Application Notes
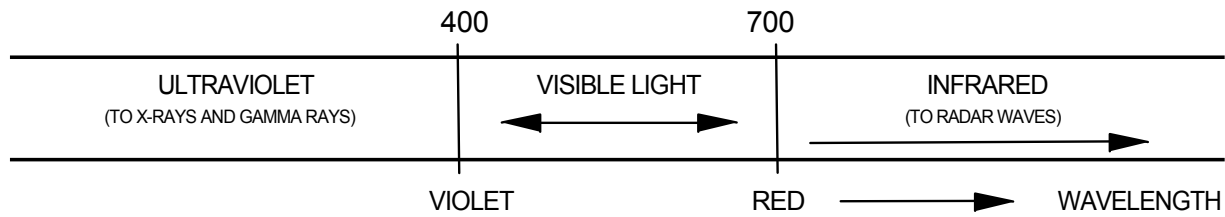
APPLICATION NOTE #1
Light - Some Physical Basics

Light is produced by the release of energy from the atoms of a material when they are excited by heat, chemical reaction or other means. Light travels through space in the form of an electromagnetic wave.

A consequence of this wave-like nature is that each "color" can be completely defined by specifying its unique wavelength. The wavelength is defined as the distance a wave travels in one cycle. Since the wavelengths of light are very short they are normally measured in nanometers, one nanometer being equal to 1×10^{-9} meters.

The spectral response of Excelitas photodetectors are specified by plots of relative response versus wavelength (color).

	400		700	
ULTRAVIOLET (TO X-RAYS AND GAMMA RAYS)		VISIBLE LIGHT		INFRARED (TO RADAR WAVES)
	VIOLET		RED		WAVELENGTH

Color	Wavelength
VIOLET	BELOW 450 nm
BLUE	450 - 500 nm
GREEN	500 - 570 nm
YELLOW	570 - 590 nm
ORANGE	590 - 610 nm
RED	610 - 700 nm

NATURAL ILLUMINANCE

Sky Condition	Light Level (Typical)
Direct Sunlight	10000 fc
Overcast Day	1000 fc
Twilight	1 fc
Full Moon	.1 fc
Clear Night Sky (moonless)	.001 fc

ROOM ILLUMINATION

| Lighting Condition	Light Level (Typical)
Candle - Lit Room	5 fc
Auditorium	10 fc
Classroom	30 fc
Inspecion Station	250 fc
Hospital Operating Room	500 -1000 fc

Application Notes

APPLICATION NOTE #2
Spectral Output of Common Light Sources

Incandescent lamps can be considered as black body radiators whose spectral output is dependent on their color temperature. The sun has approximately the same spectral radiation distribution as that of a black body @ 5900 K. However, as viewed from the surface of the earth, the sun's spectrum contains H_2O and CO_2 absorption bands.
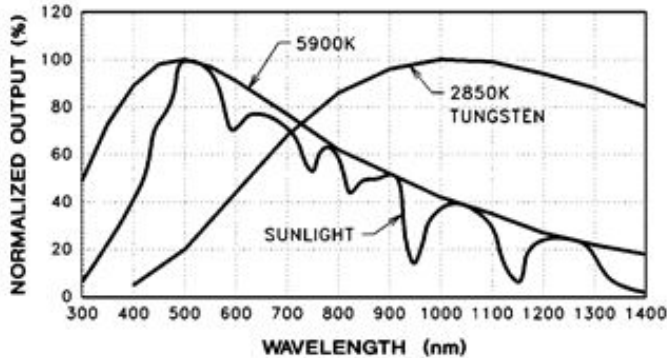

Black Body Sources Output vs Wavelength

Fluorescent lamps exhibit a broad band spectral output with narrow peaks in certain parts of the spectrum. Shown below is a plot of the light output of a typical daylight type fluorescent tube.
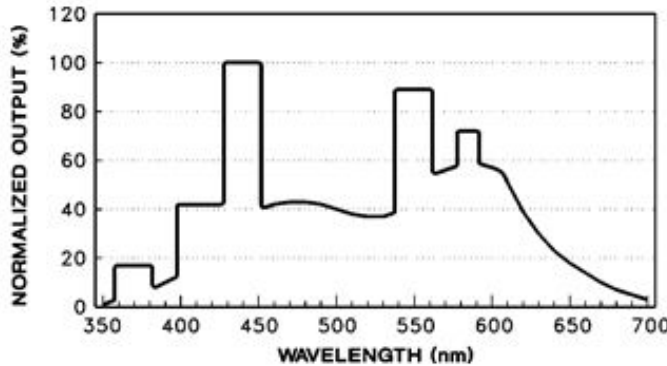
Fluorescent Lamp Output vs Wavelength

