Application Notes

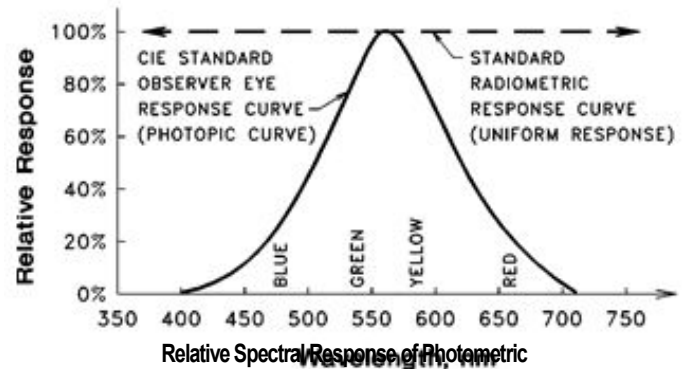## APPLICATION NOTE #1
Photometric and Radiometric Terms

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 of 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 application. 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.

Relative Spectral Response of Photometric

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 perpendicularly upon a surface	E_e - (Radiometric)	Radiant Incidence (Irradiance)	$\dfrac{d\Phi_e}{dA}$	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 - (Radiometric)	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 $\omega=S/r^2$			$d\omega = \dfrac{dS}{r^2}$	sr, Steradians
Intensity, 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	$\dfrac{d\Phi_v}{d\omega}$	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 (Luminance) **(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
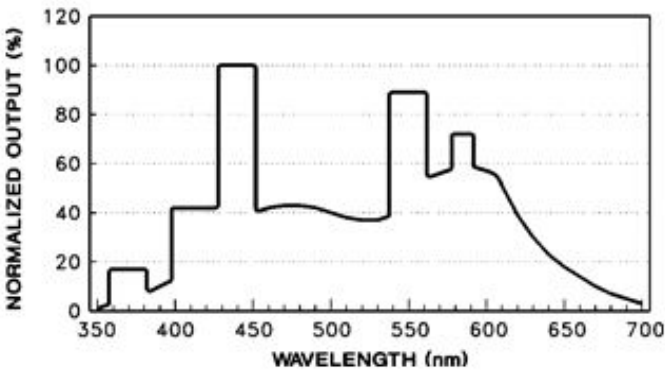
Application Notes

APPLICATION NOTE #2
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.
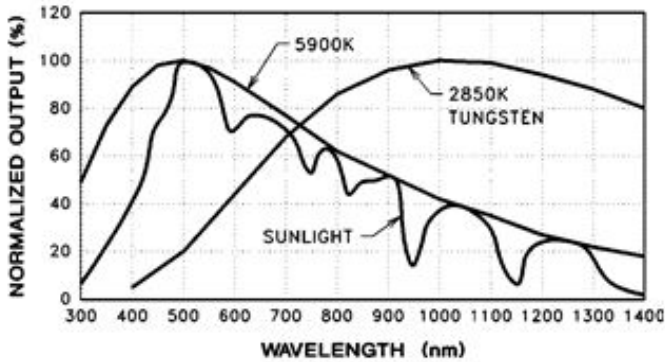

Black Body Sources Output vs. Wavelength

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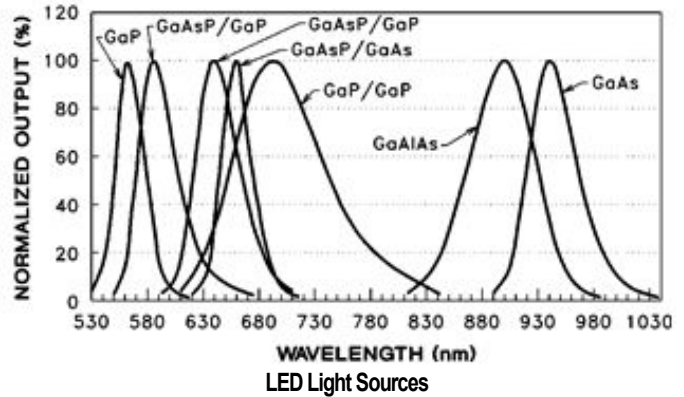
LED TYPE	COLOR	λ_P
GaP	GREEN	569 nm
GaAsP/GaP	YELLOW	585 nm
GaAsP/GaP	ORANGE	635 nm
GaAsP/GaAs	RED	655 nm
AlGaAs	RED	660 nm
GaP/GaP	RED	697 nm
GaAlAs	INFRARED	880 nm
GaAs	INFRARED	940 nm

The intensity of the light emitted by visible LEDs is often given in units of millicandela. Millicandela is a photometric unit of measure which assumes the human eye as the detector. For most detectors other than the human eye the most convenient system for measurement is the radiometric system. Listed below is the typical light power output of some LEDs measured at two different forward drive currents. Note that LEDs of a given type can show a 5:1 manufacturing spread in power outputs.

