak Wavelength (nm) typ	Responsivity (A/W) 450 nm typ	Responsivity (A/W) 950 nm typ	Depletion Voltage (V) typ	Dark Current (nA) Depletion Voltage typ	Dark Current (nA) Depletion Voltage max	Capacitance (pF) Depletion Voltage typ	Capacitance (pF) Depletion Voltage max	NEP (W/√Hz) Depletion Voltage 950 nm typ	Reverse Voltage (V) 10 µA max	Temp Range (ºC) Operating	Temp Range (ºC) Storage	Package Style ¶
LARGE ACTIVE AREA, RADIATION DETECTORS															
PIN-RD100	100	10 Sq	950	0.3	0.65	120	2	10	50	60	3.2 e-14	75	-20 ~ +60	-20 ~ +80	24 / Ceramic
PIN-RD100A	100	10 Sq		0.3	0.60	35	2	10	40	45	3.4 e-14	70			

Measured at V_{bias} = -50V

¶ For mechanical drawings please refer to pages 59 thru 71.

DIRECT DETECTION

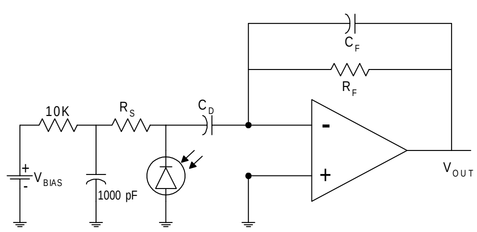
For direct detection of high-energy particles, the pre-amplifier is a FET input op-amp, followed by one or more amplification stages, if necessary, or a commercial charge sensitive preamplifier. The counting efficiency is directly proportional to the incident radiation power. The reverse bias voltage must be selected as such to achieve the best signal-to-noise ratio. For low noise applications, all components should be enclosed in a metal box. Also, the bias supply should be either simple batteries or a very low ripple DC supply. The detector should also be operated in the photovoltaic mode.

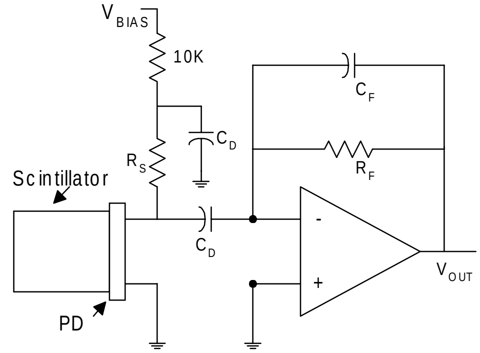
INDIRECT DETECTION (WITH SCINTILLATOR CRYSTAL)

The circuit is very similar to the direct detection circuit except that the photodiode is coupled to a scintillator. The scintillator converts the high-energy γ-rays and/or X-rays into visible light. Suitable scintillator include CsI(TL), $CdWO_4$, BGO and NaI(TL). The amplifier should be a FET input op-amp, followed by one or more amplification stages, or a commercial charge sensitive preamplifier. The output voltage depends primarily on the scintillator efficiency and should be calibrated by using radioactive sources.

Amplifier: OPA-637, OP-27 or similar
R_F : 10 MΩ to 10 GΩ
R_S : 1 MΩ; Smaller for High Counting Rates
C_F: 1pF
C_D : 1pF to 10 µF

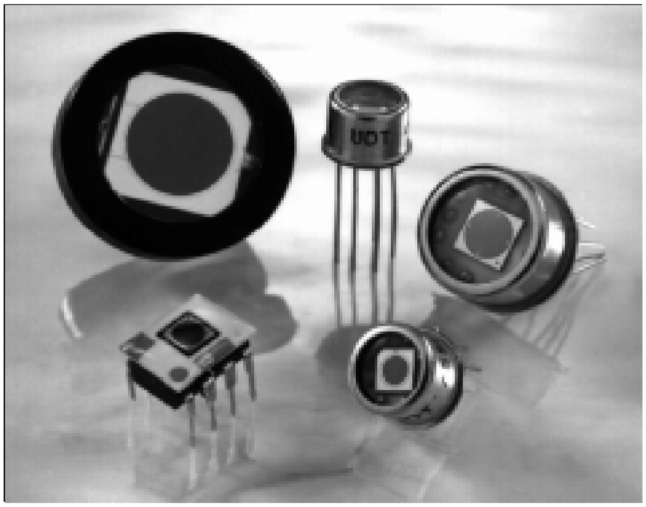
OUTPUT $V_{OUT} = Q / C_F$
Where Q is the Charge Created by One Photon or One Particle





PHOTOPS™

PHOTODIODE-AMPLIFIER HYBRIDS

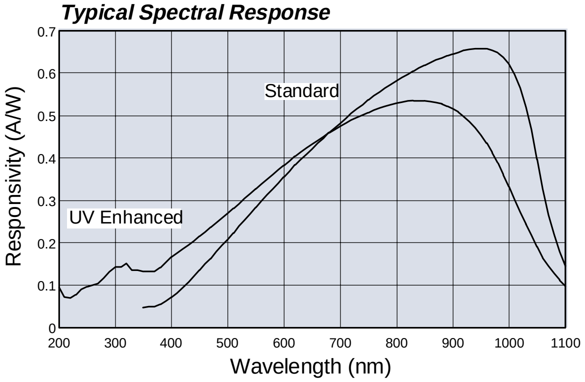


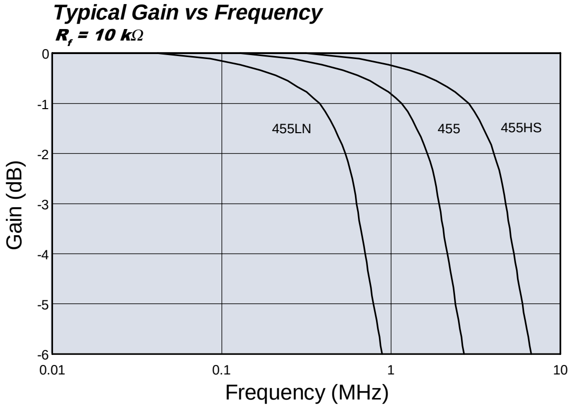
APPLICATIONS	FEATURES
• General Purpose Light Detection	• Detector/Amplifier Combined
• Laser Power Monitoring	• Adjustable Gain/Bandwidth
• Medical Analysis	• Low Noise
• Laser Communications	• Wide Bandwidth
• Bar Code Readers	• DIP Package
• Industrial Control Sensors	• Large Active Area
• Pollution Monitoring	
• Guidance Systems	
• Colorimeter	

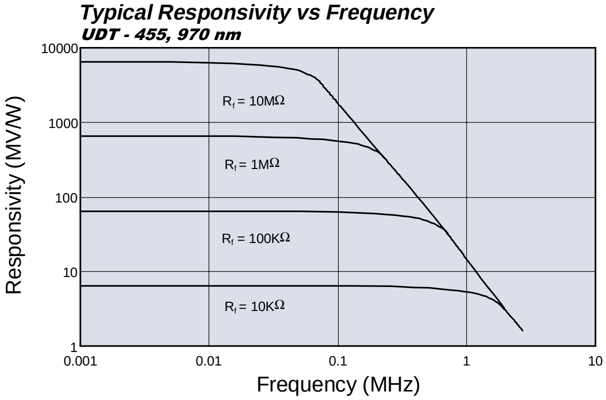
The Photop™ Series, combines a photodiode with an operational amplifier in the same package. Photops™ general-purpose detectors have a spectral range from either 350 nm to 1100 nm or 200 nm to 1100nm. They have an integrated package ensuring low noise output under a variety of operating conditions. These op-amps are specifically selected by UDT Sensors engineers for compatibility to our photodiodes.

Among many of these specific parameters are low noise, low drift and capability of supporting a variety of gains and bandwidths determined by the external feedback components. Operation from DC level to several MHz is possible in an either unbiased configuration for low speed, low drift applications or biased for faster response time.

Any modification of the above devices is possible. The modifications can be simply adding a bandpass optical filter, integration of additional chip (hybrid) components inside the same package, utilizing a different op-amp, photodetector replacement, modified package design and / or mount on PCB or ceramic. For your specific requirements, contact one of our Applications Engineers.







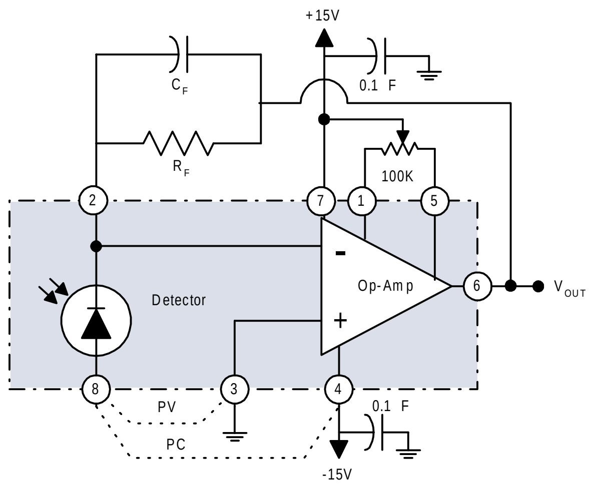
Model No.	Active Area		Responsivity (A/W)				Capacitance (pF)		Dark Current (nA)		Shunt Resistance (MΩ)	NEP (W/√Hz)		Reverse Voltage (V)	Temp Range (℃)		Package Style ¶
	Area (mm^2)	Dimension (mm)	200 nm		970 nm		0 V	-10 V	-10 V		-10 mV	0 V 200 nm	-10V 970 nm		Operating	Storage	
			Min	typ	min	typ	typ	typ	typ	max	typ	typ	typ	max			
350-1100 nm Spectral Range																	
UDT-451	5.1	2.54 φ			.60	.65	85	15	.25	3			1.4 e- 14	30	0 ~ +70	-30 ~ +100	28/ DIP
UDT-455																	29 / TO-5
UDT-455LN																	
UDT-455HS																	
UDT-020D	16	4.57 φ					330	60	.5	10			1.9 e- 14				30 / TO-8
UDT-555D	100	11.3 φ					1500	300	2	25			3.9 e -14				31 / Special
200-1100 nm Spectral Range																	
UDT-455UV	5.1	2.54 φ	.10	.14			300				100	9.2 e -14		5			29 / TO-5
UDT-455UV/LN																	
UDT-020UV	16	4.57 φ					1000				50	1.3 e -13					30 / TO-8
UDT-055UV	50	7.98 φ					2500				20	2.1 e -13					31 / Special
UDT-555UV	100	11.3 φ					4500				10	2.9 e -13					31 / Special
UDT-555UV/LN																	

¶ For mechanical drawings please refer to pages 59 thru 71.

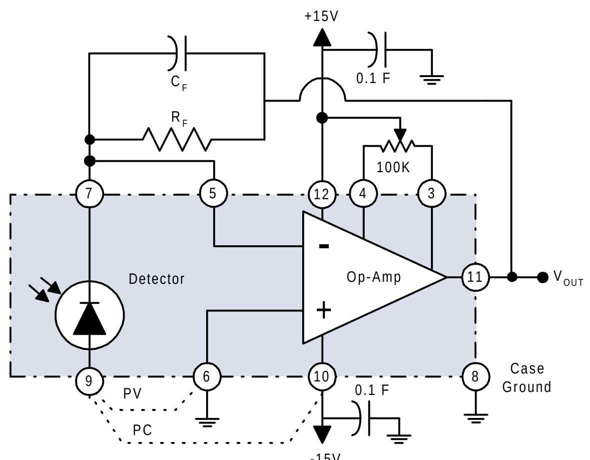
OPERATIONAL AMPLIFIER SPECIFICATIONS

TYPICAL ELECTRO-OPTICAL SPECIFICATIONS AT T_A=23 ”C

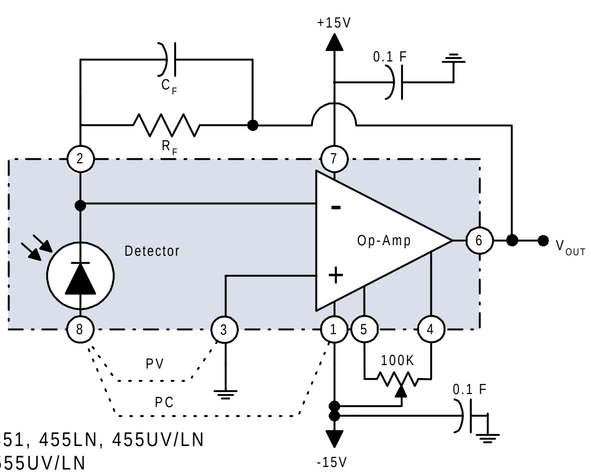
Model No.	Supply Voltage (V)			Quiescent Supply Current (mA)		Input Offset Voltage (mV)		Temp Coefficient Input Offset Voltage (µV / ℃)		Input Bias Current (pA)		Gain Bandwidth Product (MHz)		Slew Rate (V / µs)		Open Loop Gain, DC (V / mV)		Input Noise Voltage (nV/√Hz)		Input Noise Current (fA/√Hz)
				– 15 V														100 Hz	1 kHz	1 kHz
	min	typ	max	typ	max	typ	max	typ	max	typ	max	min	typ	min	typ	min	typ	typ	typ	typ
UDT-451	---	–15	–18	1.4	2.5	3.0	6.0	10	---	30	200	---	4.0	---	13	50	150	---	18	10
UDT-455	---	–15	–18	2.8	5.0	0.5	3	4	30	–80	–400	3.0	5.4	5	9	50	200	20	15	10
UDT-455UV																				
UDT-020D																				
UDT-020UV																				
UDT-455HS	---	–15	–18	4.8	8.0	0.5	3	4	30	–80	–500	11	26	25	40	50	200	20	15	10
UDT-455LN	–5	–15	–18	0.9	1.8	.26	1	---	20	.15	0.3	0.5	1	0.5	3	50	2500	78	27	0.22
UDT-455UV/LN																				
UDT-055UV	---	–15	–22	2.7	4.0	0.4	1	3	10	–40	–200	3.5	5.7	7.5	11	75	220	20	15	10
UDT-555D																				
UDT-555UV																				
UDT-555UV/LN	–5	–15	–18	2.5	3.5	.05	0.25	0.5	1	0.5	1	---	2	1	2	1k	1770	11	7	0.4



UDT-455, 455HS
UDT-555, 555UV, 055UV



UDT-020D, 020UV



UDT-451, 455LN, 455UV/LN
UDT-555UV/LN

The output voltage is proportional to the light intensity of the light and is given by:

$$V_{OUT} = I_P \times R_L$$
$$= (P \times R_\lambda) \times R_L$$

FREQUENCY RESPONSE (PHOTODIODE /AMPLIFIER COMBINATION)

The frequency response of the photodiode / amplifier combination is determined by the characteristics of the photodetector, pre-amplifier as well as the feedback resistor (R_F) and feedback capacitor (C_F). For a known gain, (R_F), the 3 dB frequency response of the detector / pre-amp combination is given by:

$$f_{3dB} = \frac{1}{2\pi C_F R_F}$$

However, the desired frequency response is limited by the Gain Bandwidth Product (GBP) of the op-amp. In order to have a stable output, the values of the R_F and C_F must be chosen such that the 3 dB frequency response of the detector / pre-amp combination, be less than the maximum frequency of the op-amp, i.e. $f_{3dB} \leq f_{max}$.

$$f_{\max} = \sqrt{\frac{GBP}{2\pi R_F (C_F + C_J + C_A)}}$$

Where C_A is the amplifier input capacitance.

In conclusion, an example for frequency response calculations, is given below.

For a gain of 10^8, an operating frequency of 100 Hz, and an op-amp with GBP of 5 MHZ:

$$C_F = \frac{1}{2\pi f_{3dB} R_F} = 15.9\ pF$$

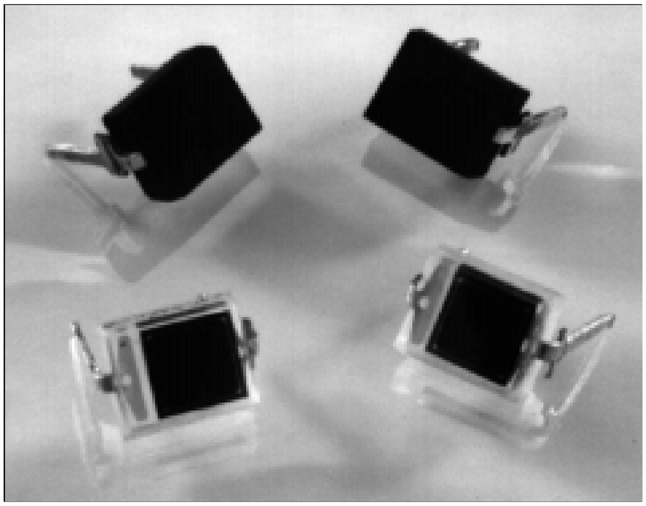
Thus, for C_F = 15.9 pF, C_J = 15 pF and C_A = 7 pF, f_{max} is about 14.5 kHz. Hence, the circuit is stable since $f_{3dB} \leq f_{max}$.

For more detailed application specific discussions and further reading, refer to the APPLICATION NOTES INDEX in the catalog.

Note: The shaded boxes represent the Photop™ components and their connections. The components outside the boxes are typical recommended connections and components.

BPW-34

Resin Mold - Lead Frame Photodiodes



Applications

- IR Sensors
- Bar Code Scanners
- Color Analysis
- Smoke Detectors

Features

- High Reliability
- High Density Package
- Rugged Resin Mold
- Fast and Low Dark Current

BPW-34 series are a family of high quality and reliability plastic encapsulated photodiodes. All three types of devices in this series, exhibit similar electrical characteristics, but vary in optical response. BPW-34B has an excellent response in the blue region of the spectrum, while BPW-34F is an excellent choice for applications requiring blocking the visible light. They are excellent for mounting on PCB and hand held devices in harsh environments.

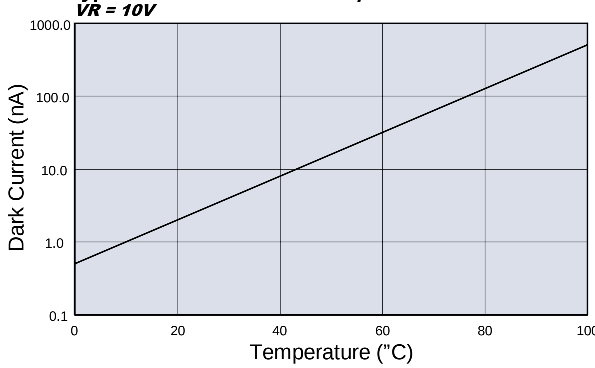
Typical Electro-Optical Specification at TA=23°C

Model No.	Active Area: Area (mm^2)	Active Area: Dimension (mm)	Spectral Range	Responsivity (A/W) 950 nm min	Responsivity (A/W) 950 nm typ	Capacitance (pF) 0 V 1 MHz typ	Capacitance (pF) -10 V 1 MHz typ	Dark Current (nA) -10 V typ	Dark Current (nA) -10 V max	NEP (W/√Hz) -10V 950 nm typ	Reverse Voltage (V) max	Rise Time (ns) -10 V 830 nm 50 Ω typ	Temp Range (°C) Operating	Temp Range (°C) Storage	Package Style ¶
BPW34	6.7	2.71 sq	350-1100	.55	.60	65	12	2	30	4.2 e -14	40	20	-25 ~ +85	-40 ~ +100	19 / Molded
BPW34B				.15*	.20*					1.3 e -13*					
BPW34F			750-1100	.50	.55					4.6 e -14					

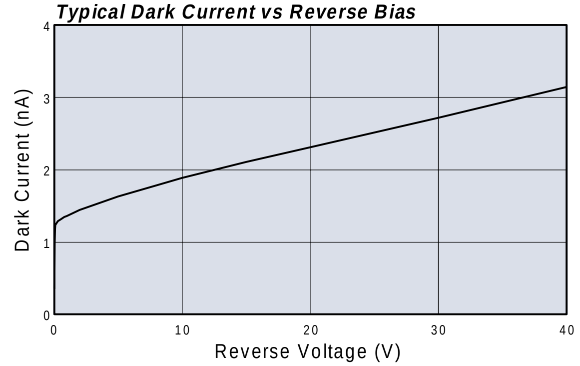
* Measured at λ= 410 nm

¶ For mechanical drawings please refer to page 57 thru 67.