Due to their long operating lifetimes, small size, low power consumption, and the fact that they generate little heat, LEDs are the light sources of choice in many applications. When biased in the forward direction LEDs emit light that is very narrow in spectral bandwidth (light of one color). The "color" of the light emitted depends on which semiconductor material was used for the LED.
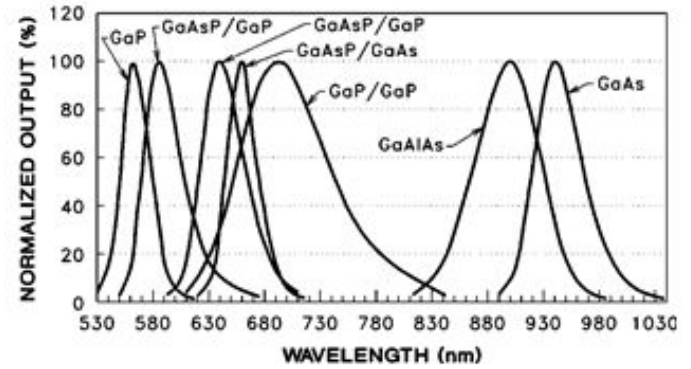
LED Light Sources

LED TYPE	COLOR	λp
GaP	GREEN	569nm
GaAsP/GaP	YELLOW	585nm
GaAsP/GaP	ORANGE	635nm
GaAsP/GaAs	RED	655nm
AlGaAs	RED	660nm
GaP/GaP	RED	697nm
GaAlAs	INFRARED	880nm
GaAs	INFRARED	940nm

Application Notes

APPLICATION NOTE #3
Photodiode Response Time

The response time of a photodiode is defined as the time it takes for light generated carriers within the body of the diode to arrive at and cross the P-N junction.

When the diode is illuminated, photons of light penetrate into the silicon and are absorbed generating electron-hole pairs. The average depth of penetration of a photon is wavelength dependent. The penetration depth has a statistical distribution so that there will be some electron-hole pairs generated at all depths. For light of very short wavelengths (ie UV and blue), most of the carriers will be generated very near the top surface of the diode. At this surface, due to the termination of the crystal lattice, the minority carrier lifetime is extremely short and most of the carriers will recombine before they can cross the P-N junction and contribute to the photocurrent. Light of longer wavelengths tends to penetrate deeper, generating a good number of carriers in the depletion region. The strong electric field that resides there sweeps the carriers across the junction at which point they contribute to the photocurrent. Light of even longer wavelengths (ie IR) penetrates even deeper generating carriers in the area below the depletion region. As these carriers slowly diffuse towards the P-N junction, a fair number will recombine and never contribute to the photocurrent. For photodiodes with long minority carrier lifetimes, a greater percentage of these carriers will survive to reach the junction.

The risetime of a photodiode consists of three components:

1. T_{CC} (charge collection time) is the time required for the electric field, residing at the P-N junction, to sweep out carriers generated within or entering the depletion region. Typically T_{CC} is less that 1 nsec.

2. T_{RC} (rise time associated with the RC time constant) is the time required to charge or discharge the photodiode's junction capacitance (C_J) through the external load resistance(R_L) and is given as:
    $$T_{RC} = 2.2 R_L C_J$$

In practice the R_L term consists of the series combination of the external load resistance and internal series resistance of the photodiode (R_S). The C_J term should include not only the junction capacitance of the photodiode but also all external capacitance such as the packaging capacitance and the external wiring capacitance.

The series resistance of the photodiode (R_S) is comprised of the resistance of the undepleted region of the diode and the contact resistance. R_S is usually of the order of 10 ohms but can be up to a few hundred ohms in small area diodes of high resistivity silicon. When the output current of the photodiode is fed into a transimpedance op-amp the effective load resistance is the feedback resistance (R_F) divided by the open loop gain.

3. T_{DIF} (diffusion time) is the time needed for carriers generated outside the depletion region to diffuse into the depletion region. Carriers can diffuse into the depletion layer from the undepleted lower portion of the silicon chip as well as laterally from outside the perimeter of the active area of the chip.

The total risetime of a photodiode is equal to the square root of the sum of the squares of the three risetime components.

$$T_R = \sqrt{T_{CC2} + T_{RC2} + T_{DIF2}}$$

TR is essentially equal to the largest of the three risetime components.

The fastest response time will be achieved for the condition where the RC time constant is as small as possible and where all carriers are generated within the depletion region. What follows is a practical guideline for achieving these conditions.

1. Within the limits imposed by the application, select the process that results in the lowest value for junction capacitance per unit of active area.

2. Choose the photodiode with the smallest active area that still generates the required photocurrent.

3. Design the external circuit such that the load resistance the diode sees is as small as possible.

4. Apply a reverse voltage across the photodiode. This will expand the width of the depletion layer resulting in a larger percentage of carriers being generated within this region. The applied voltage will result in an increase in the electric field so that carriers within that feld will experience an increase in drift velocity. Further, the junction capacitance will decrease with the increasing applied voltage.

Compiled below are some examples which illustrate how choice of light source, load resistance, and bias voltage effect the speed of a silicon photodiode. The numbers are produced by theoretical calculations, and numerous simplifying assumption have been made. Nevertheless these charts serve to show trends.