LED TYPE	COLOR	λ_P	POWER OUTPUT	
			If = 1 mA	If = 10 mA
GaP	GREEN	569 nm	1.2 µW	24.1 µW
GaAsP/GaP	YELLOW	585 nm	.3 µW	26.2 µW
GaAsP/GaP	ORANGE	635 nm	3.2 µW	101.9 µW
GaAsP/GaAs	RED	655 nm	6.2 µW	102.1 µW
AlGaAs	RED	660 nm	33.8 µW	445.1 µW
GaP/GaP	RED	697 nm	54.3 µW	296.2 µW
GaAlAs	INFRARED	880 nm	76.8 µW	1512.3 µW
GaAs	INFRARED	940 nm	35.3 µW	675.0 µW

# Application Notes

APPLICATION NOTE #3
The Effect of Packaging on the
Light Output of IREDs

When an IRED Is forward biased a percentage of the injected carriers which recombine in the vicinity of the P-N junction result in the generation of photons. Not all of the generated light is able to emerge from the interior of the IRED chip due to these power loss mechanisms:

1. absorption

2. Fresnel losses

3. internal reflection

Mounting the IRED die in a package not only serves to protect it from a potentially hostile environment but can also be used to increase the useful power output by compensating for these losses. As photons travel outward through the chip from the junction region there is a probability that absorption will take place. The longer the travel distance the greater the internal absorption. This is the reason that smaller IRED sizes exhibit the highest power conversion efficiencies.

Because the P-N junction extends to and is exposed at the four sides of the chip, a large percentage of the total light output is emitted from these sides. By mounting the IRED chip in a contoured cavity it is possible to collect a larger percentage of this side emitted light and reflect it upwards.
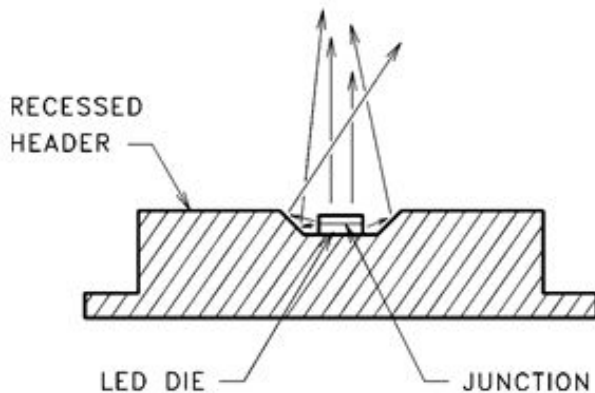
When light travels from a material with index of refraction n_1 into a medium with index of refraction n_2 some of the light is reflected

back at the interface between the two materials. This reflected power is called the fresnel loss.

For normal incidence, the Fresnel loss efficiency factor is given by:

$$\eta_{FR} = \frac{4}{n_{22} + n_2/n_1 + n_1/n_2}$$

where:

n_1 = index of refraction of the IRED
n_2 = index of refraction of the material
    surrounding the chip

For a GaAs IRED chip emitting directly into air:

$$\eta_{FR} = \frac{4}{(1+1/3.62)+(3.62/1)} = 82\%$$

Hence only 82% of the light reaching the chip's surface exits the chip. More light power can be extracted from the chip by coating it with a matching material whose index of refraction lies between that of the chip's and that of air. When an "index matching" material is used the transmission efficiency can be increased to over 90%. Optimum transmission efficiency is achieved when the index matching material used has an index of refraction of $\sqrt{n_1 n_2}$.

Loss also occurs due to total internal reflection. If photons of light are incident to the chip's surface at angles greater than the critical angle they are reflected back into the crystal.
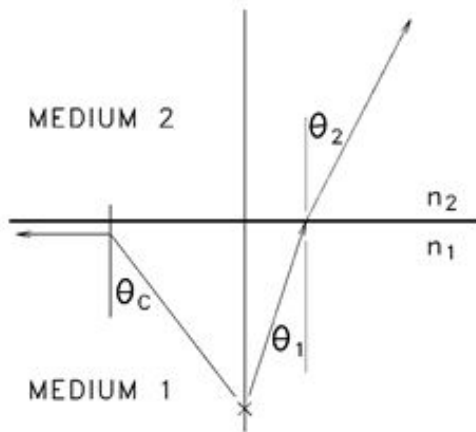
$$\theta_C = \sin^{-1}(n_2/n_1) @ 16° \text{ (for GaAlAs)}$$

where:

θ_C = critical angle
n_1 = index of refraction of the LED
n_2 = index of refraction of the material
    surrounding the chip