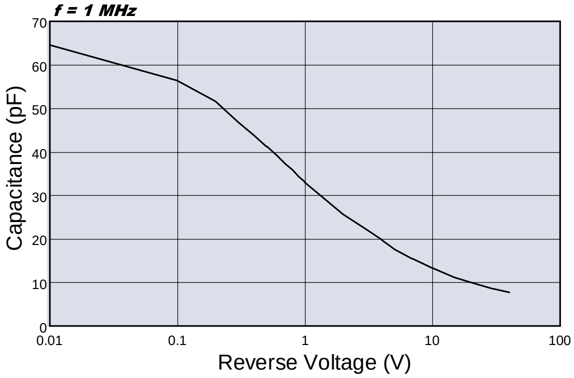
Typical Dark Current vs Temperature
VR = 10V



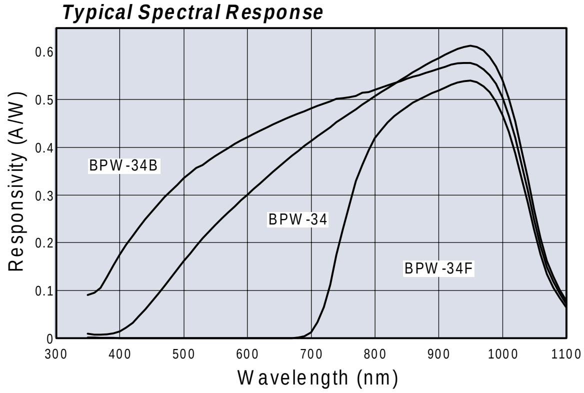
Typical Dark Current vs Reverse Bias



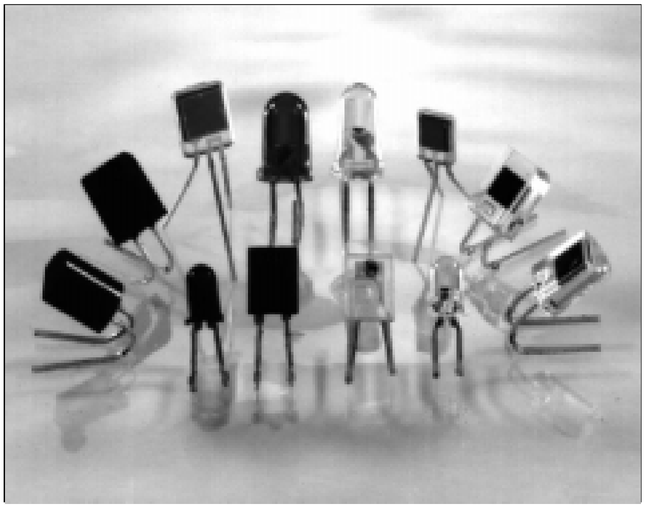
Typical Capacitance vs Reverse Bias
f = 1 MHz



Typical Spectral Response



RESIN MOLD - LEAD FRAME PHOTODIODES



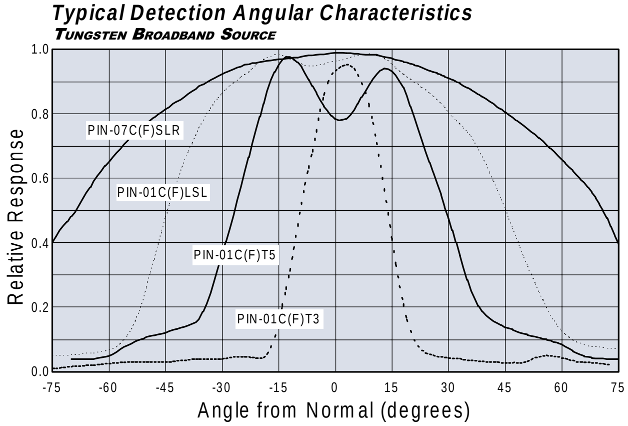
APPLICATIONS	FEATURES

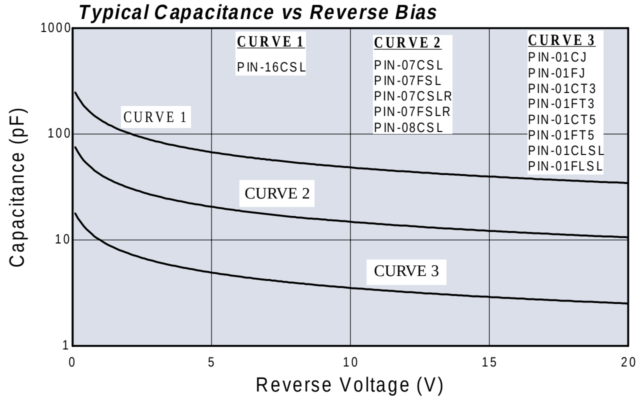
Applications
- Bar Code Readers
- Industrial Counters
- Measurement and Control
- IR Remote Control
- Reflective Switches

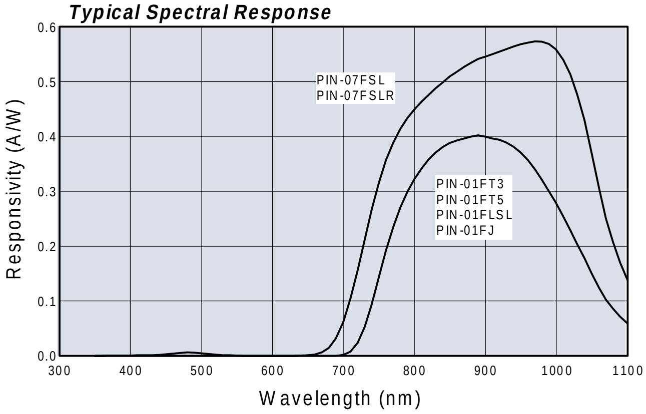
Features
- High Density Package
- Rugged Resin Mold
- Low Capacitance
- Low dark Current
- Lead frame Standard
- SMT
- Lensed Mold
- Side Lookers

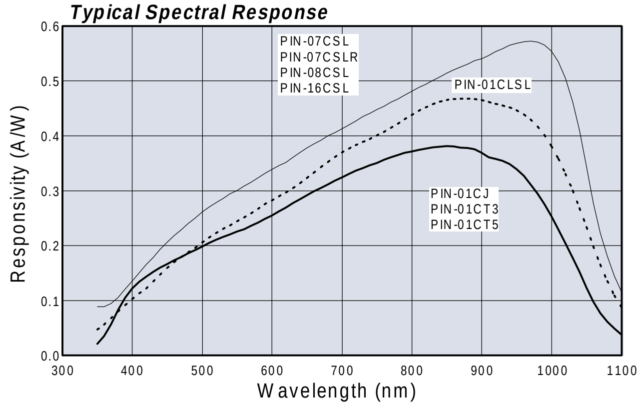
UDT Sensors, Inc. offers a line of high quality and reliability plastic encapsulated photodiodes. These molded devices are available in a variety of shapes and sizes of photodetectors and packages, including industry standard T1 and T13/4, flat and lensed side lookers as well as a surface mount version (SOT-23). They are excellent for mounting on PCB and hand held devices in harsh environments.

They have an excellent response in the NIR spectrum and are also available with visible blocking compounds, transmitting only in the 700-1100 nm range. They offer fast switching time, low capacitance as well as low dark current. They can be utilized in both photoconductive and photovoltaic modes of operation.





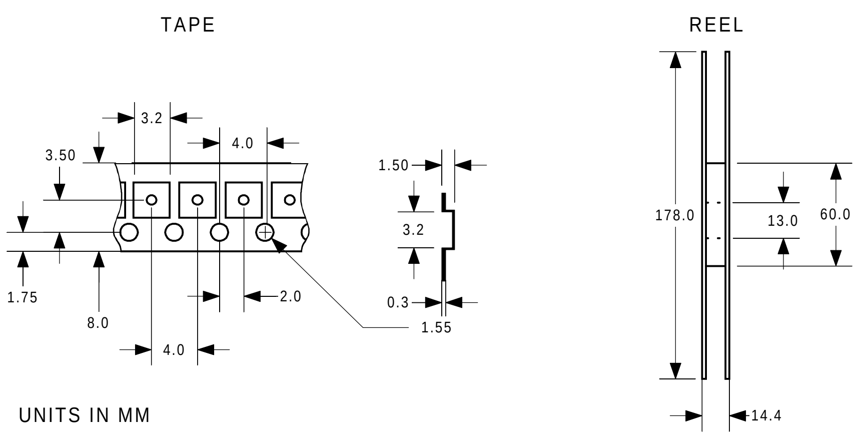




Model No.	Active Area: Area (mm^2)	Active Area: Dimension (mm)	Spectral Range	Responsivity (A/W) peak λ typ	Capacitance (pF) 1 MHz 0 V typ	Capacitance (pF) 1 MHz -10 V typ	Dark Current (nA) -10 V typ	Dark Current (nA) -10 V max	Reverse Voltage (V) max	Rise Time (ns) -10 V peak λ 50 Ω typ	Temp Range (ºC) Operating	Temp Range (ºC) Storage	Package Style ¶
PIN-01CJ	0.2	0.4 Sq	350-1100	0.40	21	4	2	30	20	11	-25 ~ +85	-40 ~ +100	54 / Resin Mold
PIN-01FJ			700-1100										
PIN-01CT3	0.2	0.4 Sq	350-1100										53 / Resin Mold
PIN-01FT3			700-1100										
PIN-01CT5	0.2	0.4 Sq	350-1100										
PIN-01FT5			700-1100										
PIN-01CLSL	0.2	0.4 Sq	350-1100	0.45									56 / Resin Mold
PIN-01FLSL			700-1100	0.40									
PIN-07CSL	8.1	2.84 Sq	350-1100	0.55	85	15	5			50			52 / Resin Mold
PIN-07FSL			700-1100										
PIN-07CSLR	8.1	2.84 Sq	350-1100										51 / Resin Mold
PIN-07FSLR			700-1100										
PIN-08CSL	8.4	2.90 Sq	350-1100		100	18	5						55 / Resin Mold
PIN-16CSL	16	4.00 Sq			330	55	5			100			

¶ For mechanical drawings please refer to pages 59 thru 71.

TAPE AND REEL SPECIFICATIONS FOR SURFACE MOUNT PIN-01C(F)J



DETECTOR-FILTER COMBINATION SERIES

PLANAR DIFFUSED SILICON PHOTODIODES

APPLICATIONS	FEATURES
• Analytical Chemistry	• CIE Match (AP series)
• Spectrophotometry	• Flat Band Response (DF)
• Densitometers	• 254 Narrow Bandpass
• Photometry/Radiometry	• w/ Amplifier Hybrid
• Spectroradiometry	• BNC Packages
• Medical Instrumentation	
• Liquid Chromatography	

The Detector-Filter combination series incorporates a filter with a photodiode to achieve a tailored spectral response. UDT Sensors offers a multitude of standard and custom combinations. Upon request, all detector-filter combinations can be provided with a NIST traceable calibration data specified in terms of Amps/Watt, Amps/lumen, Amps/lux or Amps/ footcandle.

Among many possible custom combinations, following are a few standard devices available as standard devices.

PIN-10DF - is a 1 cm^2 active area, BNC package detector-filter combination, optimized to achieve a flat responsivity, from 450 to 950 nm. This is the spectral response required for radiometric measurements. This type of detector has several advantages over thermopile, such as sensitivity, which is about a thousand times higher, as well as 10 times more stability.

PIN-10AP - is a 1 cm^2 active area, BNC package detector- filter combination which duplicates the response of the most commonly available optical aid; the human eye. The eye senses both brightness and color, with response varying as a function of the wavelength. This response curve is commonly known as the CIE curve. The AP filters accurately match the CIE curve to within ±2% of area.

PIN-555AP - has the same optical characteristics as the PIN 10-AP, with an additional operational amplifier in the same package. The package and the op-amp combination is identical to UDT-555D detector- amplifier combination (Photops™).

PIN-005E-550F - uses a low cost broad bandpass filter with peak transmission at 550nm to mimic the CIE curve for photometric applications. The pass band is similar to the CIE curve, but the actual slope of the spectral response curve is quite different. This device can also be used to block the near IR portion of the spectral range, 700 nm and above.

PIN-005D-254F - is a 6 mm^2 active area, UV enhanced photodiode-filter combination which utilizes a narrow bandpass filter peaking at 254 nm.

CUSTOMIZED CAPABILITIES

Current existing standard photodiodes can be modified by adding various optical filter(s), to match your specific spectral requirements. The filters can either replace the standard glass windows or be used in conjunction with the glass window, depending on the specific requirement and / or nature of the filter. Customer furnished optical filters can also be incorporated in the package. The following are among a few of the optical filter types available. These colored glass filters are grouped into four major categories: Shortpass Filters, Longpass Filters, Bandpass Filters, and Neutral Density Filters.

Shortpass Filters provide transmission of light in the shorter wavelengths of the spectral band in question. In general, shortpass filters have less steep cut-off slopes than the longpass filters, therefore, careful evaluation of the sensitivity of the detector should be taken into account.

Longpass Filters provide a cut-on filter performance by absorbing photons in the lower wavelengths and passing them in the higher wavelengths.

Bandpass Filters combine the cut-on performance of the longpass filters with the cut-off performance of the shortpass filters. They define a range in the wavelength spectrum, which allows the transmission of photons. The rest of the spectrum is blocked.

Neutral Density Filters provide a fairly flat response across the visible spectrum. These filters are used to attenuate the light so that the amount of passed energy is reduced. The reduction is in uniform amounts. In these filters the transmittance can also be defined as Optical Density, i.e.OD = log (1/T) where OD is the optical density and T is the transmittance.

Custom Thin Film Coatings can be applied to either or both surfaces of the filter glass to improve the performance of the glass absorption filter. The most common coatings applied are anti-reflective, neutral density, cut-on and cut-off coatings.

Anti-reflective Coatings can reduce the surface reflection loss from an average of 4% to as low as 0.25%, or less. This will raise the filter's transmittance values in the coatings performance range.

Cut-on and Cut-off Filter Coatings can be applied to glass absorption filters to attain a more defined bandpass than is normally achieved by combining filters.

ALL PHOTODIODES WITH OR WITHOUT FILTERS CAN BE CALIBRATED IN HOUSE FOR RESPONSIVITY FROM 200 NM TO 1100 NM IN 10 NM STEPS AS WELL AS SINGLE POINT CALIBRATION. ALL OPTICAL CALIBRATIONS ARE NIST TRACEABLE.

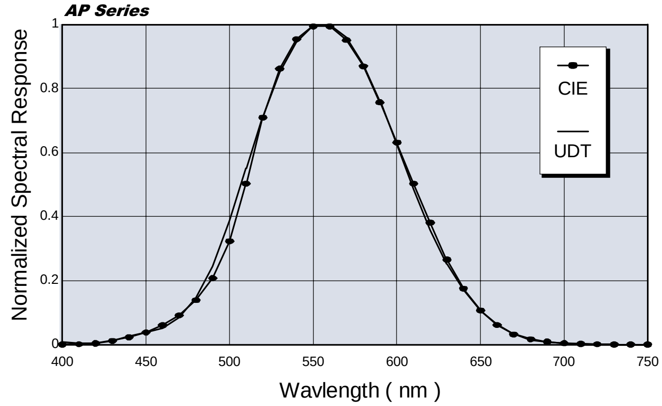
DETECTOR-FILTER COMBINATION SERIES

TYPICAL ELECTRO-OPTICAL SPECIFICATION AT TA=23°C

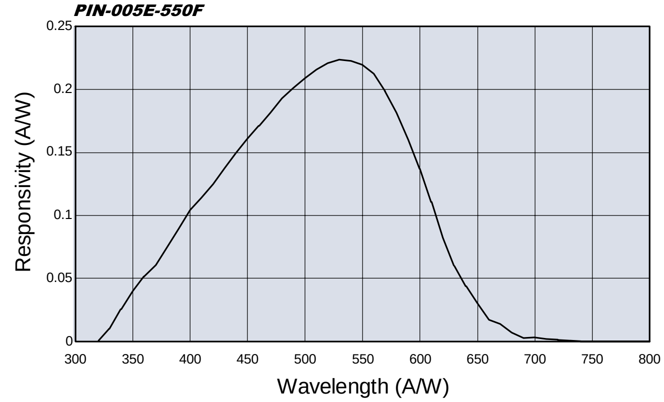
Model No.	Active Area		Typical Responsivity @ 550 nm		Spectral Match	Capacitance (pF)	Rise Time (µs)	Shunt Resistance (MΩ)	NEP (W/√Hz)	Temp Range (°C)		Package Style ¶
	Area (mm^2)	Dimension (mm)				0 V	0 V 550 nm	-10 mV	0 V 550 nm	Operating	Storage	
			A/W	mA/ Lum		typ	typ	typ	typ			
PIN-10DF	100	11.28 ϕ	0.15	---	– 7%	1550	1.0	20	1.9e-13	0 ~ +70	-25 ~ +85	13 / BNC
PIN-10AP			0.27	0.4	– 2%				1.1e-13			
PIN-555AP §												32 / Special
PIN-005E-550F	5.7	2.4 sq.	0.23	---	---	200	0.15	500	2.5e-14			5 / TO-5
PIN-005D-254F			0.025 *	---	---	100	0.10 *	300	3.0e-13 *			18 / TO-5

Point by point from 450 to 950 nm
Area
* λ= 254nm
§ PIN-555AP is a detector/opamp hybrid. For op-amp specifications please refer to page 51.
¶ For mechanical drawings please refer to pages 57 thru 67.