Application Notes

SLOWER DIODES	PARAMETER	HIGHER NOISE
LARGE	**ACTIVE AREA**	SMALL
LARGE	**JUNCTION CAPACITANCE**	SMALL
SMALL	**REVERSE APPLIED VOLTAGE**	LARGE
INFARED	**LIGHT SOURCE**	VISIBLE
LARGE	**LOAD RESISTANCE**	SMALL

$$T_R = \sqrt{T_{CC2} + T_{RC2} + T_{DIF2}}$$

LIGHT SOURCE: RED LIGHT (660 nm)	SPEED (nsec.)							
	R_L = 50 ohms				R_L = 1000 ohms			
	T_{CC}	T_{RC}	T_{DIF}	T_R	T_{CC}	T_{RC}	T_{DIF}	T_R
V_R = 0V (C_J = 120 pF)	1	13	54	55.6	1	204	54	270
V_R = 10V (C_J = 24 pF)	1	2.6	0*	2.8	1	53	0*	53

* ALL CARRIERS ARE GENERATED WITHIN THE DEPLETION REGION

| LIGHT SOURCE: RED LIGHT (940 nm	SPEED (nsec.)							
	R_L = 50 ohms				R_L = 1000 ohms			
	T_{CC}	T_{RC}	T_{DIF}	T_R	T_{CC}	T_{RC}	T_{DIF}	T_R
V_R = 0V (C_J = 120 pF)	1	13	1448	1448	1	204	1448	1472
V_R = 10V (C_J = 24 pF)	1	2.6	97	97	1	53	97	110

Application Notes

APPLICATION NOTE #4
Modes of Operation - Photovoltaic vs. Photoconductive

A silicon photodiode can be operated in either the photovoltaic or photoconductive mode. When unbiased, the photodiode is being operated in the photovoltaic mode. When illuminated, the diode will generate a photocurrent which will divide between the internal shunt resistance of the junction and any external load resistance. That part of the photocurrent that flows through the external resistor will produce a voltage across that resistor which will act as a forward bias on the photodiode.
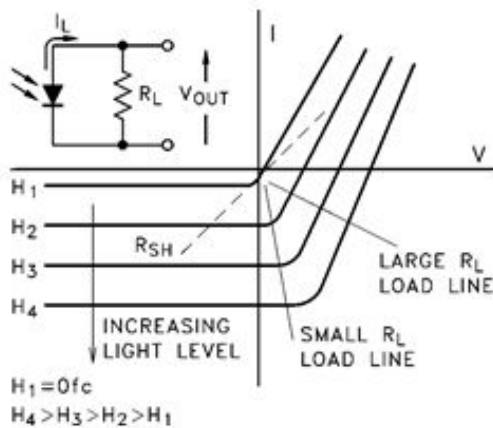
Current/Voltage Characteristics - Photovoltaic Mode
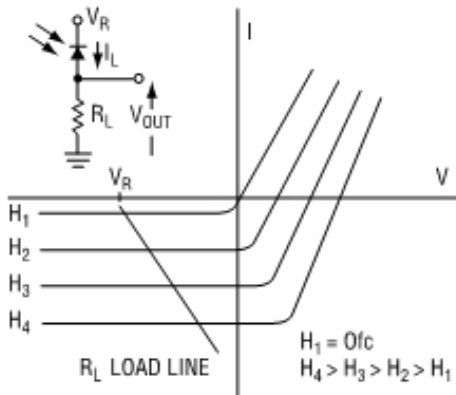
Current/Voltage Characteristics - Photoconductive Mode

When a reverse bias is applied, the photodiode is being operated in the photoconductive mode. In this mode the photodiode functions as a current source.

The choice of operating mode hinges on the trade-off between the required speed of response and the maximum noise that can be

tolerated in the actual application. As detailed in Application Note #3, applying a reverse bias across the photodiode increases its speed of response and must be used if nsec response times are needed. However, the dark leakage current of the photodiode tends to increase with applied reverse voltage resulting in an increase in the amount of shot noise generated by the photodiode. In general, a photodiode is operated in the photovoltaic mode when low nose is of prime concern, and under applied reverse bias when maximum speed is needed. A more detailed treatment on photodiode noise is given in Application Note #5.

APPLICATION NOTE #5
Photodiode Noise Characteristics

Certain figures of merit are defined to describe the performance of photodiodes:

Spectral Responsivity (R_e)

Radiant Sensitivity (S_R)

Quantum Efficiency (QE) Rise

Time (t_R)

Cutoff Frequency (f_c)

Shunt Resistance (R_{SH})

Series Resistance (R_S)

Junction Capacitance (C_J)

Maximum Reverse Voltage $(V_R$ max.)

Dark Current (I_D)

Short Circuit Current (I_{SC})

Open Circuit Voltage (V_{OC})

Noise Current (I_N)

Noise Equivalent Power (NEP)

Detectivity (D)

This application note will discuss the last three figures of merit: Noise Current (I_N), Noise Equivalent Power (NEP) and Detectivity (D).

Noise Current (I_N)

The equivalent circuit of a photodiode is shown below. It consists of an ideal current generator in parallel with an ideal diode. The junction capacitance, series resistance and the equivalent noise current generator associated with the junction shunt resistance account for the other photodiode parameters.

Application Notes
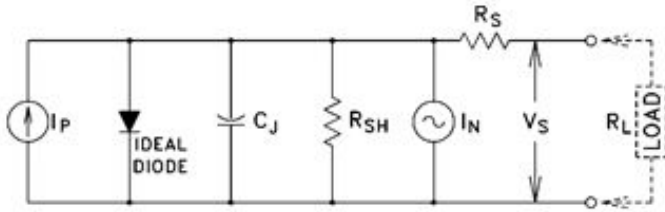
where:

I_P = photocurrent generator (A)

C_J = junction capacitance (F)

I_N = noise current generator (A, rms) R_{SH} = shunt resistance (Ω)

R_S = series resistance (Ω) V_S = signal voltage (V)

R_L = load resistance (Ω)

Like other types of light sensors, the lower limits of light detection for photodiodes are determined by the noise characteristics of the device.