This situation can be improved by coating the LED chip with a plastic encapsulant.
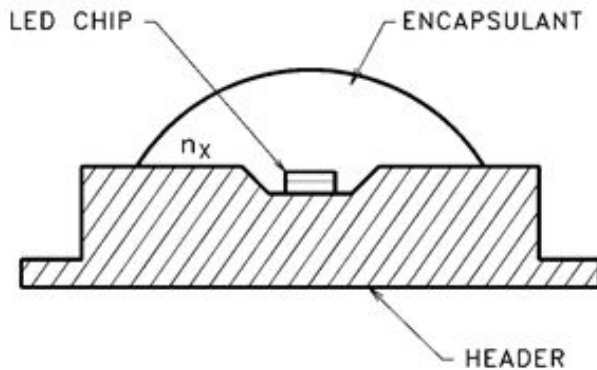
Application Notes

MEDIUM 2

θ_2

n_2

n_1

θ_c

θ_1

MEDIUM 1

$$\theta_C = \sin^{-1}(n_x/n_1)$$
$$= \sin^{-1}(1.30/3.62)$$
$$\cong 21°$$

Lenses, incorporated into the IRED package, can be used to increase the useable forward power intensity by focusing the light emitted by the IRED.

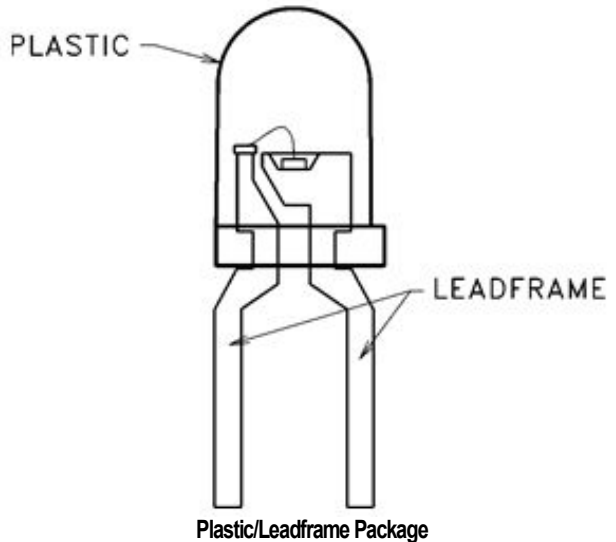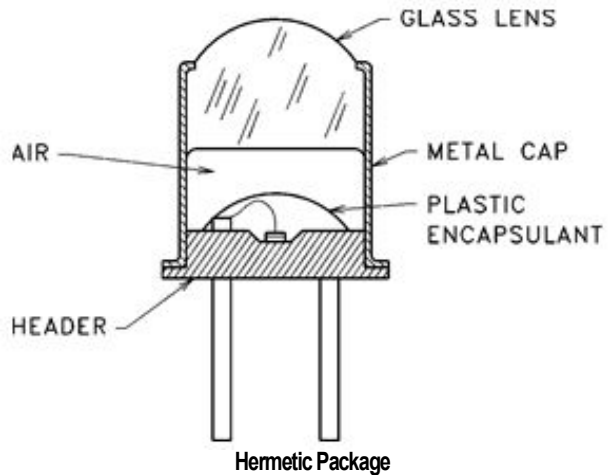LED CHIP — ENCAPSULANT

n_x

HEADER

The lenses used on metal/glass hermetic packages are made from a glass whose thermal coefficient of expansion closely matches that of the Kovar (iron-nickel-cobalt alloy) package. For IREDs which use leadframe construction, lenses can be made an integral part of the cast of molded package.

The lenses used on IRED are not precision ground. Expect variations in the light pattern from unit to unit due to lens quality, variations in chip placement, shape of the reflector cavity, number and type of material interfaces, and distance from the lens to the IRED chip.

The glass lens used in hermetic packages is formed by melting and reflowing a cut glass disc. The overall dimensions and geometry of this reflowed lens show considerable variation. They do not have closely repeatable optical geometry. The focal point, direction, and uniformity of the emitted beam of light show significant variation from unit to unit.

Plastic IREDs have only one optical surface in the lens system. The shape of this lens is controlled by the casting mold or transfer mold. The optical characteristics are more uniform from unit to unit. So, plastic IREDs have a more consistent beam pattern than hermetic IREDs.

GLASS LENS

AIR — METAL CAP

PLASTIC ENCAPSULANT

HEADER

Hermetic Package


PLASTIC

LEADFRAME

Plastic/Leadframe Package

IREDs of plastic/leadframe package design have two fewer dielectric interfaces than do IREDs in hermetic packages. As a result plastic packages generally deliver up to 50% more useable focused power than hermetic packages.