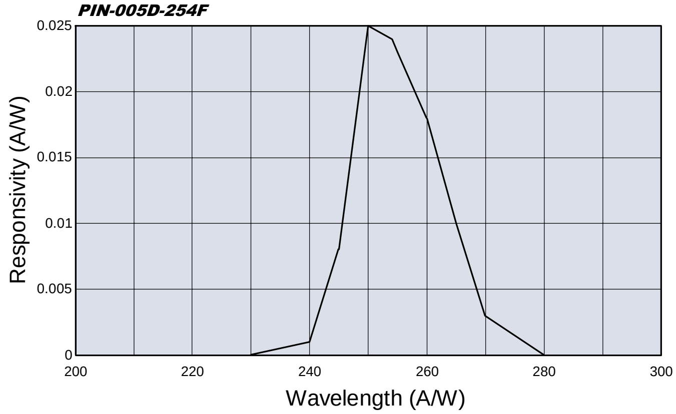
Typical Spectral Response
AP Series



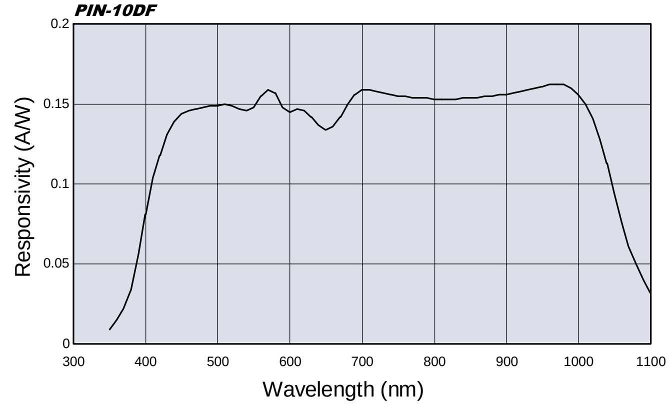
Typical Spectral Response
PIN-005E-550F



Typical Spectral Response
PIN-005D-254F

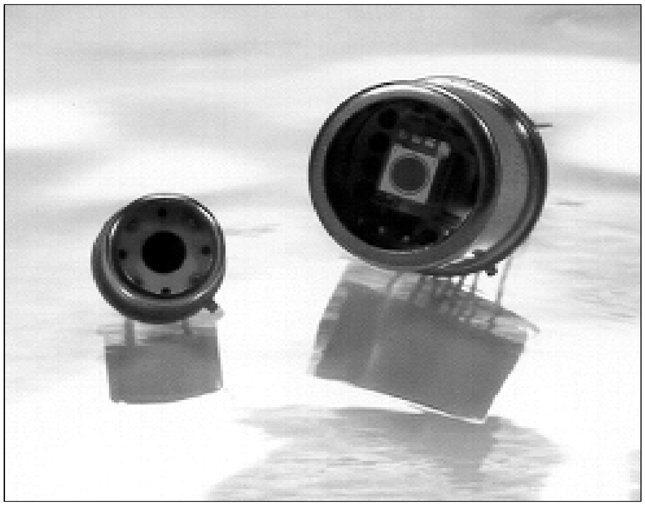


Typical Spectral Response
PIN-10DF



DUAL SANDWICH DETECTOR SERIES

TWO COLOR PHOTODIODES

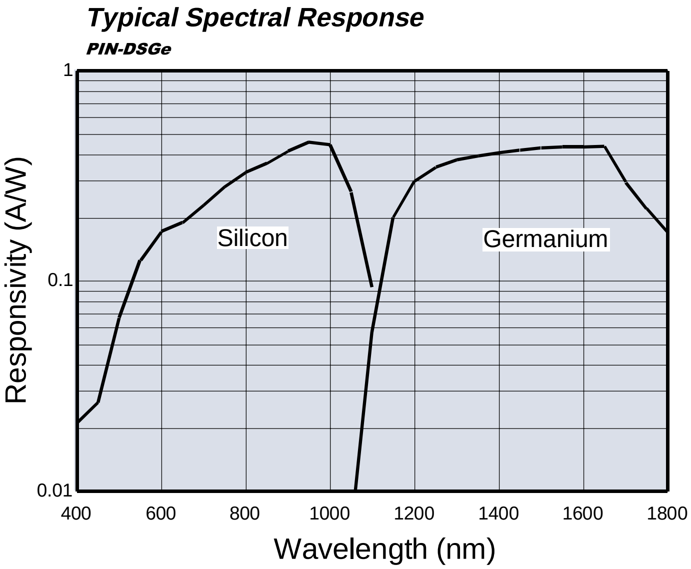


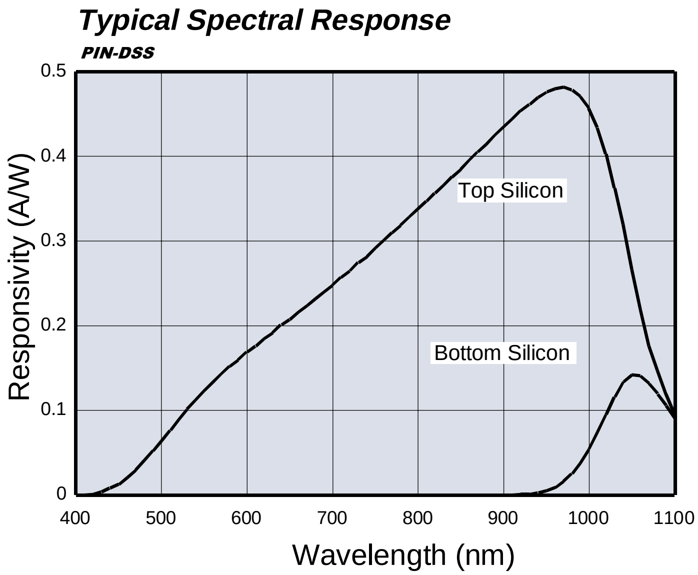
APPLICATIONS	FEATURES
• Flame Temperature sensing	• Compact
• Spectrophotometer	• Hermetically Sealed
• Dual-wavelength detection	• Low Noise
• IR Thermometers for Heat Treating, induction heating, and other metal parts processing	• Wide Wavelength Range
	• Remote Measurements
	• w/ TEC

Dual Sandwich Detectors or Two Color Detectors are mostly employed for remote temperature measurements. The temperature is measured by taking the ratio of radiation intensities of two adjacent wavelengths and comparing them with the standard black body radiation curves. The advantages of optical remote measurement have definitely made these devices the perfect match for this type of measurements. They are independent of emissivity and unaffected by contaminants in the field of view or moving targets. In addition, measurements of targets out of the direct line of sight and the ability to function from outside RF/EMI interference or vacuum areas are possible. They also have the advantages of overcoming obstructed target views, blockages from sight tubes, channels or screens, atmospheric smoke, steam, or dust, dirty windows as well as targets smaller than field of view and/or moving within the field of view. These detectors can also be used in applications where wide wavelength range of detection is needed.

UDT Sensors offers three types of dual sandwich detectors. The Silicon-Silicon sandwich, in which one silicon photodiode is placed on top of the other, with the photons of shorter wavelengths absorbed in the top silicon and the photons of longer wavelengths penetrating deeper, absorbed by the bottom photodiode. For applications requiring a wider range of wavelength beyond 1.1 µm, either a Germanium or InGaAs photodiode replaces the bottom photodiode. The Silicon-InGaAs version is also available with a two stage thermoelectric cooler for more accurate measurements by stabilizing the temperature of InGaAs detector.

All devices are designed for photovoltaic operation (no bias), however, they may be biased if needed, to the maximum reverse voltage specified. They are ideal for coupling to an operational amplifier in the current mode. For further details refer to the "Photodiode Characteristics" section of this catalog.





Model No.	Detector Element	Active Area Dimension (mm)	Spectral Range (nm)	Peak Wave-length (nm) typ	Responsivity (A/W) Peak λ typ	Cap. (pF) 0 V typ	Shunt Resistance (MΩ) -10 mV min	Shunt Resistance (MΩ) -10 mV typ	NEP (W/√Hz) 0V Peak λ typ	D* @ peak (cm√Hz/W) 0V Peak λ typ	Reverse Voltage (V) max	Rise Time (µs) 0 V 50 Ω Peak λ typ	Temp Range (°C) Operating	Temp Range (°C) Storage	Package Style ¶
NON-COOLED															
PIN-DSS	Si (top)	2.54 ϕ	400-1100	950	0.45	70	50	500	1.3 e -14	1.7 e +13	5	10	-40 ~ +100	-55 ~ +125	17 / TO-5
	Si		950-1100	1060	0.12				4.8 e -14	4.7 e +12		150			
PIN-DSGe	Si (top)	2.54 ϕ	400-1100	950	0.45	70	50	500	1.3 e -14	1.7 e +13	5	10			
	Ge	2.00 ϕ	1100-1800	1650	0.45	300	.006	.012	3.3 e -09	5.3 e +07	15	.035			
					min	max	min		max	max	max	max			
PIN-DSIn	Si (top)	2.54 ϕ	400-1100	950	0.55 §	450	150		1.9 e -14 §	1.2 e +13 §	5	4			
	InGaAs	2.00 ϕ	1000-1800	1300	0.60	500	1.0		2.1 e -13	8.4 e +11	2	4			
TWO STAGE THERMOELECTRICALLY COOLED															
PIN-DSIn-TEC	Si (top)	2.54 ϕ	400-1100	950	0.55 §	450	150		1.9 e -14 §	1.2 e +13 §	5	4	-40 ~ +100	-55 ~ +125	TO-8/23
	InGaAs	2.00 ϕ	1000-1700	1300	0.60	500	1.0		2.1 e -13	8.4 e +11	2	4			

§ @ 870 nm
VR=15
Thermo-Electric Cooler and Thermistor Specifications are specified in the tables below.
¶ For mechanical drawings please refer to pages 59 thru 71.

THERMISTOR SPECIFICATIONS

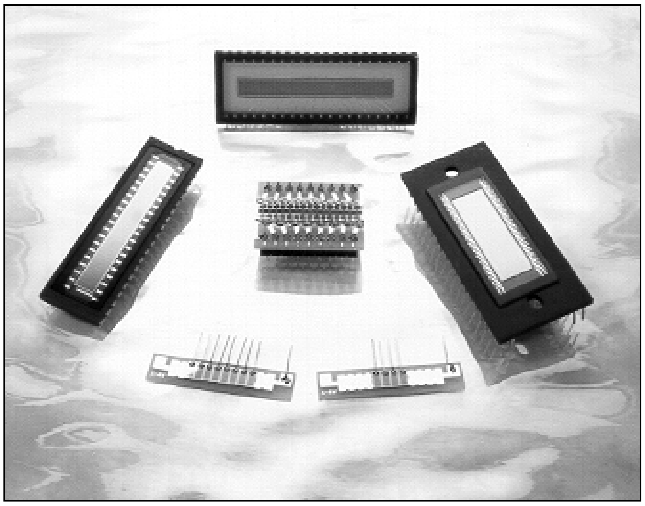
PARAMETER	CONDITION	SPECIFICATION
Temperature Range	---	-100 ”C to +100 ”C
Nominal Resistance	---	1.25 KΩ @ 25 ”C
Accuracy	-100 ”C to -25 ”C	– 6.5 ”C
	-25 ”C to +50 ”C	– 3.5 ”C
	@ 25 ”C	– 1.5 ”C
	+50 ”C to +100 ”C	– 6.7 ”C

TWO STAGE THERMO-ELECTRIC COOLER SPECIFICATIONS

PARAMETER	SYMBOL	CONDITION		SPECIFICATION
Maxiumum Achieveable Temperature Difference	ΔT_{MAX} (”C)	$I = I_{MAX}$, $Q_C = 0$	Vaccumm	91
			Dry N_2	83
Maximum Amount Of Heat Absorbed At The Cold Face	Q_{MAX} (W)	$I = I_{MAX}$, $\Delta T = 0$		0.92
Input Current Resulting In Greatest ΔT_{MAX}	I_{MAX} (A)	---		1.4
Voltage At ΔT_{MAX}	V_{NAX} (V)	---		2.0

Multi-Channel Array Series

Planar Diffused Silicon Photodiodes



Applications

- Level Meters
- Optical Spectroscopy
- Medical Equipment
- High Speed Photometry
- Computed Tomography Scanners
- Position Sensors

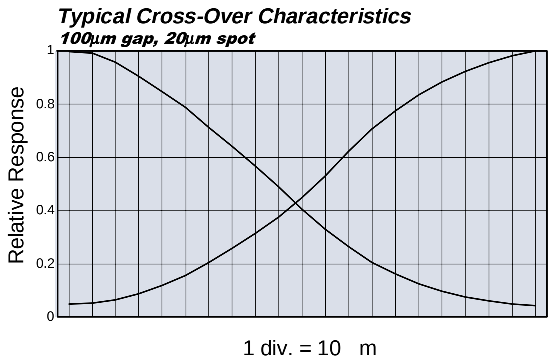
Features

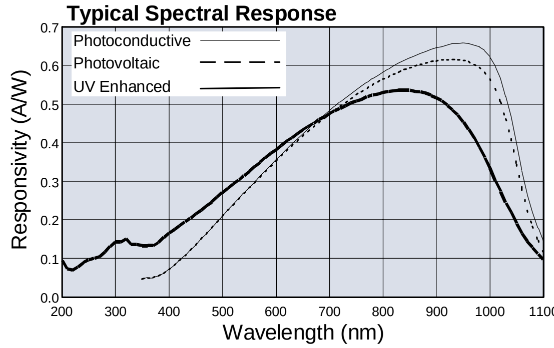
- Common Substrate Array
- Ultra Low Cross Talk
- UV Enhanced (A5V-35UV)
- Low Dark Current
- Low Capacitance
- Solderable

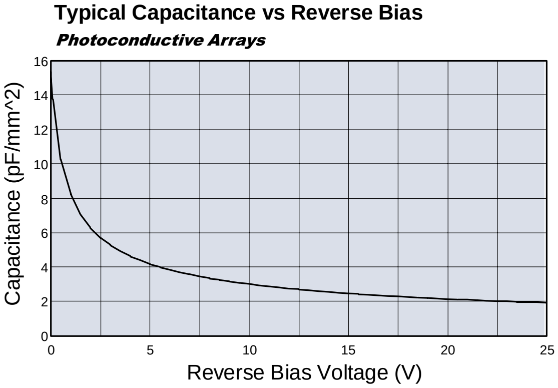
Multichannel array photodetectors consist of a number of single element photodiodes laid adjacent to each other forming a one-dimensional sensing area on a common cathode substrate. They can perform simultaneous measurements of a moving beam or beams of many wavelengths. They feature low electrical cross talk and super high uniformity between adjacent elements allowing very high precision measurements. Arrays offer a low cost alternative when a large number of detectors are required. The detectors are optimized for either UV, visible or near IR range.

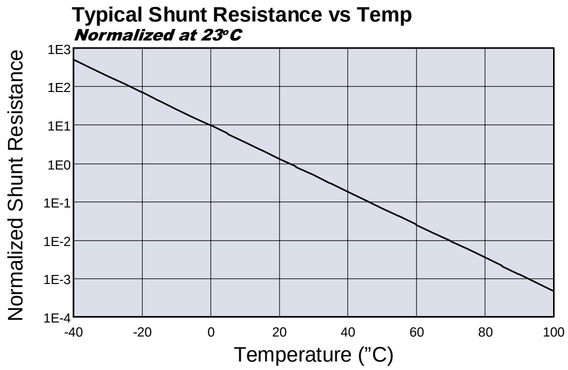
They can be either operated in photoconductive mode (reverse biased) to decrease the response time, or in photovoltaic mode (unbiased) for low drift applications. A2V-16 can be coupled to any scintillator crystal for measuring high-energy photons in the X-ray and γ-ray region of electro-magnetic spectrum. In addition, they have been mechanically designed, so that several of them can be mounted end to end to each other in applications where more than 16 elements are needed.

Figure 12 in the “Photodiode Characteristics” section of this catalog provides a detailed circuit example for the arrays.









Model No.	Number of Elements	Active Area Per Element		Pitch (mm)	Respon-sivity (A/W)	Shunt Resistance (MΩ)	Dark Current (nA)	Capacitance (pF)		NEP (W / √Hz)		Temp. Range (°C)		Package Style ¶
		Area (mm²)	Dimension (mm)		970 nm	-10 mV	-10 V	0 V	-10 V	0 V 970nm	-10 V 970nm	Operating	Storage	
					typ	typ	typ	typ		typ	Typ			
PHOTOCONDUCTIVE SERIES														
A5C-35	35	3.9	4.39 x 0.89	0.99	0.65	---	0.05	---	12	---	6.2 e -15	-30 ~ +85	-40~+125	50 / 40 pin DIP
A5C-38	38													
PHOTOVOLTAIC SERIES														
A2V-16	16	1.92	1.57 x 1.22	1.59	0.60	1000	---	170	---	4.8 e -15	---			48 / PCB
A5V-35	35	3.9	4.39 x 0.89	0.99	0.60	1000	---	340	---	4.8 e -15	---			50 / 40 pin DIP
A5V-38	38													
A2V-76	76	1.8	6.45 x 0.28	0.31	0.50	500	---	160	---	8.2 e -15	---			49 /Ceramic
UV ENHANCED SERIES (All Specifications @ λ = 254 nm, V_{BIAS} = -10V)														
A5V-35UV	35	3.9	4.39 x 0.89	0.99	0.06	500	---	340	---	6.8 e -14	---			50 / 40 pin DIP

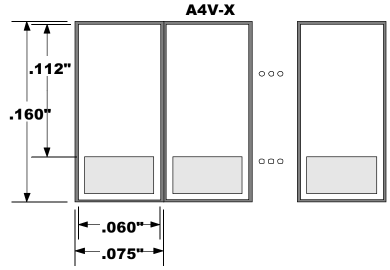
MONOLITHIC SOLDERABLE CHIP ARRAYS

TYPICAL ELECTRO-OPTICAL SPECIFICATIONS AT T_A=23 °C

Model No.	Number of Elements	Element Size mm (inches)	Active Area per Element mm² (inches²)	Pitch mm (inches)	Short Circuit Current / element (mA)	Open Circuit Voltage / element (mV)	Shunt Resistance (MΩ)	Capacitance (pF)
					10 mW/cm² 2850 °K	10 mW/cm² 2850 °K	-10 mV	0 V
					typ	typ	typ	typ
A4V-2 **A4V-2L §**	2	1.52 X 2.79 (0.06 X 0.110)	4.24 (0.007)	1.91 (0.075)	0.07	500	1000	500
A4V-4 **A4V-4L**	4							
A4V-6 **A4V-6L**	6							
A4V-8 **A4V-8L**	8							
A4V-10 **A4V-10L**	10							
A4V-12 **A4V-12L**	12							

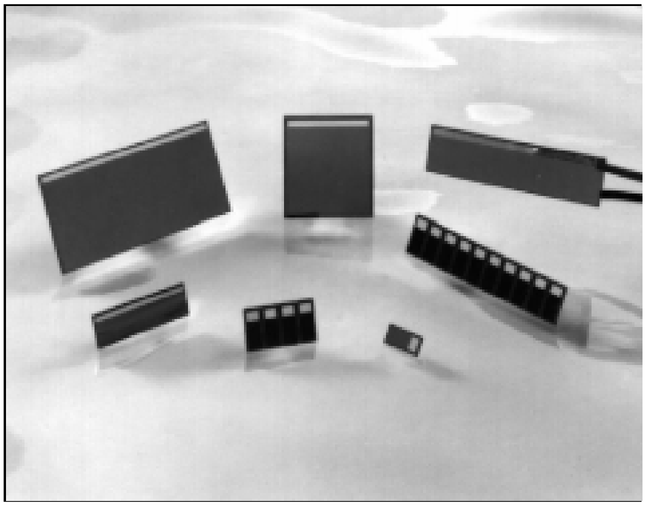
§ The L series solderable chips are mounted on a 1.25" x 0.25" PCB at the center.
The chips are equiped with a 2" long bare tinned leads soldered to all anodes and the common cathode.

V suffix indicates the device is optimized for photovoltaic operation
C suffix indicates the device is optimized for photoconductive operation.
¶ For mechanical drawings please refer to pages 59 thru 71.