The main sources of noise in photodiodes are thermal noise (or Johnson noise), shot noise and flicker noise (1/f or contact noise). These noise sources are independent of each other and the total noise current is the root of the sum of the square of each of these noise sources.
Hence:

$$I_N = \sqrt{I_J^2 + I_S^2 + I_F^2}$$

where:

I_N = total noise current (A)

I_J = thermal or Johnson noise current (A) I_S = shot noise current (A)

I_F = flicker noise current (A)

Thermal or Johnson Noise (I_J)

Thermal noise is a fundamental physical phenomenon generated by the random thermal motion of electrons and is present in any linear passive resistor. Photodiode thermal noise is caused by its shunt

resistance R_{SH} and is directly proportional to absolute temperature such that:

$$I_J = \sqrt{4kTB / R_{SH}}$$

where:

I_J = Johnson noise (A)

k = Boltzmann's constant (1.38 x 10-23 joules/K) T = absolute temperature (K)

B = noise bandwidth (Hz)

R_{SH} = photodiode shunt resistance (Ω)

In photodiodes, Johnson noise may become the dominant type when either low leakage/high dynamic resistance photodiodes are used in the zero bias configuration or when high value resistors (megohm to gigohm) are used as current sensing elements. Because thermal noise is independent of frequency and contains constant noise power density per unit bandwidth (B), it is considered white noise and is expressed in units of amps-per-root-Hertz ($A\sqrt{Hz}$). For example, a photodiode having $R_{SH} = .5 M\Omega$ at 25°C:

$$I_J/\sqrt{B} = \sqrt{4KT/R_{SH}}$$

$$= \sqrt{1.6 \times 10^{-20} / 0.5 \times 10^6}$$

$$= 0.18 \text{ pA (rms)} / \sqrt{Hz}$$

Shot Noise (IS)

Shot noise is generated by the random fluctuations in the normal current flow through the P-N junction. Because each electron carries a discrete amount of charge and the flow of electrons is subject to small random fluctuations, a noise current is generated. It has been shown that shot noise can be expressed by the following equation:

$$I_S = \sqrt{2qI_{dc}B}$$

where:

I_S = shot noise (A, rms)

I_{dc} = dc current through the junction q = electron charge (1.6 x 10-19 coulombs) B = noise bandwidth (Hz)

Application Notes

Like thermal noise, shot noise is independent of frequency and is also called "white noise". Shot noise may become significant when either high leakage photodiodes are used in reverse bias or when very weak signals must be detected. For example:

For a photodiode with I_D = 100 nA, the resultant shot noise will be:

$$I_S / \sqrt{B} = \sqrt{2qI_{dc}}$$

$$= \sqrt{2 \times 1.6 \times 10^{-19} 100 \times 10^{-9}}$$

$$= 0.18 \text{ pA (rms)} / \sqrt{Hz}$$

Flicker or 1/f Noise

Flicker noise is one of the least understood. It is usually attributed to manufacturing noise mechanisms or device surface states. Experimental data shows that this type of noise has a dependence on dc current and is similar to shot noise. A general equation for this type of noise follows:

$$I_F = \sqrt{KI_{dc} B / f}$$

where:

I_F = flicker noise (A)
K = a constant that depends on the type of material and its geometry.

I_{dc} = dc junction current (A) B = bandwidth of interest (Hz) f = frequency (Hz)

Unlike thermal and shot noises, flicker noise has 1/f spectral density and in the ideal case for which I_f is exactly proportional to $1/f$, it is termed "pink noise". Unfortunately, the constant (K) can only be determined empirically and may vary greatly even for similar devices. Flicker noise may dominate when the bandwidth of interest contains frequencies less than about 1 kHz.

Noise Equivalent Power (NEP)

The lower limit of light detection for a photodiode is expressed as the intensity of incident light required to generate a current equal to the noise current, I_N. This limit is referred to as Noise Equivalent Power, NEP and is defined as follows:

$$NEP = I_N / S_R$$

where:

NEP = noise equivalent power $(W / \sqrt{Hz})$ I_N = noise current $(A / \sqrt{Hz})$
S_R = peak radiant sensitivity (A/W)

NEP values range from about 10^{-15} $W / \sqrt{Hz}$ for small area, low noise silicon photodiodes, to over 10^{-12} $W / \sqrt{Hz}$ for large area cells. Excelitas's VTB (blue enhanced series) and VTP (fast response series) are among the lowest noise photodiodes with NEP values on the order of 10^{-15} $W / \sqrt{Hz}$, and the VTS (solar processed, large area series) photodiode NEP values are on the order of 10^{-13} $W / \sqrt{Hz}$.

Detectivity (D)

The inverse value of NEP is the detectivity (detection capability). The detectivity is a measure of the least detectable radiant power or detector signal to noise ratio. A higher D indicates ability to detect lower levels of radiant power.

$$D = 1/NEP$$

where:

$$D = \text{detectivity } (\sqrt{Hz} / W)$$

Since noise is normally proportional to the square root of the photosensitive area, the smaller the photosensitive area (A_D), the better the apparent NEP and detectivity.