Application Notes

APPLICATION NOTE #4
## Characterization of IRED Power Output

Almost all applications have an optical geometry containing a detector of a certain physical area that intercepts a portion of a "beam" of IR power emitted by the IRED.
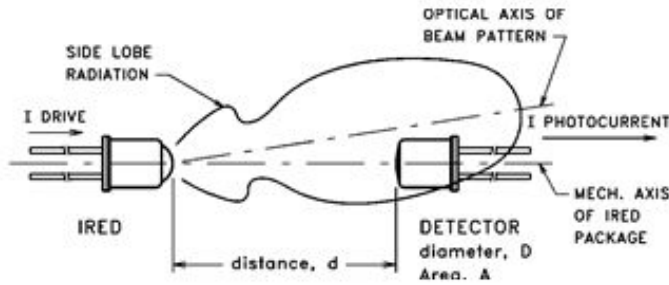
This note explains the conceptual relationship between this basic geometry and several ways used to measure and sort IREDs in manufacturing.

Total Power Output:

This is the quantity which is easiest to measure with a high degree of reproducibility. The measurement set-up consists of some physical approximation to an integrating sphere. Nearly all of the power emitted by the IRED is collected and measured.
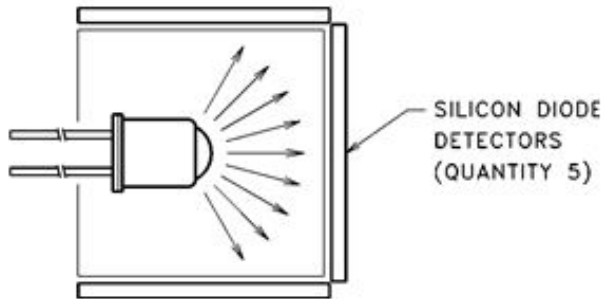

Advantages:

- *Easy to get reproducible measurements*

- *Independent of optical irregularities in the IRED lens*

- *Independent of variations in mechanical positioning of the IRED under test.*

Disadvantage:

- *Total power output does not describe the beam pattern of the IRED (spatial distribution of emitted power). It provides incomplete information for the optical designer.*

Wide Angle IRED

Narrow Angle IRED
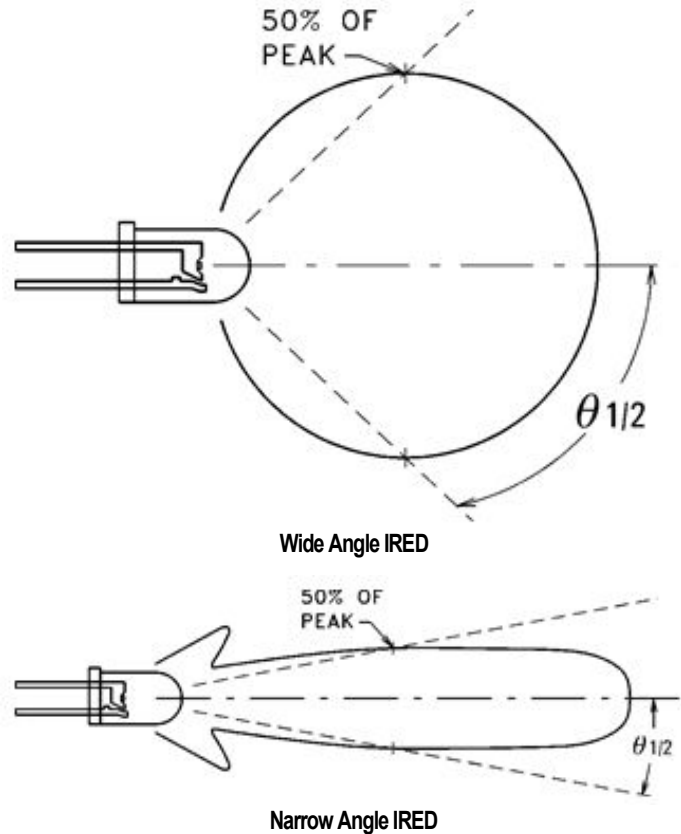
Manufacturers commonly rate their IREDs by "power output" in milliwatts at a specified drive current. However, the specs will also include a "half power beam angle", $\theta_{1/2}$. The half power beam angle can be used as a semi-quantitative guide to predict the behavior of the IRED in a given application. Within certain limits, "narrow angle" IREDs will contain more power in their "beam" than "wide angle" IREDs.

Radiant Intensity

Radiant intensity is defined as:

$$I_e = \Delta W / \Delta \omega$$

where:

$$\omega = \text{acceptance angle in steradians}$$

and is normally applied to the "far field" radiation pattern where the IRED an be approximated as a point source of power (viewing distance is at least ten times greater than the IRED lens diameter). Since it is defined in terms of power per solid angle, the radiant intensity is independent of the distance from the IRED.