SOLDERABLE CHIP SERIES

PLANAR DIFFUSED SILICON PHOTODIODES

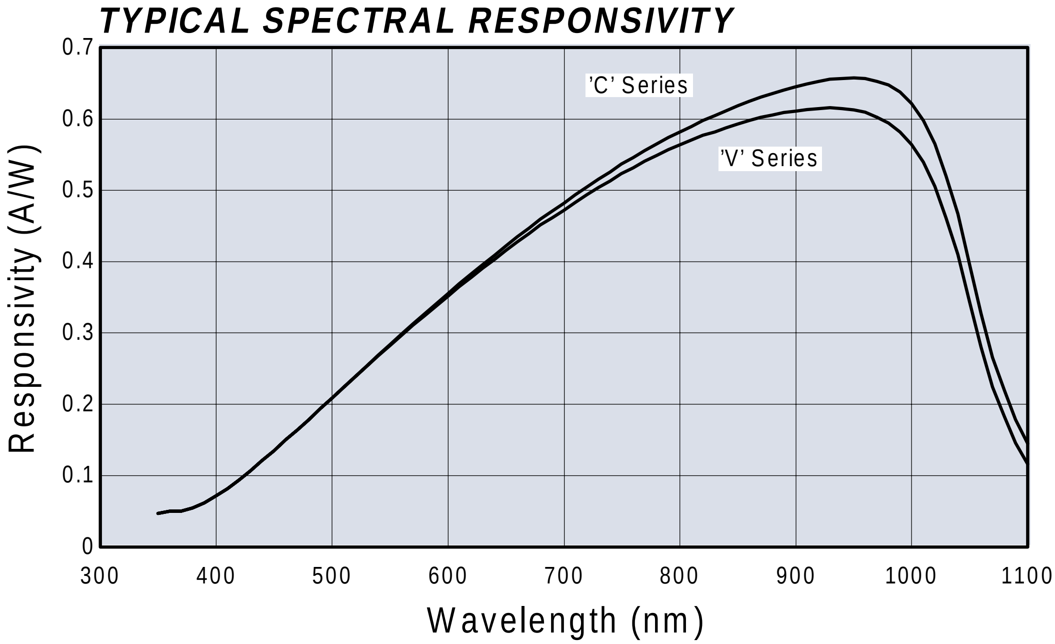


APPLICATIONS	FEATURES
• Solar Cells	• Large Active Areas
• Low Cost Light Monitoring	• Various Sizes
• Diode Laser Monitoring	• High Shunt
• Low Capacitance	

The Solderable photodiode chip series offer a low cost approach to applications requiring large active area photodetectors with or without flying leads for ease of assembly and / or situations where the detector is considered "disposable". They have low capacitance, moderate dark currents, wide dynamic ranges and high open circuit voltages. These detectors are available with two 3" long leads soldered to the front (anode) and back (cathode). There are two types of photodiode chips available. "Photoconductive" series, (S-XXCL) for low capacitance and fast response and "Photovoltaic" series (S-XXVL) for low noise applications.

All of the devices are also available in chip form without any leads. For ordering subtract suffix 'L' from the model number, e.g. S-100C.

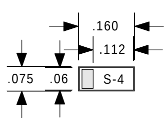
For large signal outputs, the detectors can be connected directly to a current meter or across a resistor for voltage measurements. Alternately, the output can be measured directly with an oscilloscope or with an amplifier. Please refer to the "Photodiode Characteristics" section for further details.

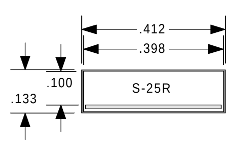


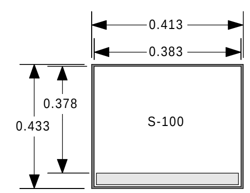
Model No.	Active Area		Chip size	Short Circuit Current (mA)	Open Circuit Voltage (mV)	Shunt Resistance (MΩ)	Dark Current (nA)	Capacitance (pF)	
	Area mm^2 ($inches^2$)	Dimensions mm (inches)	mm (inches)	100 mW/cm^2 2850 ºK	100 mW/cm^2 2850 ºK	-10 mV	-5 V	0 V	-5 V
				typ	min	min	max	typ	typ
S-4CL §	4.7 (0.007)	1.7 x 2.8 (0.07 x 0.11)	1.9 x 4.1 (0.08 x 0.16)	0.75	400	---	20	---	15
S-4VL				0.65		10	---	370	---
S-10CL	9.6 (0.015)	2.3 x 4.2 (0.09 x 0.17)	2.5 x 5.1 (0.10 x 0.10)	1.5		---	40	---	30
S-10VL				1.4		8	---	750	---
S-25CL	25.8 (0.04)	5.1 x 5.1 (0.20 x 0.20)	5.5 x 6.0 (0.22 x 0.24)	4.0		---	100	---	95
S-25VL				3.8		5	---	2100	---
S-25CRL	25.4 (0.039)	2.5 x 10.1 (0.10 x 0.40)	3.4 x 10.5 (0.13 x 0.41)	4.0		---	100	---	95
S-25VRL				3.8		5	---	2100	---
S-50CL	51.0 (0.079)	2.5 x 20.3 (0.10 x 0.80)	3.4 x 20.6 (0.13 x 0.81)	9.0		---	300	---	200
S-50VL				8.0		3	---	4000	---
S-80CL	82.6 (0.128)	4.1 x 20.1 (0.16 x 0.79)	5.2 x 20.4 (0.21 x 0.80)	12.0		---	500	---	300
S-80VL				11.0		2	---	6000	---
S-100CL	93.4 (0.145)	9.7 x 9.7 (0.38 x 0.38)	10.5 x 11.00 (0.42 x 0.43)	14.0		---	600	---	375
S-100VL				13.0		1.0	---	8500	---
S-120CL	105.7 (0.164)	4.5 x 23.5 (0.18 x 0.93)	5.5 x 23.9 (0.22 x 0.94)	17.0		---	800	---	450
S-120VL				15.0		0.5	---	10000	---
S-200CL	189.0 (0.293)	9.2 x 20.7 (0.36 x 0.81)	10.2 x 21.0 (0.40 x 0.83)	27.0		---	1200	---	750
S-200VL				25.0		0.2	---	17000	---

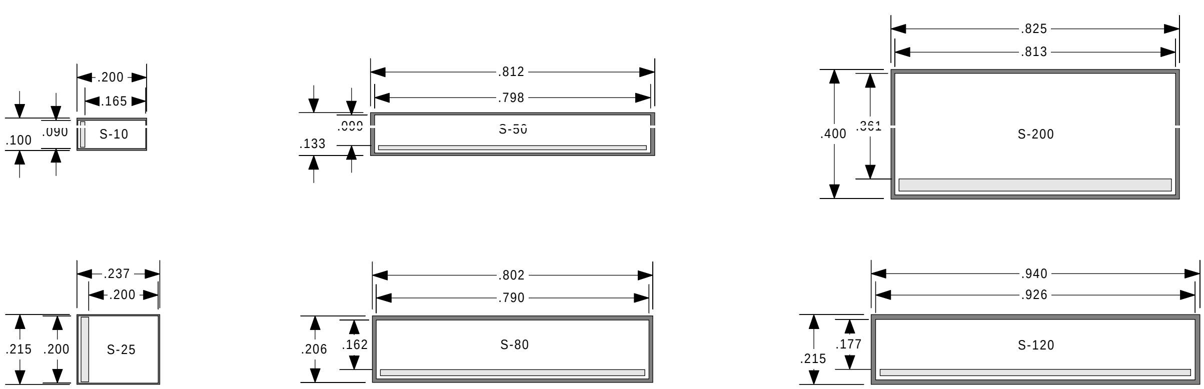
§ ALL OF THE ABOVE BARE CHIPS ARE PROVIDED WITH TWO 3" LONG 29-30 AWG INSULATED COLOR CODED LEADS ATTACHED TO THE FRONT FOR ANODE (RED) AND TO THE BACK FOR CATHODE (BLACK). THEY ARE ALSO AVAILABLE IN CHIP FORM ONLY (LEADLESS). FOR ORDERING SUBTRACT SUFFIX L FROM THE MODEL NUMBER, I.E. S-100C.

All chip dimensions in inches.



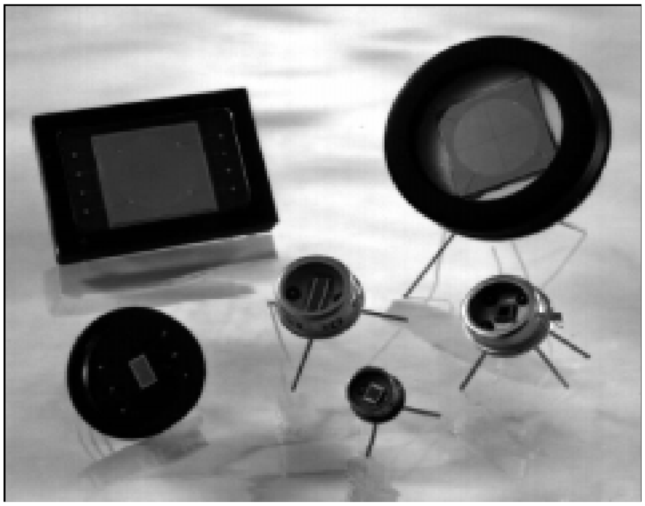






SEGMENTED PHOTODIODES (SPOT SERIES)

POSITION SENSING DETECTORS (PSD)



APPLICATIONS

- Machine Tool Alignment
- Position Measuring
- Beam Centering
- Surface Profiling
- Targeting
- Guidance Systems

FEATURES

- High Accuracy
- Excellent Resolution
- High-Speed Response
- Ultra Low Dark Current
- Excellent Response Match
- High Stability over Time and Temperature

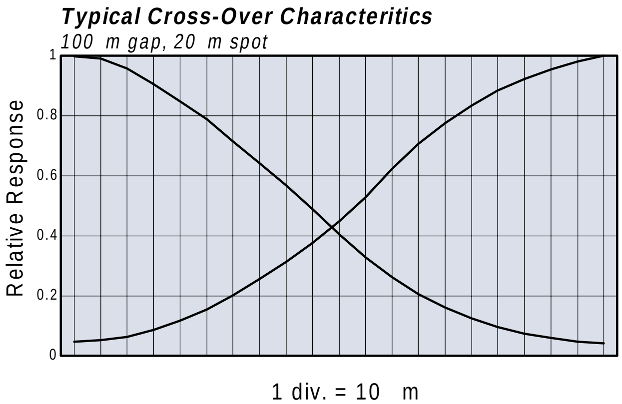
The SPOT Series are common substrate photodetectors segmented into either two (2) or four (4) separate active areas. They are available with either a 0.005" or 0.0004" well defined gap between the adjacent elements resulting in high response uniformity between the elements. The SPOT series are ideal for very accurate nulling or centering applications. Position information can be obtained when the light spot diameter is larger than the spacing between the cells.

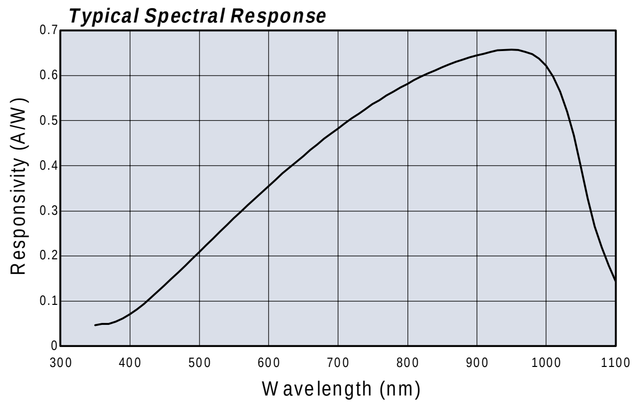
Spectral response range is from 350-1100nm. Notch or bandpass filters can be added to achieve specific spectral responses.

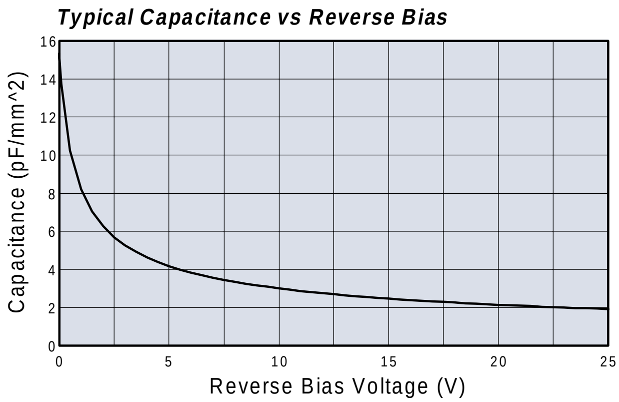
These detectors exhibit excellent stability over time and temperature, fast response times necessary for high speed or pulse operation, and position resolutions of better than 0.1 µm.

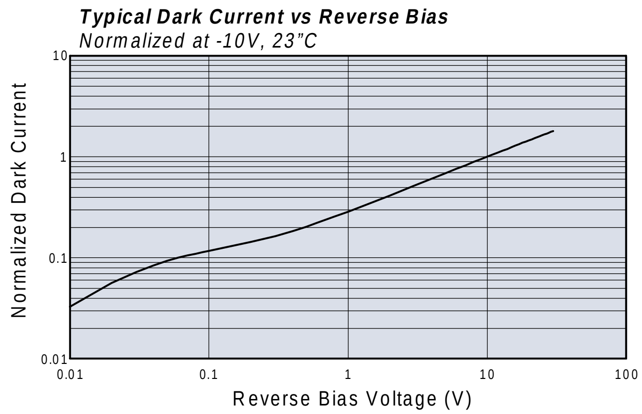
Maximum recommended power density is 10 mW / cm^2 and typical uniformity of response for a 1 mm diameter spot is ±2%.

The circuit on the opposite page represents a typical biasing and detection circuit set up for both bi and quad cells. For position calculations and further details, refer to “Photodiode Characteristics” section of the catalog.









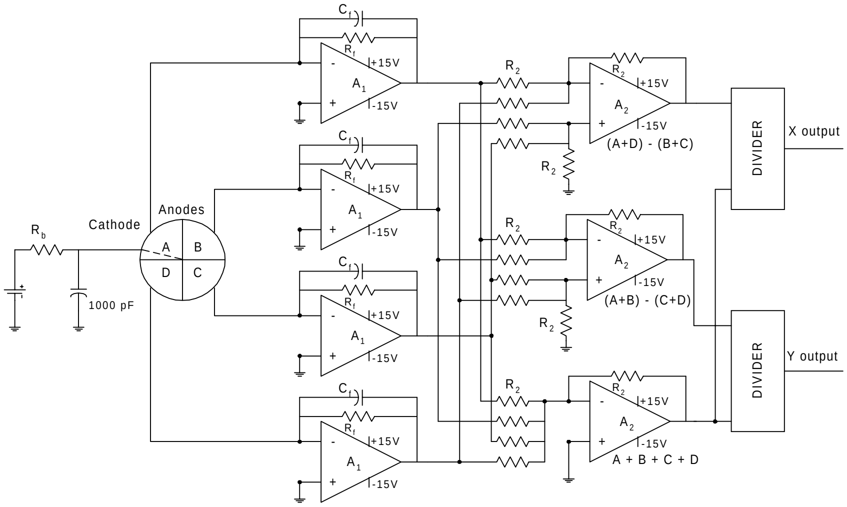
Model No.	Active Area Per Element		Element Gap (mm)	Responsivity (A/W)		Capacitance (pF)	Dark Current (nA)		NEP (W/√Hz)	Reverse Voltage (V)	Rise Time (ns)	Temp Range (ºC)		Package Style ¶
	Area (mm^2)	Dimension (mm)		970 nm		-10 V	-10 V		-10 V 970 nm		-10V 780 nm 50 Ω	Operating	Storage	
				min	typ	typ	typ	max	typ	max	typ			
TWO-ELEMENT SERIES, METAL PACKAGE														
SPOT-2D	3.3	1.3 X 2.5	.127	0.60	0.65	11	0.15	2.0	1.1 e -14	30	5	-40 ~ +100	-55 ~ +125	38 / TO-5
SPOT-2DMI	0.7	0.6 x 1.2	.013			3	0.05	1.0	6.2 e -15		7			37 / TO-18
SPOT-3D	2.8	0.6 X 4.6	.025			7	0.13	2.0	9.9 e -15		4			38 / TO-5
FOUR-ELEMENT SERIES, METAL PACKAGE														
SPOT-4D	1.61	1.3 sq	.127	0.60	0.65	5	0.10	1.0	8.7 e -15	30	3	-40 ~ +100	-55 ~ +125	38 / TO-5
SPOT-4DMI	0.25	0.5 sq	.013			1	0.01	0.5	2.8 e -15					
SPOT-9D	19.6	10 ϕ	.102			60	0.50	10.0	1.9 e -14					40 / LoProf
SPOT-9DMI			.010											
PLASTIC PACKAGE §														
FIL-S2DG	3.3	1.3 X 2.5	.127	0.60	0.65	11	0.15	2.0	1.1 e -14	30	5	-10 ~ +60	-20 ~ +70	14 / Plastic
FIL-S4DG	1.6	1.3 sq	.127			5	0.10	1.0	8.7 e -15		3			
FIL-S9DG	19.6	10 ϕ	.102			60	0.50	10.0	1.9 e -14					15 / Plastic

§ The photodiode chips in FIL series are isolated in a low profile plastic package. The have a large field of view as well as in line pins. FIL-S2DG has the same photodiode as SPOT-2D, FIL-S4DG has the same photodiode as SPOT-4D and FIL-S9DG has the same photodiode chip as SPOT-9D.

Overall Diameter (All four Quads)

¶ For mechanical drawings please refer to pages 59 thru 71.

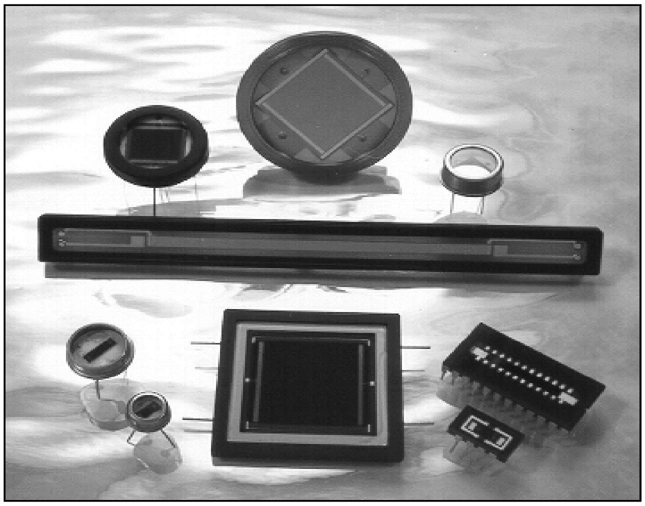
Chip centering within –0.010".



For further details refer to the Photodiode Characteristic section of the catalog.