The specific detectivity D* (D-Star) takes account of this factor and produces a figure of merit which is area independent. By definition:

$$D^* = D \times \sqrt{A_D}$$

where:

D* = specific detectivity $(cm \sqrt{Hz} / W)$ A_D = photodiode active area

D* values range from as high as 10^{13} $cm \sqrt{Hz}/W$ to as low as 10^{11} $cm \sqrt{Hz}/W$.

Both NEP and D* may be expressed either as an absolute or relative with respect to values at a given wavelength or at peak sensitivity.

Application Notes

Photodiode Noise Measurement

Photodiode noise current can be measured directly. A very low noise, high gain, broadband current to voltage converter amplifier is required along with a band pass filter and a true rms volt meter. A typical measurement circuit is shown below.
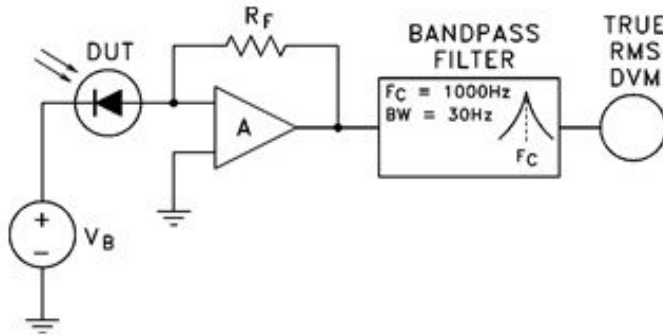
where:

DUT = photodiode under test

V_B = variable low noise dc power supply A = low noise broadband amplifier

R_F = feedback resistor

NOTE: A wave analyzer with true rms read out can be used in place of bandpass filter and true rms DVM.

Test Procedure

Set wave analyzer frequency span @ 1 kHz and resolution bandwidth @ 30 Hz.

Connect the output of amplifier A to the wave analyzer input.

Adjust the well regulated and low noise power supply to set the required bias voltage.

Measure the system noise, N_S, by inserting a capacitance equal to the photodiode's junction capacitance, C_J, at the operating reverse bias voltage between power supply and amplifier.

Replace the above capacitance by the photodiode and measure the system plus Photodiode noise, $N_S + N_D$.

Calculate the photodiode's current noise (I_N) as follows:

Photodiode noise voltage

$$N_D = \sqrt{(N_S + N_D)^2 - N_{S2}}$$

where:

N_D = photodiode noise voltage (V) N_S = system noise voltage (V)

Photodiode noise current

$$I_N = N_D / (R_F \times B)$$

where:

R_F = feedback resistor (ohms) B = bandwidth (Hz)

Photodiode noise equivalent power

$$NEP = I_N / S_R$$

Detectivity

$$D = 1 / (NEP)$$

$$D^* = D \times A_D$$

LOWER NOISE	PARAMETER	HIGHER NOISE
SMALL	ACTIVE AREA	LARGE
LARGE	SHUNT RESISTANCE	SMALL
SMALL	DARK CURRENT	LARGE
SMALL	JUNCTION CAPACITANCE	LARGE

APPLICATION NOTE #6 Processes

Photodiodes find use in a wide range of applications because they can be made with a wide range of performance characteristics. Each application places different demands on their performance.

It is often desirable to enhance one or more of the photodiode's performance characteristics such as sensitivity to a particular wavelength of light, speed of response, shunt resistance, etc. Within certain constraints this can be accomplished through the choice of method of crystal growth, resistivity, crystal orientation, carrier lifetime, and other properties of the silicon wafer as well as through wafer processing and photodiode chip layout.

Excelitas offers three standard silicon diode processes. Each process represents a different trade-off in diode performance characteristics. The following charts list the three standard processes and illustrate the tradeoffs.

Application Notes

PROCESS	DESCRIPTION
	PACKAGED DEVICES
VTB	BLUE ENHANCED
VTP	FAST RESPONSE
	LARGE AREA DEVICES
VTS	LOW CAPACITANCE

Diode Characteristics

VTB PROCESS	PARAMETER	VTP PROCESS
LOWER	**SR@2850K**	HIGHER
HIGHER	**SR@400nm**	LOWER
HIGHER	V_{OC}	LOWER
LOWER	I_D	HIGHER
HIGHER	R_{SH}	LOWER
HIGHER	C_J	LOWER
LOWER	V_{BR}	HIGHER

APPLICATION NOTE #7
## Array and Custom Detector Guidelines

Semicustom and fully custom photodiodes can be used to deliver performance not available from catalog devices. Excelitas offers a full spectrum of specialized or custom services ranging from the sorting of stock devices for some electrical characteristic such as V_{BR}, R_D, or I_D; to placing a stock chip in a package it is not usually supplied in; to the use of filters incorporated into the package in order to modify the spectral response; to a totally custom chip and/or package design involving a major tooling effort.