Application Notes

In practice, the radiant intensity is measured by clamping the body of the IRED (thus establishing its "mechanical axis") and measuring the output of a photodetector of diameter "D". The solid angle is:

$$\omega \cong (\pi/4\, D^2)/d^2$$

and the IREDs are sorted into radiant intensity bins of "xx" mW/sr. It is important that the solid acceptance angle of the measuring apparatus be small enough to produce an essentially constant irradiance over the surface of the detector. Otherwise, different diameter detectors will produce different measured values of "radiant intensity". Generally, the measuring solid angle is in the vicinity of 0.01 sr (steradians). Each manufacturer usually lists the steridian value of the test apparatus in the data sheet footnotes.

Advantages of Radiant Intensity Measurement:

- *The designer can use Radiant Intensity quantitatively in many different design situations.*

- *IREDs which exceed a minimum Radiant Intensity value will usually show more consistent performance in the customer's application.*

## Disadvantages of Radiant Intensity Measurement:

- *It is hard to get highly reproducible measurements of Radiant Intensity. This is because it is difficult to establish the mechanical axis of the IRED reproducibly. The optical and mechanical axis of the IRED under test almost never coincide. The IRED bodies are tapered and never exactly circular. This leads to slight variations in the position of the IRED in the measuring apparatus each time it is measured. Increased scatter in the measured values of Radiant Intensity is the result. In practice, Radiant Intensity is useful as a minimum specification only.*

- *Many applications of IREDs use a close spacing between the IRED and detector. Thus, Radiant Intensity — which is measured in the "far field" (spacing at least ten times IRED diameter) does not quantify the available power to be coupled from the IRED.*
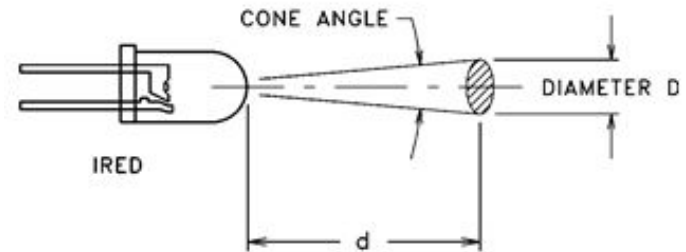
Irradiance:

Irradiance is defined by the power which passes through an aperture (usually circular, diameter D) which is spaced at a distance "d" from the tip of the IRED's lens. Usually, both the aperture diameter "D" and the distance "d" are chosen to have

values that are representative of many (but, unfortunately, not all) applications. Thus, Irradiance is a very practical—but geometry dependent—quantity. It should be noted that Irradiance has a precise mathematical definition in geometrical optics and is easy to calculate in the case of a sufficiently small diameter detector moved into the far field radiation pattern of the IRED.

Typical cone angles are in the range of 10 to 30 degrees. Larger cone angles give more reproducible measurements. However, larger cone angles reduce the absolute accuracy of the irradiance measurement since the radiant flux density (power density) emitted by the IRED is usually not constant over a large diameter.
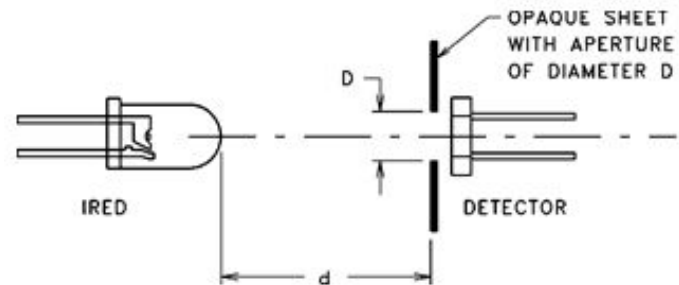
Equivalent to:

Irradiance can be calculated from the Radiant Intensity is the far field (d/D > 10) from the relationship:

$$E_e = I_e / d_2$$

In summary:

Total Power Output is conventionally used throughout the industry to specify IREDs. It has the highest measurement reproducibility.

Radiant Intensity is useful as a far field (d/D > 10) specification but has no use close to the IRED lens. Radiant Intensity is hard to measure accurately because of difficulty in locating and clamping the mechanical axis of the IRED.

Application Notes

Irradiance is a useful measurement technique in the near field of the IRED's beam pattern. Measuring the power through an aperture of diameter "D" spaced distance "d" from the IRED lens tip approximates many real-life application geometries. If the aperture "D" is large compared to the spacing "d" (large cone angle), the reproducibility of the irradiance measurement is improved, but, the absolute accuracy is decreased.

APPLICATION NOTE #5
IRED Axial Power Out Measurement

The on-axis power emitted by an IRED is measured by placing a detector, with a given active area, at some distance in front of the IRED and recording the average power falling upon the surface of that detector. The on-axis power is defined as an average power since more light might fall upon one portion of the detector than another.