DUO-LATERAL, SUPER LINEAR PSD's

POSITION SENSING DETECTORS (PSD)



APPLICATIONS

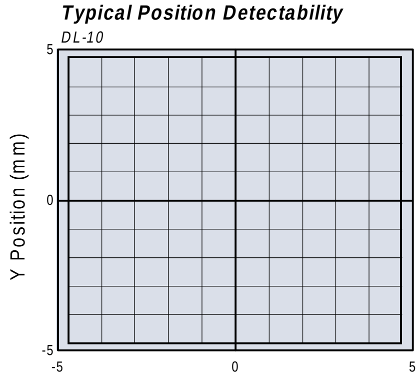
- Beam Alignment
- Position Sensing
- Angle Measurement
- Surface Profiling
- Height Measurements
- Targeting
- Guidance System
- Motion Analysis

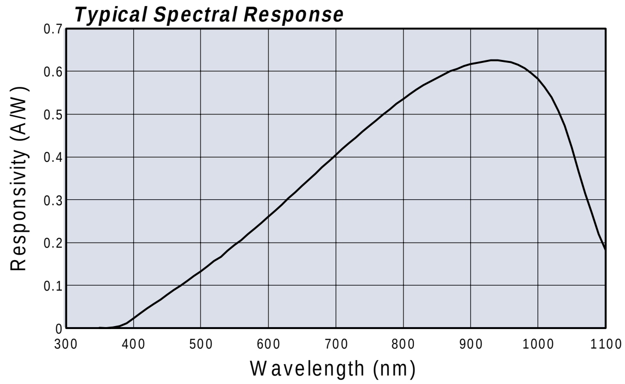
FEATURES

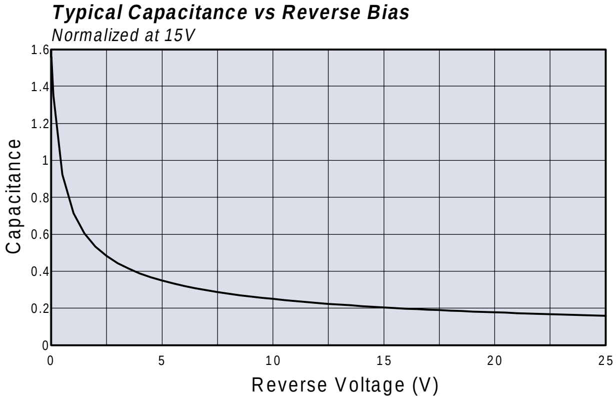
- Super Linear
- Ultra High Accuracy
- Wide Dynamic Range
- High Reliability
- Duo Lateral Structure

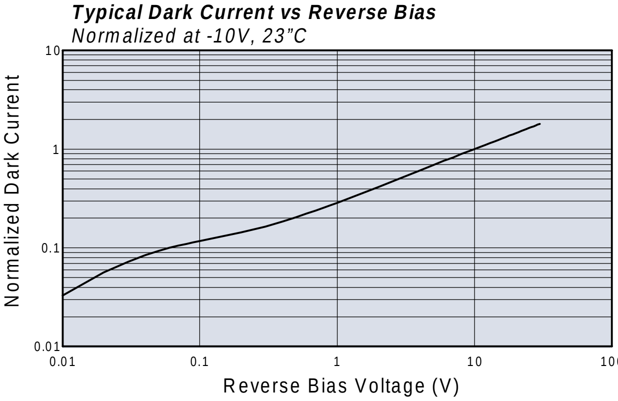
The Super Linear Position Sensors feature state of the art duo-lateral technology to provide a continuous analog output proportional to the displacement of the centroid of a light spot from the center, on the active area. As continuous position sensors, these detectors are unparalleled; offering position accuracies of 99% over 64% of the sensing area. These accuracies are achieved by duo-lateral technology, manufacturing the detectors with two separate resistive layer, one located on the top and the other at the bottom of the chip. One or two dimensional position measurements can be obtained using these sensors.
A reverse bias should be applied to these detectors to achieve optimum current linearity at high light levels. For position calculations and further details on circuit set up, refer to the "Photodiode Characteristics" section of the catalog.

The maximum recommended power density incident on the duo lateral PSDs are 1 mW / cm^2. For optimum performance, incident beam should be perpendicular to the active area with spot size less than 1 mm in diameter.









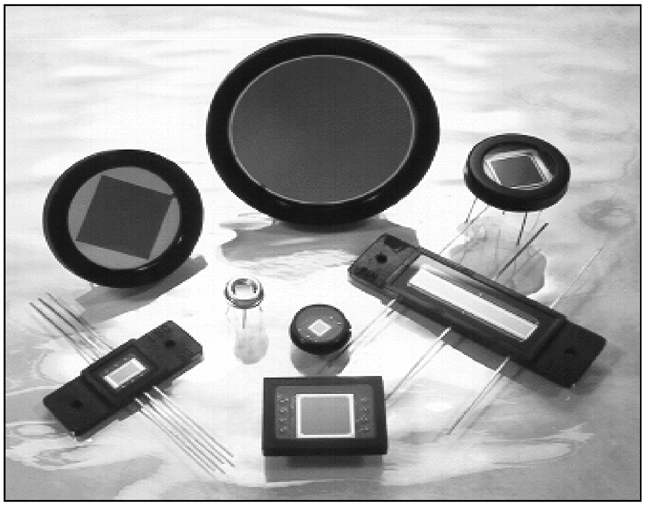
Model No.	Position Sensing Area		Respon-sivity (A/W)		Position Detection Error (µm)	Dark Current (nA)		Capacitance (pF)		Rise Time (µs)	Position Detection Drift (µm / °C)	Inter-electrode Resistance (KΩ)		Temp Range (°C)		Package Style ¶
	Area (mm^2)	Dimension (mm)	670 nm		Over 80% of Length 64% of Sensing Area	-15V, SL Series -5 V, DL Series		-15V, SL Series -5V, DL Series		670 nm 50 Ω				Operating	Storage	
			min	typ	typ	typ	max	typ	max	typ	typ	min	max			
ONE-DIMENSIONAL SERIES METAL PACKAGE (V_{BIAS}=-15V)																
SL3-1	3	3 X 1	0.3	0.4	3	5	50	3	7	0.04	0.06	15	80	-10 ~ +60	-20 ~ +80	38 / TO-5
SL5-1	500	5 X 1			5	10	100	5	9	0.10	0.10	20	100			39 / TO-8
ONE-DIMENSIONAL SERIES CERAMIC PACKAGE (V_{BIAS}=-15V)																
SL3-2	3	3 X 1	0.3	0.4	3	5	50	3	7	0.04	0.06	15	80	-10 ~ +60	-20 ~ +80	45 / 8-pin DIP
SL5-2	5	5 X 1			5	10	100	5	9	0.10	0.10	20	100			
SL15	15	15 x 1			15	150	300	15	25	0.60	0.10	60	300			46 / 24-pin DIP
SL76-1	190	76 x 2.5			76	100	1000	190	250	14.00	1.4	120	600			47 / Special
TWO-DIMENSIONAL SERIES METAL PACKAGE § (V_{BIAS}=-5V)																
DL-2	4	2 sq	0.3	0.4	30	30	600	10	30	0.25	0.20	5	25	-10 ~ +60	-20 ~ +80	36 / TO-8
DLS-2						10	175	8	14		0.40					
DL-4	16	4 sq			50	50	1000	35	60	0.08	0.20					
DLS-4						25	300	30	40		0.40					
DL-10	100	10 sq			100	500	5000	175	375	0.20	0.20					41 / Special
DL-20	400	20 sq			200	2000	12000	600	1500	1.00	0.40					34 / Special
TWO-DIMENSIONAL SERIES CERAMIC PACKAGE § (V_{BIAS}=-5V)																
DLS-10	100	10 sq	0.3	0.4	100	50	400	160	200	0.20	0.2	5	25	-10 ~ +60	-20 ~ +80	35 / Ceramic
DLS-20	400	20 sq			200	100	1000	580	725	1.00	0.4					

The position temperature drift specifications are for the die mounted on a copper plate without a window and the beam at the electrical center of the sensing area.
§ The DLS Series are packaged with A/R coated windows and have a lower dark current than the DL series.
Also available in the same package as DL-10. Specificy DL-10-1.
¶ For mechanical drawings please refer to pages 59 thru 71.

NOTES:
1. DL(S) series are available with removable windows.
2. Chip centering within – 0.010".

TETRA-LATERAL PSD'S

POSITION SENSING DETECTORS (PSD)



APPLICATIONS

- Tool Alignment and Control
- Leveling Measurements
- Angular Measurements
- 3 Dimensional Vision
- Position Measuring

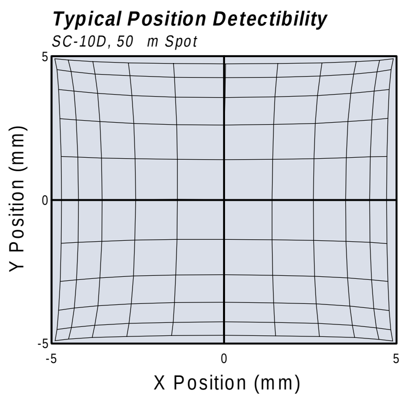
FEATURES

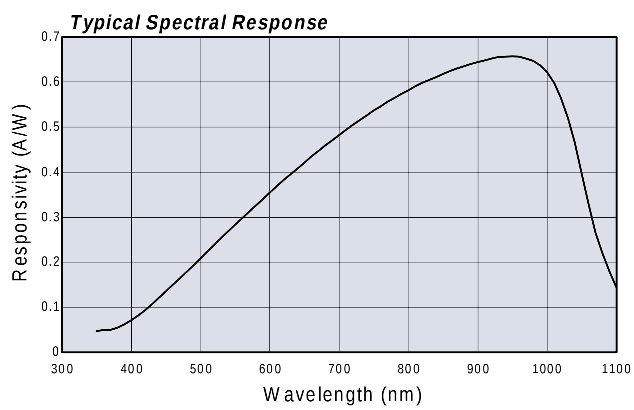
- Single Resistivity Layer
- High Speed Response
- High Dynamic Range
- Very High Resolution
- Spot Size & Shape Independence

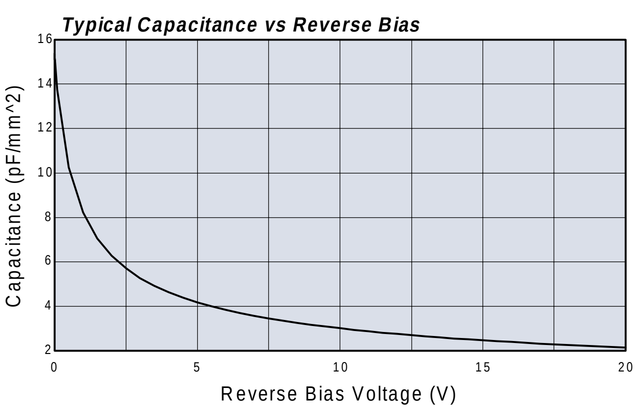
Tetra-lateral position sensing detectors are manufactured with one single resistive layer for both one and two dimensional measurements. They feature a common anode and two cathodes for one dimensional position sensing or four cathodes for two dimensional position sensing.

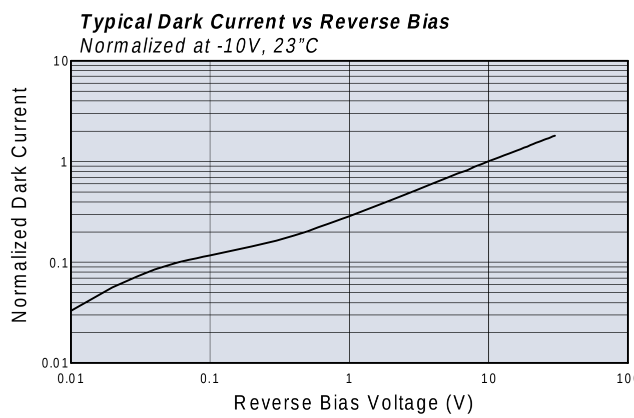
These detectors are best when used in applications that require measurement over a wide spacial range. They offer high response uniformity, low dark current, and good position linearity over 64% of the sensing area.

A reverse bias should be applied to these detectors to achieve optimum current linearity when large light signals are present. The circuit on the opposite page represents a typical circuit set up for two dimensional tetra-lateral PSDs. For further details as well as the set up for one dimensional PSDs refer to the "Photodiode Characteristics" section of the catalog. Note that the maximum recommended incident power density is 10 mW / cm^2. Furthermore, typical uniformity of response for a 1 mm ϕ spot size is ± 5% for SC-25D and SC-50D and ± 2% for all other tetra-lateral devices.









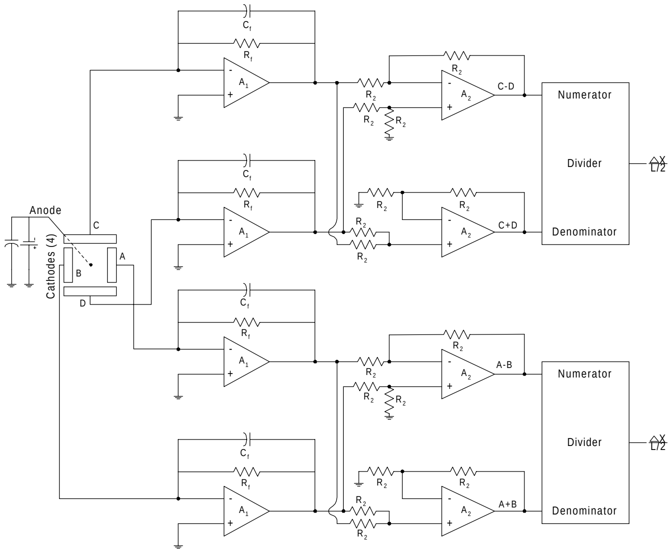
Model No.	Position Sensing Area		Responsivity (A/W)		Absolute Position Detection Error (mm)	Dark Current (nA)		Capacitance (pF)	Rise Time (µs)	Inter-electrode Resistance (KΩ)		Temp Range (ºC)		Package Style ¶
	Area (mm^2)	Dimension (mm)	670 nm		Over 80% of Length 64% of Area	-15 V		-15 V	-15 V 670 nm 50Ω			Operating	Storage	
			min	typ	typ	typ	max	typ	typ	min	max			
ONE-DIMENSIONAL SERIES PLASTIC PACKAGE														
LSC-5D	11.5	5.3 x 2.2	0.35	0.42	0.040	1	20	50	0.25	2	50	-10 ~ +60	-20 ~ +70	44 / Plastic
LSC-30D	122	30 x 4.1			0.240	3	60	300	3.00	4	100			43/ Plastic
TWO-DIMENSIONAL SERIES METAL PACKAGE														
SC-4D	6.45	2.54 sq	0.35	0.42	0.080	0.5	10	20	0.66	3	30	-0 ~ +70	-20 ~ +80	38 / TO-5
SC-10D	103	10.16 sq			1.30	3	50	300	1.00					41 / Special
SC-13D	173	13.0 sq			2.20	5	100	500	1.70					
SC-25D	350	18.80 sq			4.45	12	250	1625	5.00					42 / Special
SC-50D	957	30.94 sq			12.25	50	1000	3900	13.00					20 / Special
TWO DIMENSIONAL SERIES PLASTIC PACKAGE §														
FIL-C4DG	6.45	2.54 sq	0.35	0.42	0.080	0.5	10	20	0.66	3	30	-10 ~ +60	-20 ~ +70	14 / Plastic
FIL-C10DG	103	10.16 sq			1.30	3	50	300	1.00					15 / Plastic

Rise time specifications are with a 1 mm ϕ spot size at the center of the device.

§ The photodiode chips in FIL series are isolated in a low profile plastic package. The have a large field of view as well as in line pins.

¶ For mechanical drawings please refer to pages 59 thru 71.

Chip centering within – 0.010".



For further details refer to the Photodiode Characteristics section of the catalog

PHOTODIODE CARE AND HANDLING

AVOID DIRECT LIGHT

Since the spectral response of silicon photodiode includes the visible light region, care must be taken to avoid photodiode exposure to high ambient light levels, particularly from tungsten sources or sunlight. During shipment from UDT Sensors, your photodiodes are packaged in opaque, padded containers to avoid ambient light exposure and damage due to shock from dropping or jarring.

AVOID SHARP PHYSICAL SHOCK

Photodiodes can be rendered inoperable if dropped or sharply jarred. The wire bonds are delicate and can become separated from the photodiode's bonding pads when the detector is dropped or otherwise receives a sharp physical blow.

CLEAN WINDOWS WITH OPTICAL GRADE CLOTH / TISSUE

Most windows on UDT Sensors photodiodes are either silicon or quartz. They should be cleaned with isopropyl alcohol and a soft (optical grade) pad.

OBSERVE STORAGE TEMPERATURES AND HUMIDITY LEVELS

Photodiode exposure to extreme high or low storage temperatures can affect the subsequent performance of a silicon photodiode. Storage temperature guidelines are presented in the photodiode performance specifications of this catalog.

OBSERVE ELECTROSTATIC DISCHARGE (ESD) PRECAUTIONS

UDT Sensors photodiodes, especially with IC devices (e.g. Photops) are considered ESD sensitive. The photodiodes are shipped in ESD protective packaging. When unpacking and using these products, anti-ESD precautions should be observed.

DO NOT EXPOSE PHOTODIODES TO HARSH CHEMICALS

Photodiode packages and/or operation may be impaired if exposed to CHLOROTHENE, THINNER, ACETONE, or TRICHLOROETHYL-ENE.

INSTALL WITH CARE

Most photodiodes in this catalog are provided with wire or pin leads for installation in circuit boards or sockets. Observe the soldering temperatures and conditions specified below:

Soldering Iron:	Soldering 30 W or less Temperature at tip of iron 300°C or lower.
Dip Soldering:	Bath Temperature: 260±5°C. Immersion Time: within 5 Sec. Soldering Time: within 3 Sec.
Vapor Phase Soldering:	DO NOT USE
Reflow Soldering:	DO NOT USE

Photodiodes in plastic packages should be given special care. Clear plastic packages are more sensitive to environmental stress than those of black plastic. Storing devices in high humidity can present problems when soldering. Since the rapid heating during soldering stresses the wire bonds and can cause wire to bonding pad separation, it is recommended that devices in plastic packages to be baked for 24 hours at 85°C.

The leads on the photodiode SHOULD NOT BE FORMED. If your application requires lead spacing modification, please contact UDT Sensors Applications group before forming a product's leads. Product warranties could be voided.

PACKAGE MECHANICAL SPECIFICATIONS AND PARAMETERS

1. Parameter Definitions:

A = Distance from top of chip to top of glass.

a = Photodiode Anode.

B = Distance from top of glass to bottom of case.

c = Photodiode Cathode **(Note: cathode is common to case in metal package products unless otherwise noted)**.

W = Window Diameter.

F.O.V. = Filed of View (see definition below).

2. Dimensions are in inches (1 inch = 25.4 mm).

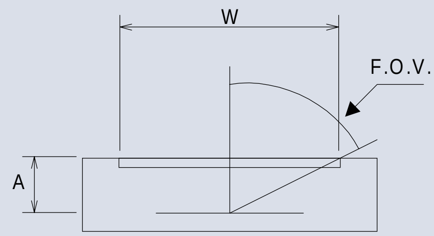
3. Pin diameters are 0.018 ± 0.001" unless otherwise specified.