LEVEL OF CUSTOMIZING	WHEN JUSTIFIED	NOTES
CUSTOM ELECTRICAL SORT OF EXISTING STOCK DEVICE	MODERATE VOLUMES	QUICK TURN-AROUND
SUPPLY EXISTING CHIP IN A DIFFERENT PACKAGE	HIGH VOLUMES	LONGER LEAD TIMES, NRE*
TOOL CUSTOM CHIP AND/OR TOOL CUSTOM HOUSING	HIGH VOLUMES	LONGEST LEAD TIMES NRE, TOOLING

* NRE - NON RECURRING ENGINEERING CHARGE

Excelitas also has the capability to design and manufacture custom multichannel arrays of various configurations. There are two general categories of arrays: monolithic and hybrid. Monolithic arrays have all detector elements incorporated within one silicon chip. Hybrid arrays are arrays assembled by placing individual detector chips down onto some sort of substrate, usually ceramic or printed circuit board.

Tooling costs and lead times can become a major concern if a monolithic array chip must be made from scratch. A possible alternative, should the geometries work out, is to cut out a block of discrete photodiode chips from the parent silicon wafer, thus eliminating the need to tool a custom array. However, for this approach to work, an existing detector chip must be found not only with the same active area as a single element of the array, but the spacing between the diodes on the wafer must be the same as the center-to-center spacing required for the array.
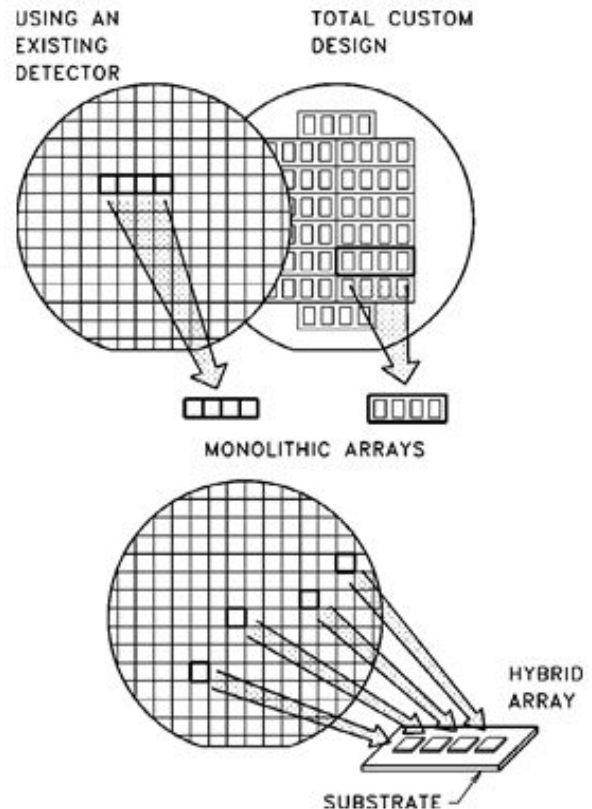
Application Notes

Comparison of Monolithic and Hybrid Arrays

MONOLITHIC	PARAMETER	HYBRID
COMMON CATHODE	ELECTICAL CONFIGURATION	FLEXIBLE
LESS (ONE CHIP)	COMPLEXITY OF PACKAGE	MORE (MULTIPLE CHIPS)
LONGER*	LEADTIMES	SHORTER
LESS	PACKAGING COSTS	**MORE
TIGHTER	DIMENSIONAL TOLERANCES	LOOSER

* TOTAL CUSTOM DESIGN
** PATTERNED METALLIZED SUBSTRATE OFTEN NEEDS TO BE TOOLED

Since arrays tend to be custom in nature, it is important for the customer to supply Excelitas with enough information to achieve the most cost effective design for the particular application. The information required includes the following:

1. Number of light detecting elements

2. Desired layout

3. Active area of each element

4. Center-to-center spacing between elements

5. Electrical configuration (common cathode, etc.)

6. Packaging requirements - including pin-out configuration

7. Anticipated volumes

8. Price goals

9. Desired delivery date

APPLICATION NOTE #8

Handling and Soldering Opto Components

Care must be taken in the handling and soldering of all opto components, especially those that use a cast or molded plastic and lead frame construction.

In lead frame type construction, the detector chip is mounted directly to one lead and a wire bond is made from the chip to the other lead. The encapsulating plastic is the only support for the lead frame. Unlike plastic IC packages, opto epoxies have no fiberglass filler. Thus they are not as strong as plastic IC packages. Care must be taken when forming the leads of plastic opto packages. Excessive mechanical force can cause

the leads to move inside the plastic package and damage the wire bonds. Weakened bonds can then "open up" under further mechanical or thermal stressing.

In order to safely form leads it is necessary to firmly clamp the leads near the base of the package in order not to transfer any force (particularly tension forces) to the plastic body. This can be accomplished either through use of properly designed tooling or by firmly gripping the leads below the base of the package with a pair of needle nose pliers while the leads are being bent.