For example, a silicon photodiode[1] with Sr @ 880 nm = .5 A/W is being used to measure the on-axis power of a GaAlAs IRED. When a current meter is attached to the diode, a short circuit current, ISC, of 50 µA is read.
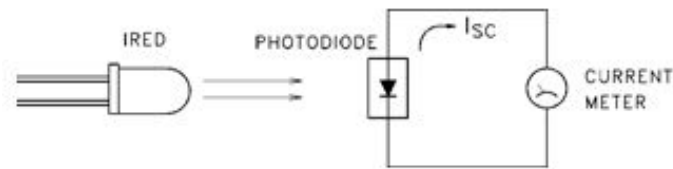

On-Axis Power = 50 µA ÷ 0.5A/W = 100 µW

Thus, 100 µW of power is incident on the photodiode. It might all fall on one portion or it might be evenly distributed over the entire surface of the detector.

The measurement of on-axis power is informative and could be used to compare the output of IREDs in packages of the same lens type. However, it does nothing to help the designer who needs to know what their magnitude of output can be expected from a detector of a different active area and sensitivity positioned at different distances from the IRED.

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1. For information on photodiodes and their characteristics, see Excelitas' Silicon Photodiodes Catalog.
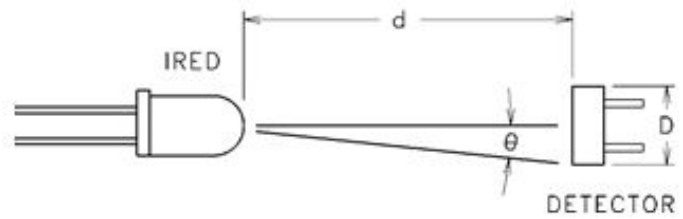
To perform these calculations, the designer needs to know the on-axis power intensity of the IRED. The on-axis power intensity can be states as an irradiance, E_e (mW/cm^2) or as a radiant intensity, I_e (mW/sr). We will deal with radiant intensity shortly, for the moment let's study irradiance and how the diameter of the detector used and distance from the emitter to detector affects the detector.

The graph presented below illustrates the relationship between E_e and the size of the detector used to make the measurement. If the diameter of the detector is a good deal smaller than the distance between the detector and the IRED being measured, then E_e is independent of the size of the detector.

**Irradiance vs. Diameter of Detector Used**
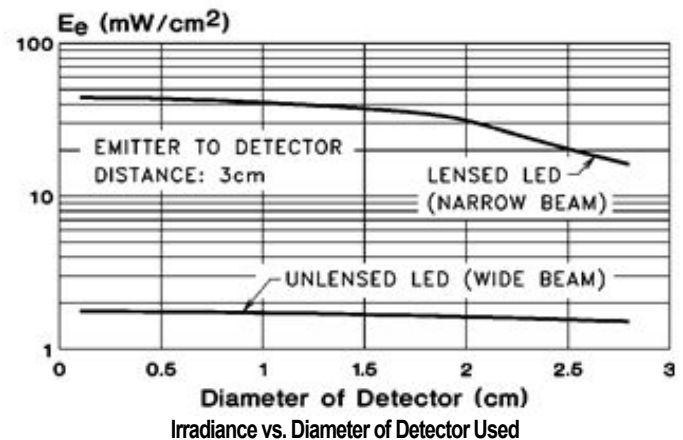
In most practical cases, spacing (d) is much larger than detector diameter (D). The E_e obtained is then an accurate quantity, independent of the optical geometry and can be used to calculate the output signal for detector/IRED combinations.

Here is an example of such a calculation.

A silicon photodiode with an active area of .100" x .100" and an Sr @ 880 nm = 0.5 A/W is positioned 6 cm in front of a lensed IRED and then in front of an IRED with no focusing lens. The total power output of each IRED is identical. What is the output signal from the detector for both cases?

Application Notes

Irradiance vs. Distance - Emitter to Detector
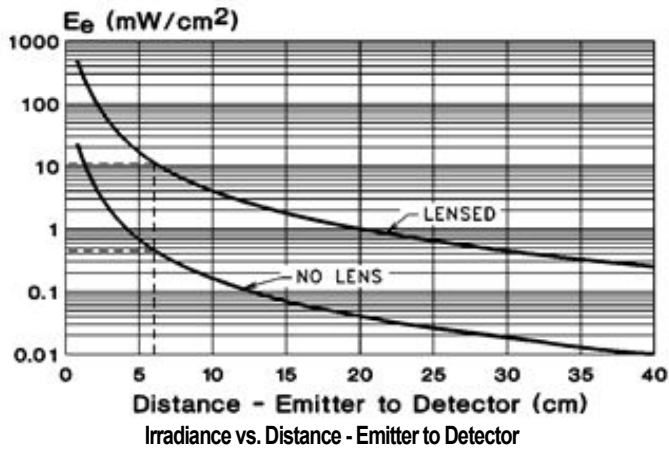
From the graph, the E_e for both IRED/detector combinations can be found.