4. Tolerances (unless otherwise noted)

General:	0.XX	± 0.01"
	0.XXX	± 0.005"
Chip Centering:	± 0.010"	
Dimension 'A':	± 0.015"	

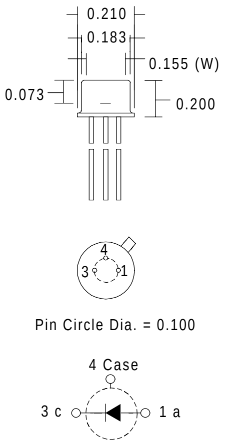
5. Windows

All 'UV' Enhanced products are provided with QUARTZ glass windows, 0.027 ± 0.002" thick.
All 'XUV' products are provided with removable windows.
All 'DLS' PSD products are provided with A/R coated glass windows.
All 'FIL' *photoconductive* and *photovoltaic* products are epoxy filled instead of glass windows.



$$F.O.V. = \tan^{-1}[W/2A]$$

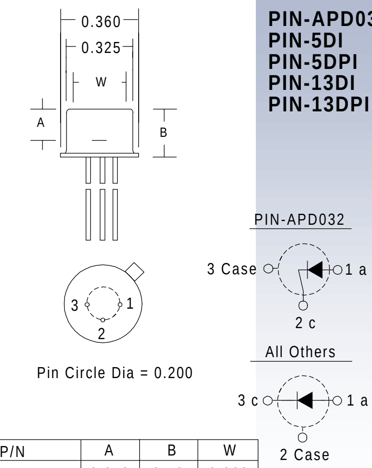
1 TO-18



Products

PIN-020A
PIN-040A

2 TO-5

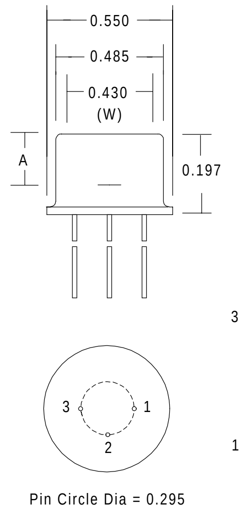


P/N	A	B	W
PIN-APD032	0.073	0.167	0.260
All Others	0.094	0.180	0.240

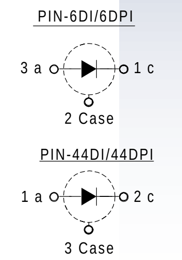
Products

PIN-APD032
PIN-5DI
PIN-5DPI
PIN-13DI
PIN-13DPI

3 TO-8



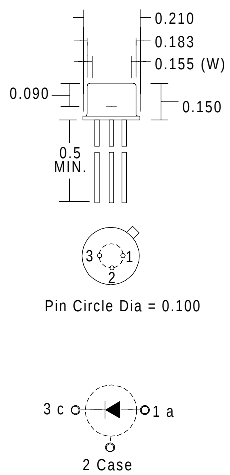
P/N	A
PIN-6DI PIN-6DPI	0.115
PIN-44DI PIN-44DPI	0.125



Products

PIN-6DI
PIN-6DPI
PIN-44DI
PIN-44DPI

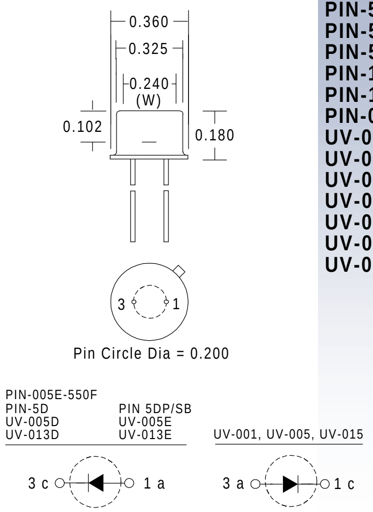
4 TO-18



Products

PIN-2DI
PIN-2DPI
PIN-3CDI
PIN-3CDPI

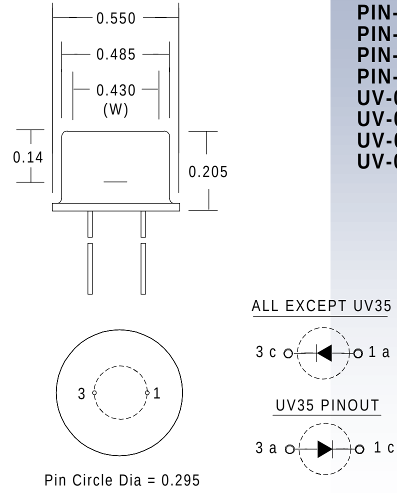
5 TO-5



Products

PIN-5D
PIN-5DP
PIN-5DP/SB
PIN-13D
PIN-13DP
PIN-005E-550F
UV-001
UV-005
UV-005D
UV-005E
UV-013D
UV-013E
UV-015

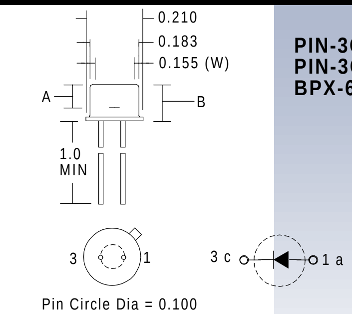
6 TO-8



Products

PIN-6D
PIN-6DP
PIN-44D
PIN-44DP
UV-020
UV-035D
UV-035E
UV-035

7 TO-18

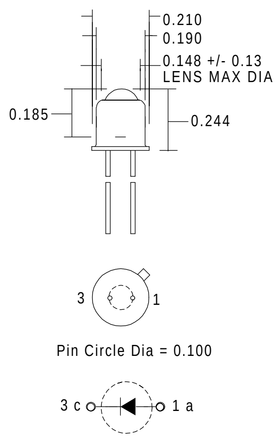


P/N	A	B
PIN-3CD/CDP	0.087	0.146
BPX-65	0.075	0.200

Products

PIN-3CD
PIN-3CDP
BPX-65

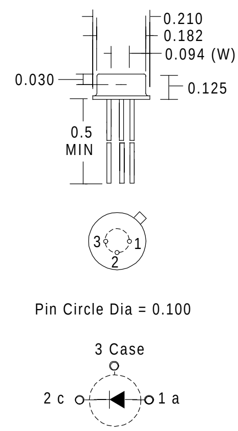
8 TO-18



Products

PIN-125DPL

9 TO-18



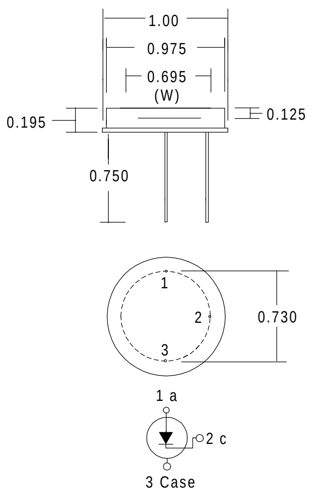
Products

PIN-HR005
PIN-HR008
PIN-HR020
PIN-HR026
PIN-HR040
PIN-HS005
PIN-HS008
PIN-HS020
PIN-HS026
PIN-HS040
PIN-UHS016

10 LOW PROFILE

Products

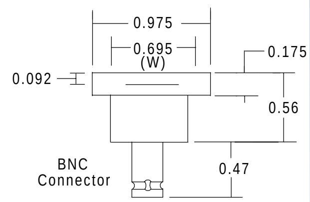
PIN-10DI
PIN-10DPI
PIN-10DPI/SB
UV-50L
UV-100L



11 BNC

Products

PIN-10D
PIN-10DP
PIN-10DP/SB
UV-50
UV-100



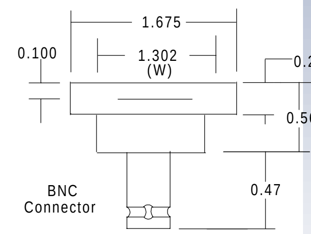
Outer Contact =Anode (PIN-10D, PIN-10DP, PIN-10DP/SB)

Outer Contact = Cathode (UV-50 & UV-100)

12 BNC

Products

PIN-25D
PIN-25DP

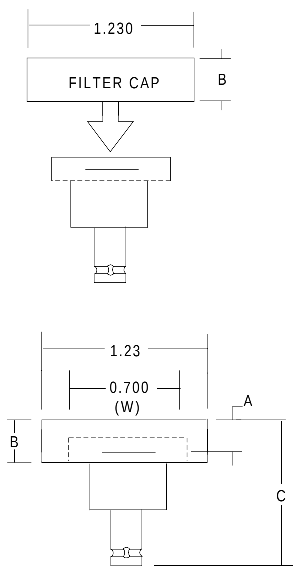


Outer Contact = Anode

13 SPECIAL BNC

Products

PIN-10AP
PIN-10DF



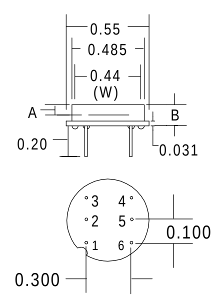
DIMENSIONS

P/N	A	B	C
PIN-10DF	0.217	0.330	1.02
PIN-10AP	0.386	0.550	1.30

14 SPECIAL PLASTIC

Products

FIL-3C
FIL-5C
FIL-20C
FIL-3V
FIL-5V
FIL-20V
FIL-UV20
FIL-UV005
FIL-S2DG
FIL-S4DG
FIL-C4DG



DIMENSIONS

P/N	A	B
FIL-3V FIL-5V FIL-20V FIL-3C FIL-5C FIL-20C	0.060	0.130
FIL-UV005 FIL-UV20 FIL-S4DG FIL-C4DG FIL-S2DG	0.087	0.152

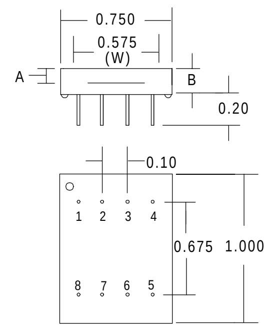
PINOUTS

P/N	1	2	3	4	5	6
FIL-3V FIL-5V FIL-20V FIL-3C FIL-5C FIL-20C FIL-UV005 FIL-S2DG	a	-	c	a	-	c
FIL-UV20	c	-	a	c	-	a
FIL-S4DG	a	a	c	a	a	c
FIL-C4DG	c	a	c	c	a	c

15 SPECIAL PLASTIC

Products

FIL-44C
FIL-100C
FIL-44V
FIL-100V
FIL-UV50
FIL-UV100
FIL-S9DG
FIL-C10DG



DIMENSIONS

P/N	A	B
FIL-44C FIL-100C FIL-44V FIL-100V	0.052	0.130
FIL- UV50 FIL-UV100	0.090	0.155
FIL-S9DG	0.072	0.155
FIL-C10DG	0.082	0.155

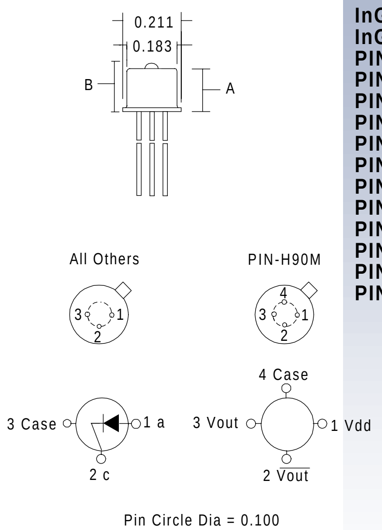
PINOUTS

P/N	1	2	3	4	5	6	7	8
FIL-44C FIL-100C FIL-44V FIL-100V	a	-	-	c	a	-	-	c
FIL-UV50 FIL- UV100	c	-	-	a	c	-	-	a
FIL-S9DG	a	c	c	a	a	c	c	a
FIL-C10DG	c	a	a	c	c	a	a	c

16 TO-18 LENSED CAP

Products

InGaAs-100L
InGaAs-300L
PIN-H90M
PIN-HS005L
PIN-HS008L
PIN-HS020L
PIN-HS026L
PIN-HS040L
PIN-HR005L
PIN-HR008L
PIN-HR020L
PIN-HR026L
PIN-HR040L
PIN-UHS016L

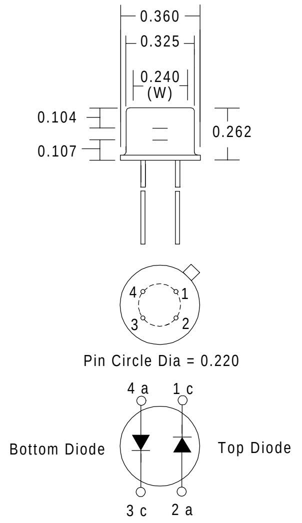


P/N	A	B
All Others	0.146	0.173
PIN-H90M	0.176	0.203

17 TO-5

Products

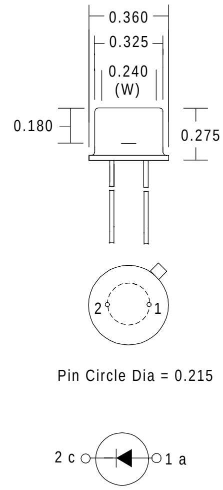
PIN-DSS
PIN-DSGe
PIN-DSIn



18 TO-5

Products

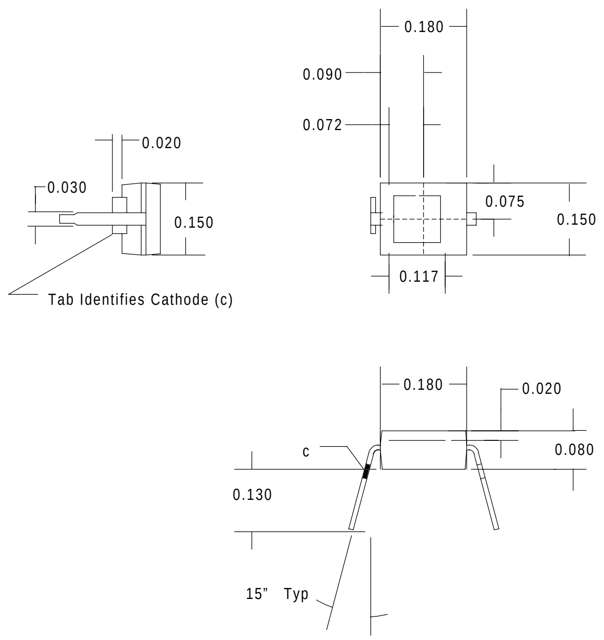
PIN-005D-254F



19 PLASTIC MOLD

Products

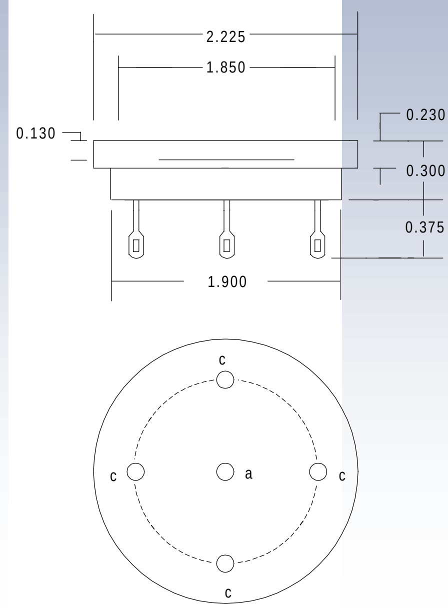
BPW34
BPW34F
BPW34B



20 SPECIAL METAL

Products

SC-50D

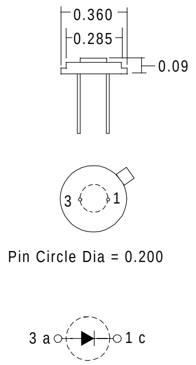


Pin Circle Dia = 1.110

21 TO-5

Products

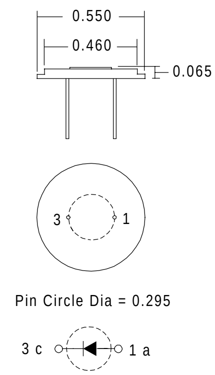
XUV-005



22 TO-8

Products

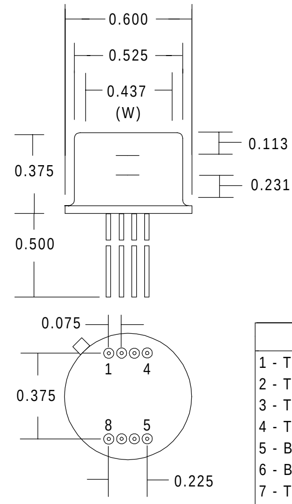
XUV-020
XUV-035



23 TO-8

Products

PIN-DSIn-TEC



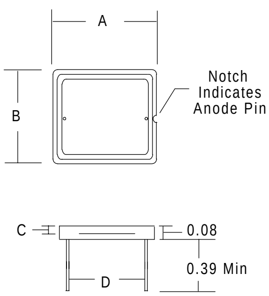
PINOUT

1 - TEC (-)
2 - Thermistor
3 - Thermistor
4 - TEC (+)
5 - Bottom InGaAs, Cathode
6 - Bottom InGaAs, Anode
7 - Top Silicon, Anode
8 - Top Silicon, Cathode

24 SPECIAL CERAMIC/PLASTIC

Products

RD-100
RD-100A
UV-35P
UV-005EC
UV-035EC
UV-100EC
UV-005DC
UV-035DC
UV-100DC
XUV-50C
XUV-100C



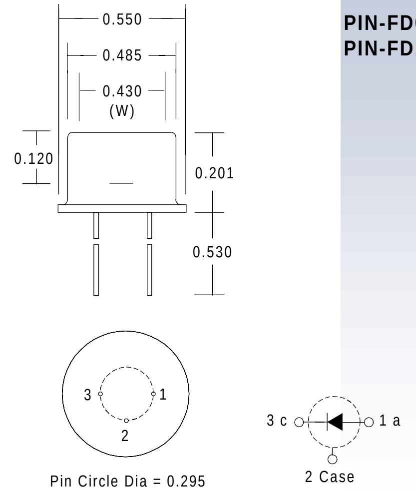
DIMENSIONS

P/N	A	B	C	D
UV-005EC	0.30	0.24		0.18
UV-035EC	0.40	0.35	0.048	0.29
UV-100EC	0.65	0.59		0.50
UV-005DC	0.30	0.24		**0.18**
UV-035DC	0.40	0.35	0.053	0.29
UV-100DC	0.59	0.59		0.50
XUV-50C	0.49			
XUV-100C	0.49	0.59	0.027	0.49
RD-100	0.65			
RD-100A	0.65			
UV-35P	0.390	0.345	0.050	0.275

25 TO-8

Products

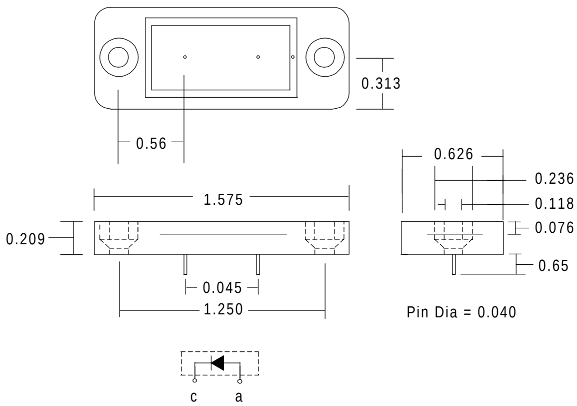
PIN-FD07
PIN-FD15



26 SPECIAL PLASTIC

Products

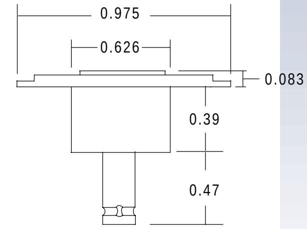
PIN-220D
PIN-220DP
PIN-220DP/SB



27 BNC

Products

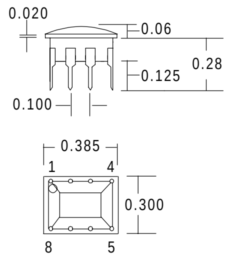
XUV-100



BNC Connector
Outer Contact = Cathode

28 8-PIN DIP

Products: UDT-451

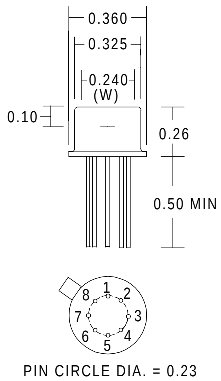


PINOUT

1. Offset Null
2. Inverting Input
   Detector Cathode
3. Noninverting Input
4. V -
5. Offset Null
6. Output
7. V +
8. Detector Anode