Examples of Tooling Fixtures Used to Form Leads
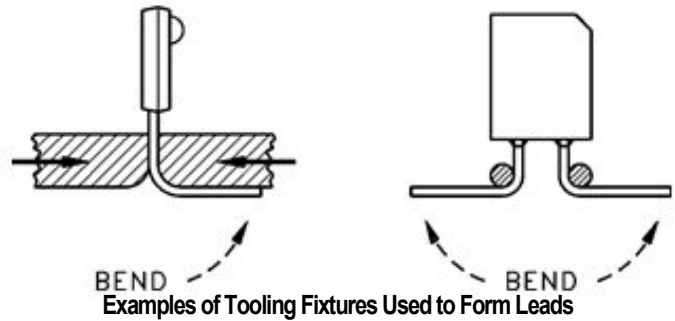
For highest reliability, avoid flush mounting the plastic body of the printed circuit board. This minimizes mechanical stresses set up between the circuit board and the plastic packages. It also reduces solder heat damage to the plastic package.
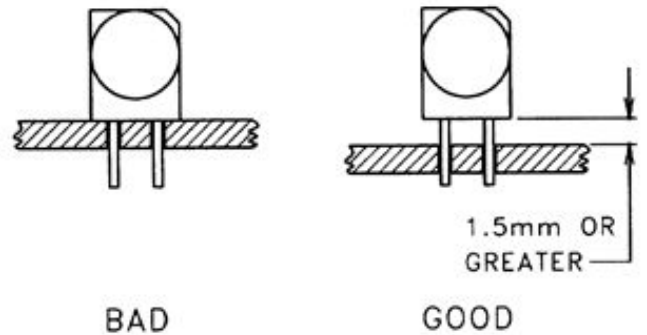
Good printed circuit board layout avoids putting any spreading (plastic under tension) force of the leads of a plastic package.
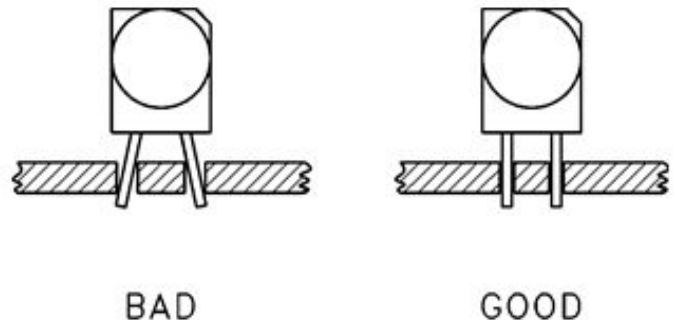
Application Notes

When hand soldering it is important to limit the maximum temperature of the iron by controlling the power. It is best if a 15W or 25W iron is used. The maximum recommended lead soldering temperature (1/16" from the case for 5 seconds) is 240°C. An RMA rosin core solder is recommended.

For wave soldering the components into printed circuits boards a Sn60 (60% tin/40% lead) solder is recommended. Other alternatives are Sn62 and Sn63. The maximum recommended soldering temperature is 240°C with a maximum duration of 5 seconds.

When soldering devices with silver plated leads the amount of tarnish on the leads determines the type of flux to use.

Condition of Leads	Recommended Flux
Clear Bright Finish (Tarnish Free)	R - Non Activated Rosin Flux
Dull Finish (Minimal Tarnish)	RMA - Mildly Activated
Light Yellow Tint (Mild Tarnish)	RA - Activated
Light Yellow / Tan Color (Moderate Tarnish)	AC - Water Soluble, Organic Acid Flux
Dark Tan / Black Color (Heavy Tarnish)	Leads Need to be Cleaned Prior to Soldering

Cleaners designed for the removal of tarnish from the leads of electronic components are acidic and it is best to keep the immersion time as short as possible (less than 2 seconds) and to immediately wash all devices thoroughly in cold water.

The best policy is one which prevents tarnish from forming. Tarnish, which is a compound formed when silver reacts with sulfur (Ag_2S), can be prevented by keeping the components away from sulfur or sulfur compounds. Since two major sources of sulfur are room air and paper products it is best to store the devices in protective packaging such as "silver saver" paper or tightly sealed polyethylene bags.

After soldering, it is necessary to clean the components to remove any rosin and ionic residues. For a listing of recommended cleaning agents please refer to Application
Note # 9.

APPLICATION NOTE #9

Recommended Cleaning Agents

Excelitas offers many of its photodiodes in a number of package styles which employ a wide range of construction techniques. Package styles include:

1. hermetic glass/metal cans

2. cast and molded leadframe packages

3. ceramic or metal headers covered with a layer of clear epoxy (blob-top construction).

Some packages are more resistant to attack by chemical cleaning agents than others. Blob-top construction is the least resistant. Cast or molded leadframe packages offer better resistance. Of course the glass/metal hermetic packages are the most chemically resistant of all.

In many cases the detectors will be exposed to a post solder cleaning operation which uses one or more solvents to remove the residual solder flux and ionic contaminants. Only certain cleaning solvents are compatible with the plastics typically used in optoelectronic device packages.

RECCOMENDED	NOT RECOMMENDED
ARKLONE A	ACETONE
ARKLONE K	CARBON TETRACHLORIDE
ARKLONE F	METHYL ETHYL KETONE
BLACO-TRON DE -15	METHYLENE CHLORIDE
BLACO-TRON DI-15	TRICHLORETHYLENE (TCE)
FREON TE	XYLENE
FREON TES	TRICHLOROETHANE FC-111
FREON TE-35	TRICHLOROETHANE FC-112
FREON TP	FREON TF
FREON TF-35	FREON TA
GENESOLV D	FREON TMC
GENESOLV DE-15	FREON TMS
GENESOLV DI-15	GENESOLV D
ISOPROPYL ALCOHOL	GENESOLV DA
WATER	GENESOLV DM
	GENESOLV DMS

This listing of recommended/not-recommended solvents represents only a very small percentage of available chemical cleaning agents. Even with this list of recommended solvents it is important to be aware that:

1. Solvent exposure times should be as small as possible.

2. The exact details of the cleaning process will vary from customer to customer.

3. Additives and concentrations will vary from supplier to supplier.

Application Notes

Because of these uncertainties, our recommendation is that each customer carefully evaluate their own cleaning process and draw their own conclusions about the effectiveness and reliability of the process. Excelitas cannot assume any responsibility for damage caused by the use of any of the solvents above or any other solvents used in a cleaning process.