For the case of the lensed IRED:

$$I_{SC} = .5 \text{ A/W} \times .0645 \text{ cm}^2 \times 11 \text{ mW/cm}^2$$
$$= 355 \text{ μA}$$

For the case of the unlensed IRED:

$$I_{SC} = .5 \text{ A/W} \times .0645 \text{ cm}^2 \times .44 \text{ mW/cm}^2$$
$$= 14.2 \text{ μA}$$

In some cases the Irradiance vs. Distance curve may not provide data at the separation distance(s) of interest, or the curve itself may not be available. In such situations, if the irradiance is known at one distance of separation, E_e can be calculated by use of the inverse square law.

$$E_e @ d_2 = E_e @ d_1 / [d_2 / d_1]^2$$

For example, let's consider the output signal from the photodiode/lensed IRED pair used above when they are 30 cm apart.

$$E_e = 11 \text{ mW/cm}^2 / [30 \text{ cm} / 6 \text{ cm}]^2$$
$$= .44 \text{ mW/cm}^2$$

$$I_{SC} = .5 \text{ A/W} \times .0654 \text{ cm}^2 \times .44 \text{ mW/cm}^2$$
$$= 14.2 \text{ μA}$$

Note: The inverse square law assumes that the light source (IRED) appears as a "point" source to the detector. In practical terms this means that the diameter of the light source is less than 1/10 the distance between the emitter and detector.

As already mentioned, on-axis power intensity can also be described in terms of radiant intensity, I_e. Radiant intensity defines on-axis power intensity as power per solid angle (mW/sr). The concept of a solid angle is described by the figure below.

A cone of a solid angle ω, has its apex at the center of a sphere of radius R and defines an area A, on that sphere as that

$$\omega = A / R^2 \cong \pi r^2 / R^2 \qquad (sr)$$

The unit of measurement is the steradian (sr).
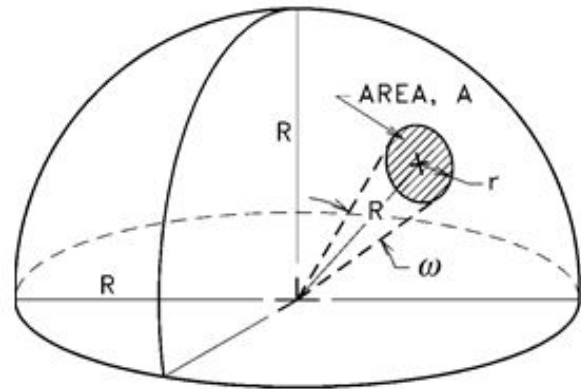
Example: A photodiode, with a circular active area .50 cm in diameter and sensitivity @ 880 nm of .5 A/W, is located 10 cm in front of a GaAlAs IRED whose I_e = 100 mW/sr. The value of the detector's short circuit current can be calculated as:

$$\omega = \pi r^2 / R^2$$
$$= \pi \times (.50 \text{ cm} / 2)^2 / (10 \text{ cm})^2 =$$
$$.001963 \text{ (sr)}$$

$$I_{SC} = .5 \text{ A/W} \times 100 \text{ mW/sr} \times .001963 \text{ sr}$$
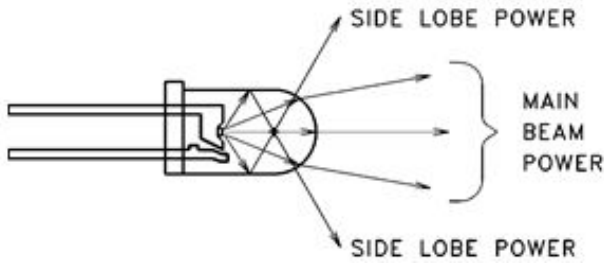$$= 98.15 \text{ μA}$$