29 TO-5

Products: UDT-455, UDT-455HS, UDT-455LN, UDT-455UV, UDT-455UV/LN

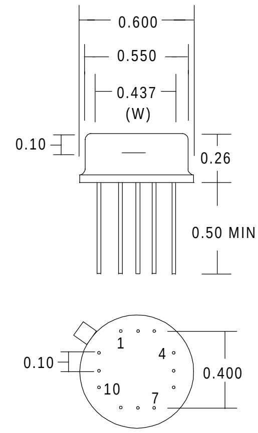


PINOUT

1. Offset Null
2. Inverting Input
   Detector Cathode
3. Noninverting Input
4. V -
5. Offset Null
6. Output
7. V +
8. Detector Anode

30 TO-8

Products: UDT-020D, UDT-020UV

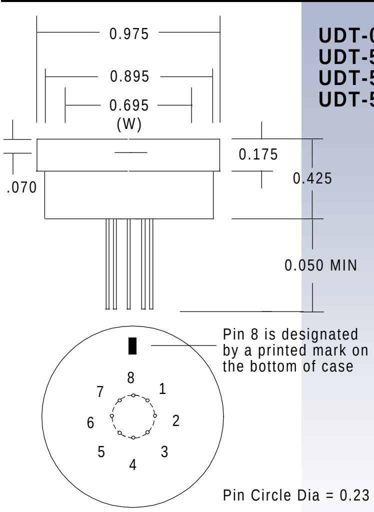


PINOUT

1 - Not Used
2 - Not Used
3 - Offset Null
4 - Offset Null
5 - Inverting Input
6 - Noninverting Input
7 - Detector Cathode
8 - Case Ground
9 - Detector Anode
10 - V-
11 - Output
12 - V+

31 SPECIAL

Products: UDT-055UV, UDT-555D, UDT-555UV, UDT-555UV/LN

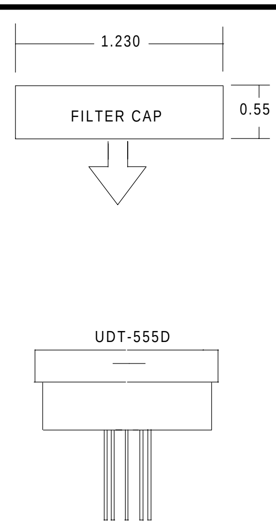


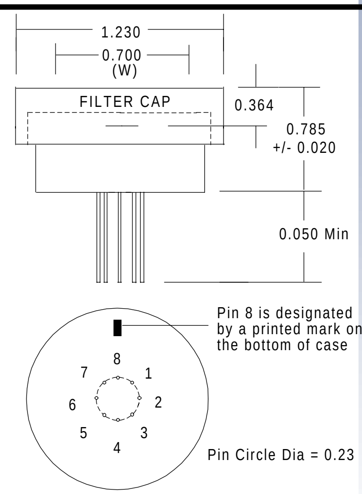
PINOUT

1. Offset Null
2. Inverting Input
   Detector Cathode
3. Noninverting Input
4. V -
5. Offset Null
6. Output
7. V +
8. Detector Anode & Case

32 SPECIAL

Products: PIN-555AP





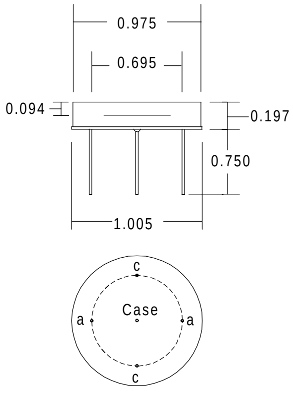
PINOUT

1. Offset Null
2. Inverting Input
   Detector Cathode
3. Noninverting Input
4. V -
5. Offset Null
6. Output
7. V +
8. Detector Anode & Case

33 SPECIAL

Products

DL-10

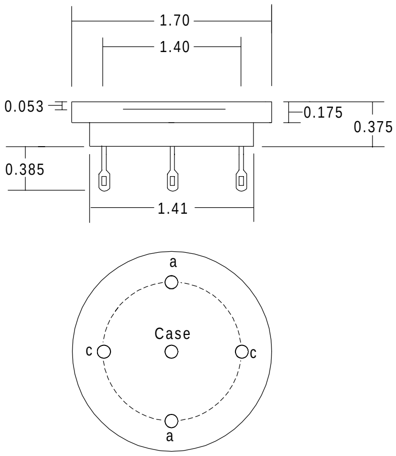


Pin Circle Dia = 0.730

34 SPECIAL

Products

DL-20

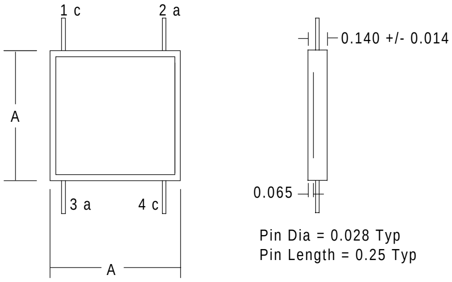


Pin Dia = 0.040
Pin Circle Dia = 1.110

35 SPECIAL CERAMIC

Products

DLS-10
DLS-20



Pin Dia = 0.028 Typ
Pin Length = 0.25 Typ

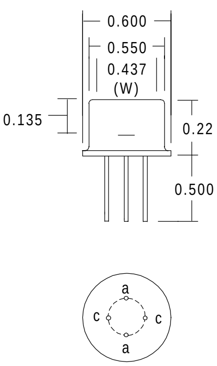
DIMENSIONS

P/N	DLS-10	DLS-20
A	1.000	1.500

36 TO-8

Products

DL-2
DLS-2
DL-4
DLS-4

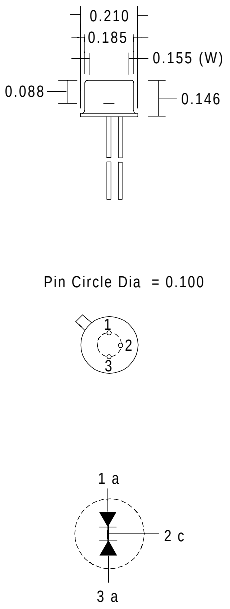


Pin Circle Dia = 0.400

37 TO-18

Products

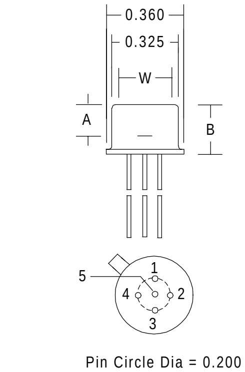
SPOT-2DMI



38 TO-5

Products

SC-4D
SL3-1
SPOT-2D
SPOT-3D
SPOT-4D
SPOT-4DMI



PINOUT

P/N	1	2	3	4	5
SC-4D	c	c	c	c	a
SL3-1	a	c	a	-	-
SPOT-2D	a	a	a	a	c
SPOT-4D	a	a	a	a	c
SPOT-4DMI	a	a	a	a	c
SPOT-3D	a	c	a	-	-

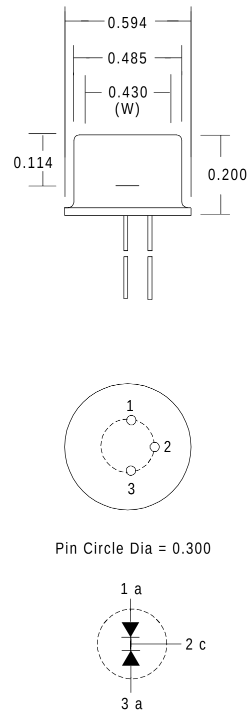
PARAMETER DEFINITION

P/N	A	B	W
SC-4D	0.071	0.142	0.240
SL3-1	0.106	0.195	0.217
SPOT-2D	0.063	0.114	0.240
SPOT-4D	0.073	0.142	0.240
SPOT-4DMI	0.063	0.142	0.240
SPOT-3D	0.104	0.138	0.240

39 TO-8

Products

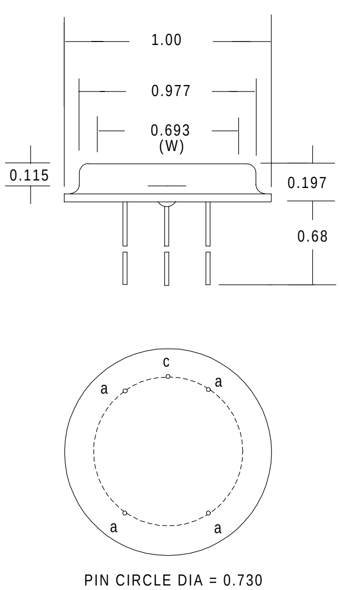
SL5-1



40 LOW PROFILE

Products

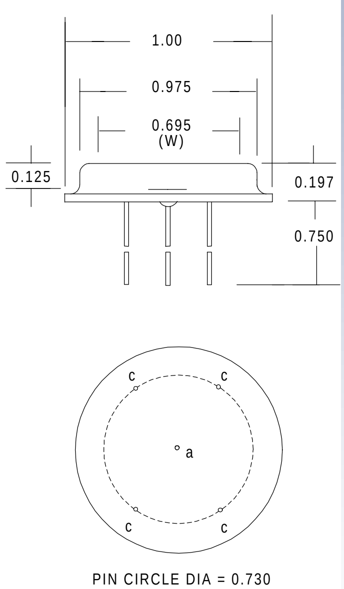
SPOT-9D
SPOT-9DMI



41 SPECIAL

Products

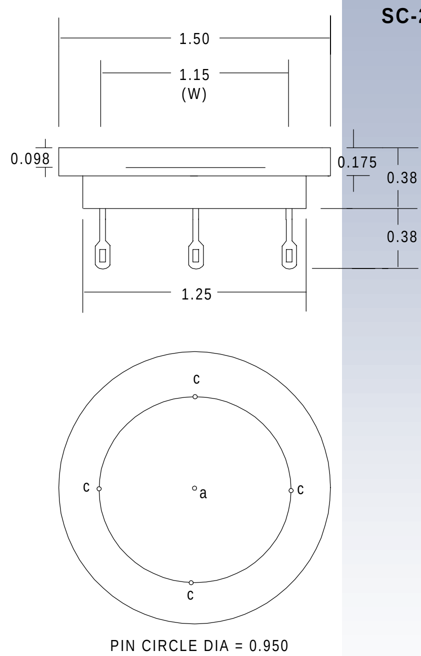
SC-10D
SC-13D



42 SPECIAL

Products

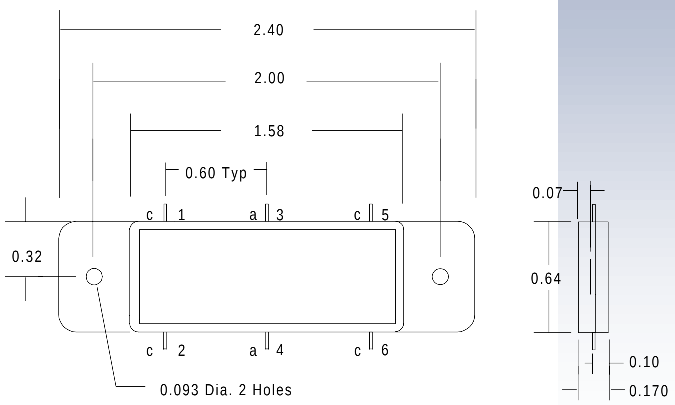
SC-25D



43 PLASTIC

Products

LSC-30D

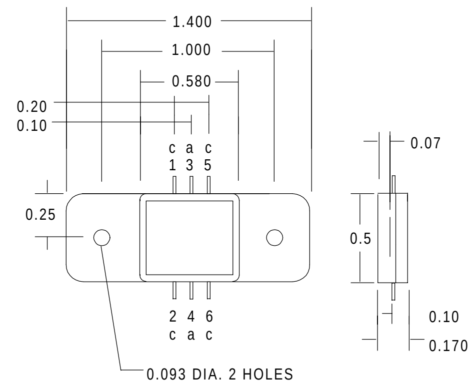


Pin Length = 0.100 Typ.

44 PLASTIC

Products

LSC-5D

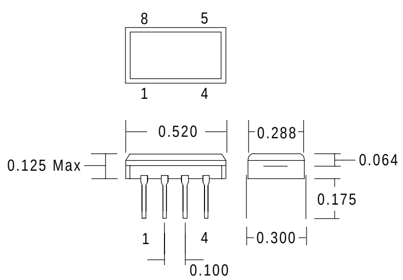


PIN LENGTH = 0.100 TYP.

45 8-PIN DIP

Products

SL3-2
SL5-2

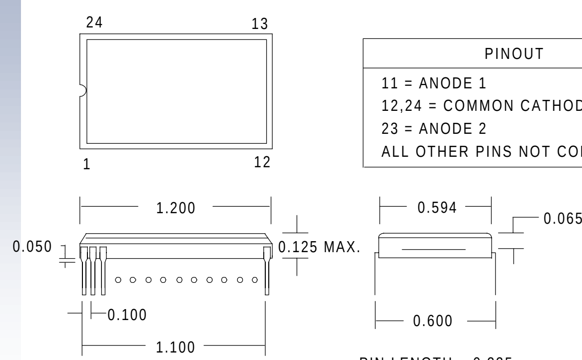


PINOUT
2,7 = ANODE 1
1,4,5,8 = COMMON CATHODE
3,6 = ANODE 2

46 24-PIN DIP

Products

SL-15



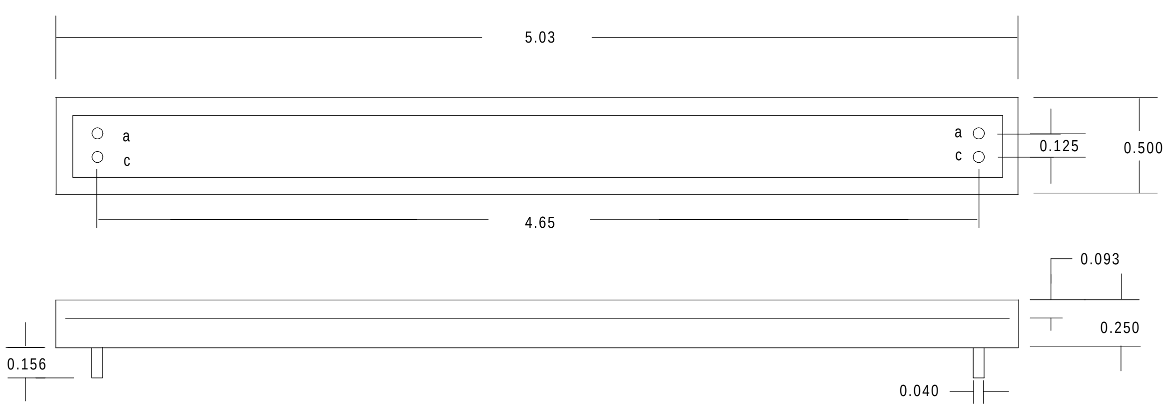
PINOUT
11 = ANODE 1
12,24 = COMMON CATHODE
23 = ANODE 2
ALL OTHER PINS NOT CONNECTED

PIN LENGTH = 0.225
PIN THICKNESS = 0.010

47 SPECIAL

Products

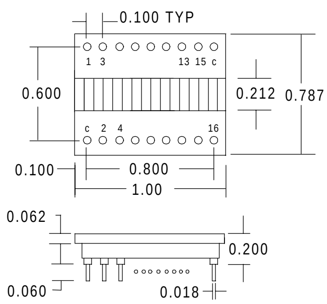
SL76-1



48 SPECIAL

Products

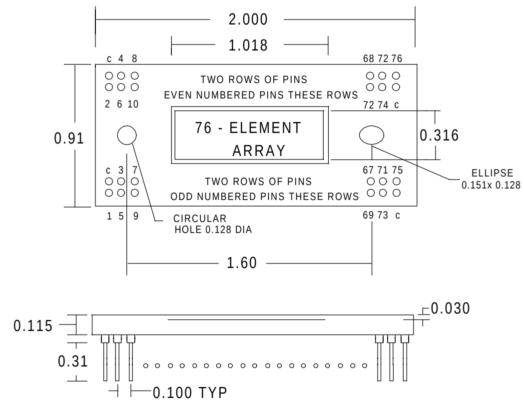
A2V-16



49 SPECIAL

Products

A2V-76



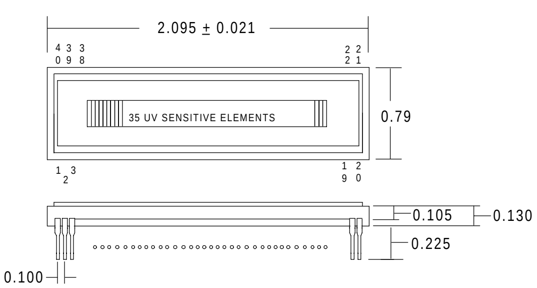
Pin Dia = 0.025

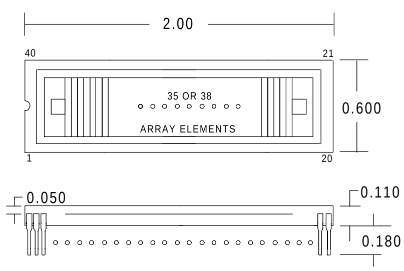
50 40-PIN DIP

Products

A5V-35UV
A5C-35
A5C-38
A5V-35
A5V-38

A5V-35UV





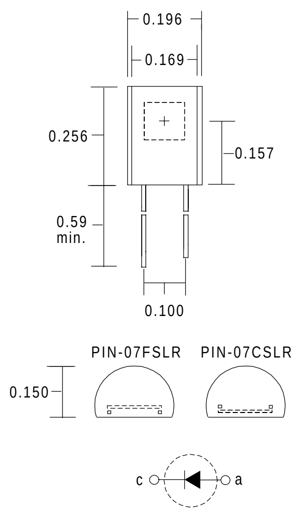
35 ELEMENT ARRAY			
PIN NO.	ELEM NO.	PIN NO.	ELEM NO.
1	C	21	C
2	2	22	35
3	4	23	33
4	6	24	31
5	8	25	29
6	10	26	27
7	12	27	25
8	14	28	23
9	16	29	21
10	18	30	19
11	---	31	17
12	20	32	15
13	22	33	13
14	24	34	11
15	26	35	9
16	28	36	7
17	30	37	5
18	32	38	3
19	34	39	1
20	C	40	C