APPLICATION NOTE #10
Photometric and Radiometric Terms

In order to describe the sensitivity of photodetectors or the brightness of light sources, it is necessary to define the amount of light being emitted or detected in quantitative terms. Many individuals, when first exposed to these terms, experience a certain amount of confusion caused by the two systems of measurement, the photometric and the radiometric.

The photometric system defines light in terms of how it is perceived by the human eye. The eye's sensitivity is dependent on the wavelength or color of the light. Peak sensitivity occurs in the green part of the visible spectrum while the eye's response to infrared or ultraviolet is zero.

The radiometric system describes light quantities in physical rather than eye response terms. The baseline detector used in the

radiometric system has uniform sensitivity across the entire spectrum. Radiometric measurements can be made with thermopiles whose response does not vary with wavelength.
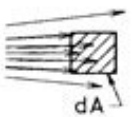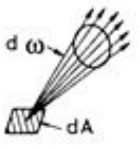
Both systems have their place. When specifying room lighting, it makes sense to use photometric units. However, if the application involves transmitting data over a beam of infrared light, the output of the light source and the sensitivity of the detector must be specified using radiometric units.

Excelitas makes use of the symbol H, (the original term for radiant incidence) when specifying the lighting conditions under which its detectors are measured for sensitivity. This symbol appears regardless if photometric (fc) or radiometric (W/cm^2) incidence is being specified.
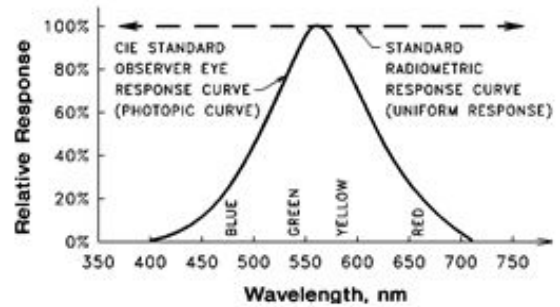
Application Notes

Commonly Used Terms

TERM	DEFINITION	NOMENCLATURE	DESCRIPTION	EQUATION	UNITS
Flux, Φ	Rate of flow of energy (Q) to, from or through a surface	Φ_e - (Radiometric)	Radiant Flux (Radiant Power)	$\dfrac{dQ_e}{dt}$	W, Watts
		Φ_V - (Photometric)	Luminous Intensity	$\dfrac{dQ_V}{dt}$	lm, lumens
Incidence, E **(Note 1)**	Flux per unit area falling perpendicularity upon a surface	E_e - (Radiometric)	Radiant Incidence	$\dfrac{d\Phi_e}{dA}$	W/cm^2
		E_V - (Photometric)	Luminous Incidence **(Note 2)**	$\dfrac{d\Phi_V}{dA}$	lx, lux (lm/m^2)
Exitance, M	Flux per unit area from an emitting surface	M_e - (Radiometric)	Radiant Exitance (Emittance)	$\dfrac{d\Phi_V}{dA}$	W/m^2
		M_V - (Photometric)	Luminous Exitance	$\dfrac{d\Phi_V}{dA}$	lm/m^2
Solid Angle, ω	A solid angle with its apex at the center of a sphere of radius, r, defines a spherical surface area, S, such that $\omega = S/r^2$			$dw = \dfrac{}{r^2}$	sr, Steradians
Iintensity, I	Flux per unit solid angle radiating from a point source	I_e - (Radiometric)	Radiant Intensity	$\dfrac{d\Phi_e}{d\omega}$	W/sr
		I_V - (Photometric)	Luminous Intensity	$\dfrac{d\Phi_{Ve}}{d\omega}$	cd, candelas (lm/sr)
Sterance, L	Flux per unit solid angle per unit area of emitting surface at angle θ with respect to the surface normal	L_e - (Radiometric)	Radiant Sterance (Radiance)	$\dfrac{d\Phi_e}{dA\cos\theta}$ $\dfrac{d^2\Phi_e}{d\omega dA\cos\theta}$	$W/(sr\,m^2)$
		L_V - (Photometric)	Luminous Sterance (Luminous) **(Note 3)**	$\dfrac{d\Phi_V}{dA\cos\theta}$ $\dfrac{d^2\Phi_V}{d\omega dA\cos\theta}$	cd/m^2

Notes:

1. For historical continuity, Excelitas uses the symbol "H" in the data sheets of this catalog.

2. Other units for luminous intensity are:

Phot, ph	lm/cm^2
Footcandle, fc	lm/ft^2 (1 fc = 10.76 lux)

3. Other units for luminous sterance are:

Lambert, L	$1/\pi$	cd/cm^2
Foot lambert, fL	$1/\pi$	cd/ft^2
Apostilb, asb	$1/\pi$	cd/m^2
Stilb, sb		cd/cm^2