38 ELEMENT ARRAY			
PIN NO.	ELEM NO.	PIN NO.	ELEM NO.
1	C	21	C
2	2	22	37
3	4	23	35
4	6	24	33
5	8	25	31
6	10	26	29
7	12	27	27
8	14	28	25
9	16	29	23
10	18	30	21
11	20	31	19
12	22	32	17
13	24	33	15
14	26	34	13
15	28	35	11
16	30	36	9
17	32	37	7
18	34	38	5
19	36	39	3
20	38	40	1

51 PLASTIC MOLD

Products

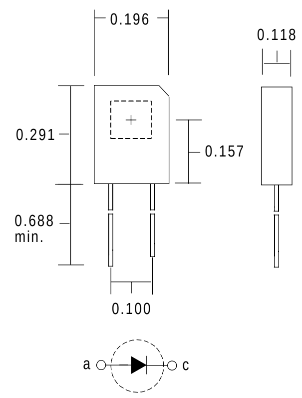
PIN-07CSLR
PIN-07FSLR



52 PLASTIC MOLD

Products

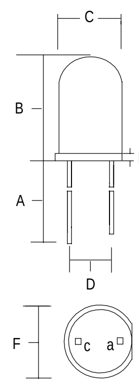
PIN-07CSL
PIN-07FSL



53 PLASTIC MOLD

Products

PIN-01CT3
PIN-01FT3
PIN-01CT5
PIN-01FT5

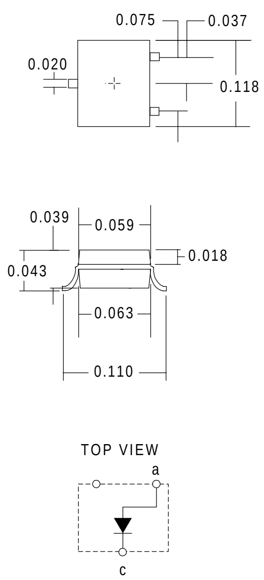


P/N	A	B	C	D	E	F
PIN-01CT3 PIN-01FT3	0.650	0.213	0.118	0.090	0.031	0.154
PIN-01CT5 PIN-01FT5	1.04	0.343	0.197	0.100	0.039	0.228

54 PLASTIC MOLD

Products

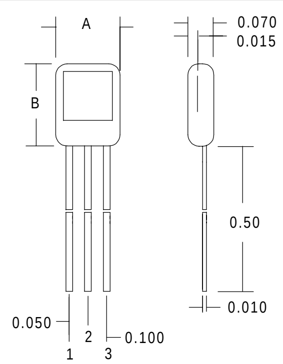
PIN-01CJ
PIN-01FJ



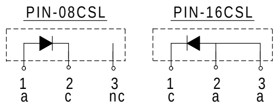
55 PLASTIC MOLD

Products

PIN-08CSL
PIN-16CSL



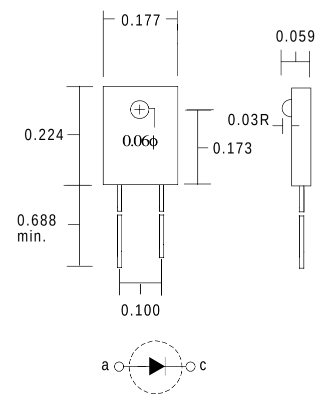
P/N	A	B
PIN-08CSL	0.170	0.220
PIN-16CSL	0.215	0.264



56 PLASTIC MOLD

Products

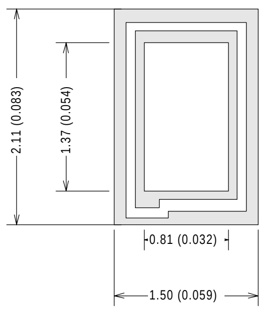
PIN-01CLSL
PIN-01FLSL



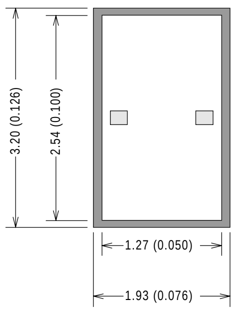
The following die topographies are for reference only. They shall not be used for any design purposes. Consult an Applications Engineer for further details and accurate dimensions.

All chip dimensions are in millimeters (inches in parentheses).

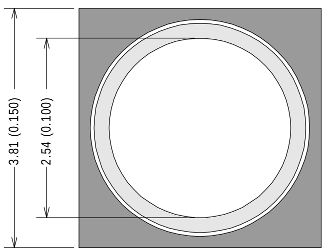
PIN-2DI/DPI



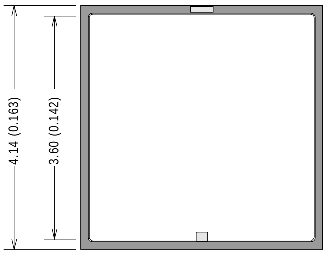
PIN-3CD/DP



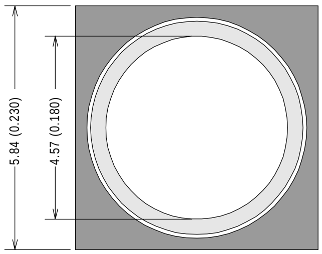
PIN-5D/DP
UV-005



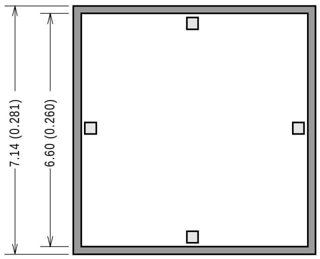
PIN 13D/DP
UV-013D/E



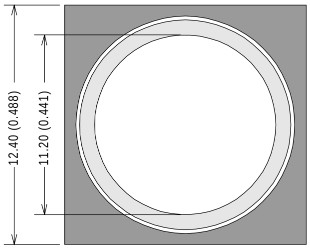
PIN 6D/DP
UV-20



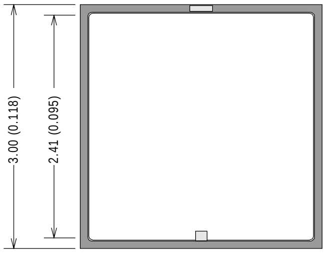
PIN 44D/DP



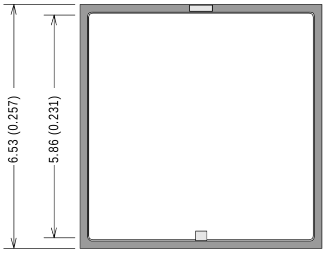
PIN-10D/DP
UV-100(L)



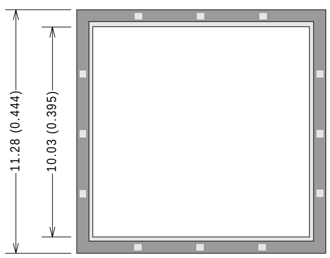
UV-005D/E



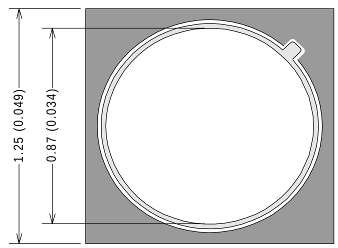
UV-035D/E



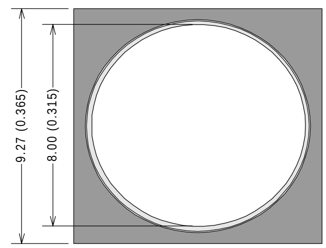
PIN-RD100(A)



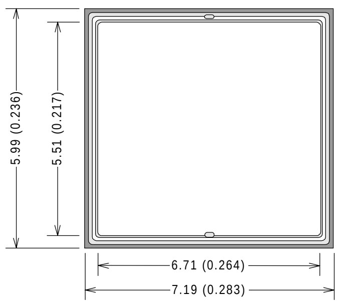
UV001



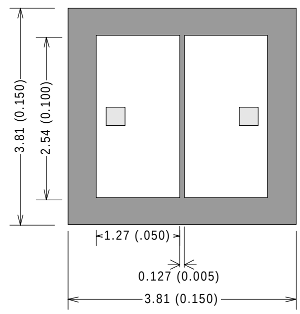
UV-50



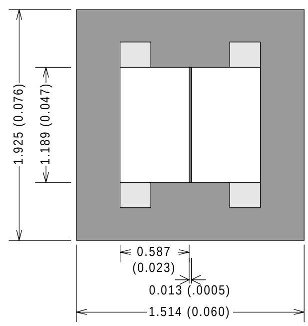
UV35(P)



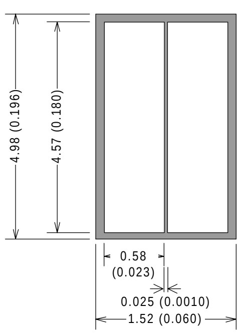
SPOT-2D



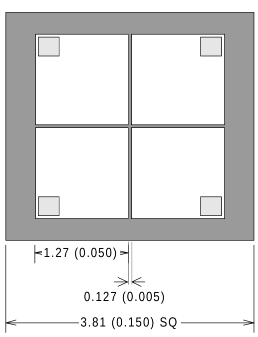
SPOT-2DM1



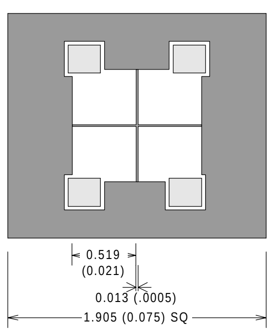
SPOT-3D



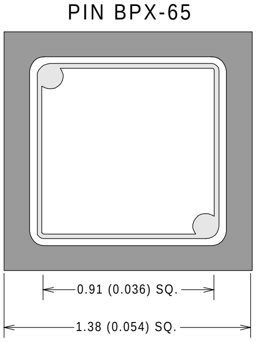
SPOT-4D



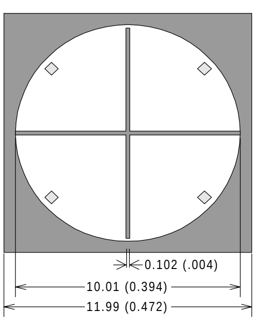
SPOT-4DM1



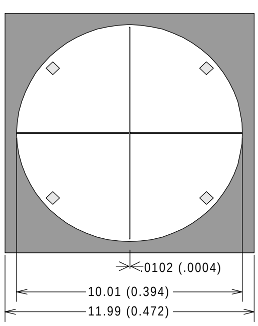
PIN BPX-65



SPOT-9D



SPOT-9DM1



CUSTOM PHOTODIODE SPECIFIER

Please fill out the items in the tables below in order to assist us in selecting the most appropriate item for your requirements. You may not need, or able to complete ALL items. Hence simply fill out what you can and fax or mail the form directly to the factory or one of our sales representatives. We will return back to you with a prompt quotation.

Company:		Name:	T#:
Address:		Tech Contact:	F#:
City:	State/Zip:	Main Product Line:	Other #:

Purchase Information

Qty. / Date Required:		Application * :
Target Price:	Competitor:	

Photodetector Electro-Optical Specifications (Fill as many specifications as you can):

Die Size:	Active Area Size:	Spectral Range:	Applied Bias:
Responsivity @ nm: A/W	Dark Current @ V: nA	Junction Capacitance @ V: pF	Rise/Fall Time @ V: nsec
Enviornmental e.g. Operating Temp, etc:			
ARRAYS: No. of Elmnts: Pitch:	**BI / QUAD CELLS:** Active Area / Elmnt: Gap:	**PHOTOPS:** Operating Frequency: Gain:	 S/N Ratio: Supply Voltage:

Mechanical Details (Package Type):

TO Type:	Ceramic:	PCB:	Chip:
Isolated: Yes___ No___	Common: Cathode__ Anode__	Wire Bond___ Solderable___	Other:

*** Please provide a brief explanation of your specific application and / or any additional requirements or information that you may consider necessary on additional sheets.**

TERMS AND CONDITIONS OF SALE

SALES OF UDT Sensors Inc. PRODUCTS ARE SUBJECT TO THE FOLLOWING TERMS AND CONDITIONS:

1. **PRICING.** Price quotations for UDT Sensors Inc. products are subject to change. Unless otherwise stated, UDT Sensors Inc.'s prices do not include sales, use, VAT, excise, or similar taxes. Consequently, in addition to the prices specified herein, the amount of any present or future sales, use, VAT, excise or other similar tax applicable to the sale of the products hereunder shall be paid by the Customer, or in lieu thereof the Customer Shall provide UDT Sensors Inc. with a tax exemption certificate acceptable to the taxing authorities.

2. **PAYMENT TERMS; U.C. SECURITY INTEREST.** A customer purchasing products must represent that it is not insolvent as that term is defined in California Commercial Code § 1201 (23). If a Customer becomes insolvent before delivery of the products, the Customer shall notify UDT Sensors Inc.. A Failure to notify UDT Sensors Inc. shall be construed as a reaffirmation of the Customers solvency at the time of delivery. Standard payment terms after credit approval by UDT Sensors Inc. are net 30 days after the original product shipment dates. However, if credit approval is not granted or if UDT Sensors Inc. thereafter determines in its sole discretion that full payment by the Customer on a timely basis is not assured, UDT Sensors Inc. reserves the right to demand at any time that the Customer provide assurance of full payment by prepaying the purchase price, providing a letter of credit, posting bond issued by a competent surety company or such other manner as may be determined by UDT Sensors Inc. in its sole discretion. Each product shipment will constitute a separate and independent transaction. The Customer shall grant a UCC security interest to UDT Sensors Inc. in all shipped products to secure payment of the purchase price and all other amounts due UDT Sensors Inc. and authorizes UDT Sensors Inc. to file financing statements with respect to such security interest. Delinquent payments will accrue interest at one percent per month, but not to exceed the maximum amount permitted by law, until paid in full.

3. **PACKAGING; SHIPMENT; INSURANCE: RISK OF LOSS.** UDT Sensors Inc. shall provide at its expense commercial packaging adequate under normal conditions to identify and protect the products during shipment by regular commercial carrier. A Customer may request special packaging at its extra expense. A Customer shall pay all freight and unloading costs. Unless a Customer requests specific carriers or methods of shipment, UDT Sensors Inc. shall ship products to Customer by regular commercial carrier. Any shipment dates specified by UDT Sensors Inc. are approximate dates only and UDT Sensors Inc. has the right to adjust the shipment dates as it deems appropriate. Unless a Customer requests specific insurance coverage or specific valuation amounts, UDT Sensors Inc. shall specify shipment without insurance coverage and at minimum valuation amounts. A customer shall pay all insurance costs. Shipping shall be made F.O.B. place of shipment and a Customer assumes all risk of loss and damage after delivery to the carrier and during shipment and shall file any damage claim forms required by the carrier or insurer.

4. **RESCHEDULING CHARGES.** Product shipments may be rescheduled by a Customer without prior written consent from UDT Sensors Inc. and payment of rescheduling charges determined by UDT Sensors Inc.. If shipments are delayed by a Customer, payment shall become due on the date when UDT Sensors Inc. is prepared to make shipment. Products held for a Customer shall be at the risk and expense of the Customer. UDT Sensors Inc. reserves the right to ship to its order and make collection by sight draft with bill of lading attached.

5. **FORCE MAJEURE; ALLOCATION.** Performance by UDT Sensors Inc. will be excused without liability during any period that performance is prevented or delayed by causes beyond the reasonable control of UDT Sensors Inc..

6. **ACCEPTANCE OF PRODUCTS.** As soon as products are delivered to the Customer, the Customer shall inspect the products. Notice in writing shall be given within 48 hours after receipt of products of any defects or omissions. The failure of the Customer to give notice within attempted revocation of acceptance thereafter shall have any effect whatsoever. If any products are rejected, the Customer shall hold the products at the Customer's place of business until UDT Sensors Inc. has been notified in writing of the rejection and has had reasonable opportunity to arrange for suitable transportation.

7. **LIMITED WARRANTIES: WARRANTY DISCLAIMER.** UDT Sensors Inc. warrants only the products will comply with product specifications contained in this catalog (or any supplement or amendment thereto) and that the products will operate properly under proper use and normal conditions without defects in parts or labor that prevent such operation for a period of 90 days after the individual product shipment dates. Minor defects or deviations from product specifications that do not materially affect such operation will not constitute a breach of warranty or a failure to meet specifications. NO OTHER WARRANTIES ARE GIVEN AND NO AFFIRMATION BY UDT Sensors Inc., BY WORDS OR ACTION, WILL CONSTITUTE A WARRANTY. UDT Sensors Inc. DISCLAIMS ANY EXPRESS OR IMPLIED WARRANTY THAT THE PRODUCTS ARE MERCHANTABLE OR THAT THE PRODUCTS ARE FIT FOR A PARTICULAR USE OR PURPOSE EVEN IF THE PARTICULAR USE OR PURPOSE IS DISCLOSED TO UDT Sensors Inc. IN ADVANCE.

8. **LIMITED REMEDIES FOR BREACH OF WARRANTY.** Defective Products may be returned to UDT Sensors Inc. freight prepaid only after obtaining a Return material Authorization Number (RMA) from UDT Sensors Inc.. If after testing and inspection any such returned product is determined by UDT Sensors Inc. to be defective, UDT Sensors Inc. shall promptly repair or replace the product and return it to Customer freight prepaid. A CUSTOMER HAS NO OTHER REMEDY FOR BREACH OF WARRANTY OR FAILURE TO MEET PRODUCT SPECIFICATIONS.

9. **LIMITATION OF LIABILITY AND DAMAGES.** UDT Sensors Inc. SHALL NOT BE LIABLE FOR INJURY TO ANY PERSON OR PROPERTY AND IN NO EVENT SHALL UDT Sensors Inc. BE LIABLE FOR ANY DIRECT OR INDIRECT CONSEQUENTIAL, INCIDENTAL OR SPECIAL DAMAGES.

10. **INDEMNITY BY CUSTOMER.** Customer shall defend and indemnify and hold UDT Sensors Inc. harmless against any claims that are based upon any subsequent resale of the products by the Customer, any sale by the customer of any of the products or any use of such products of the Customer.

11. **PATENT AND TRADEMARK INFRINGEMENT DEFENSE AND INDEMNITIES.** The Customer shall defend, indemnify and hold UDT Sensors Inc. Sensors Inc. harmless against any claims that use or combination of the products by the Customer with any material or products not sold by UDT Sensors Inc. Sensors Inc. constitutes a violation or infringement of any U.S. or foreign patents covering the use or combination products by the Customer. The Customer shall also defend, indemnify and hold UDT Sensors Inc. Sensors Inc. harmless against any claims that manufacturing or sales of products manufactured to the Customer specifications constitutes a violation or infringement of any U.S. or foreign patents or trademarks. SALE OF THE PRODUCTS BY UDT Sensors Inc. Sensors Inc. CONVEYS NO EXPRESS OR IMPLIED LICENSE UNDER PATENT OWNED OR CONTROLLED BY UDT Sensors Inc. Sensors Inc..

12. **APPLICABLE LAW: ARBITRATION: TIME FOR BRINGING ACTIONS.** California law will exclusively apply to sales of UDT Sensors Inc. Sensors Inc. products. All unresolved claims and disputes relating to such sales shall be settled by arbitration in Los Angeles, California under American Arbitration Association Commercial Rules (including mutual discovery and judgement upon the arbitration award may be entered and enforced in any competent Court with jurisdiction. Such award shall be final and binding upon both parties. Any action relating to such sales must commence within one (1) year after the cause of action has accrued.