APPLICATION NOTE #6
IREDs With Narrow Beam Patterns

A wide angle IRED distributes its radiant flux as shown below. Most of the flux impinges on the lens surface at almost normal incidence. Little is lost to total internal reflection.
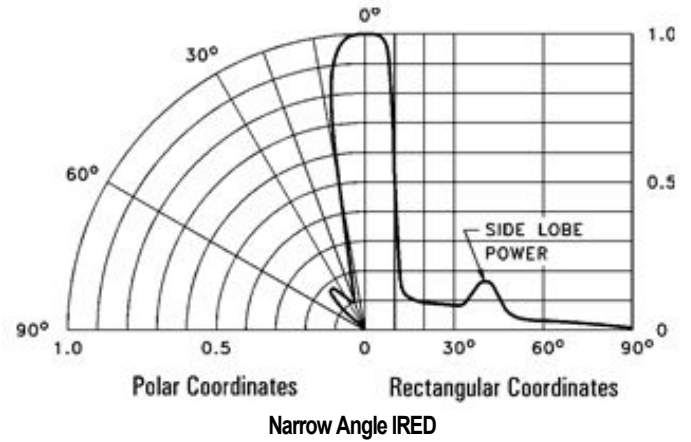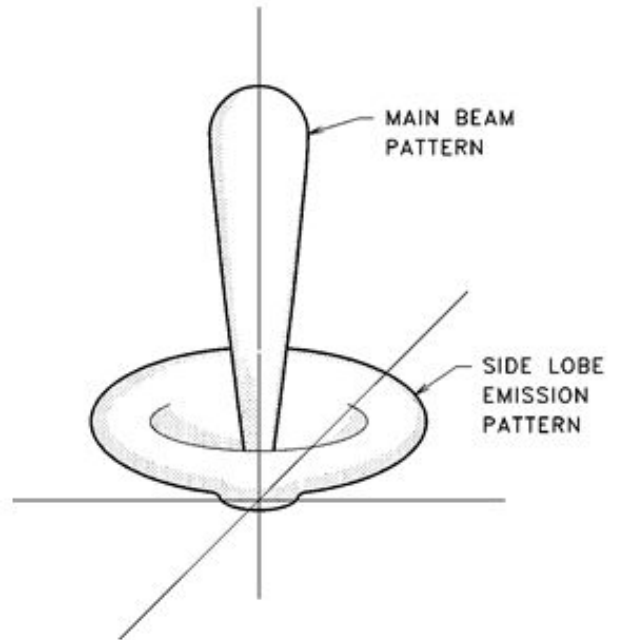
Application Notes
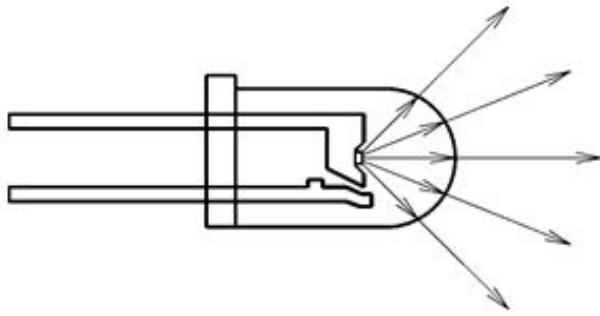
Some of the radiant flux in narrow angle IREDs is reflected internally.

The side lobe power is not useful in most applications. It is "lost" to the optical system. Typical emission patterns (beam patterns) are shown below in both polar and rectangular coordinates.
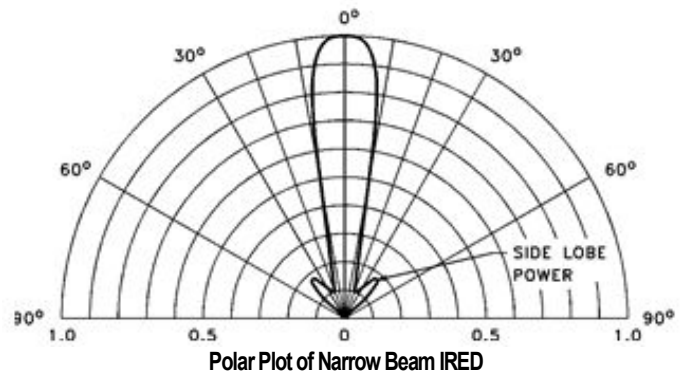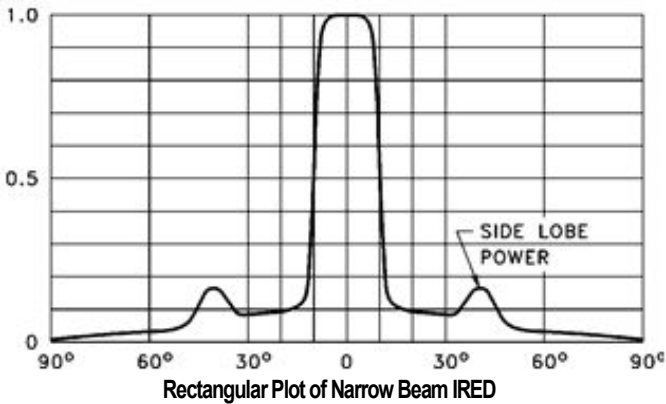

Narrow Angle IRED

3-D Representation of Emission Pattern of Narrow Beam IRED

Wide Angle IRED

Polar Plot of Narrow Beam IRED
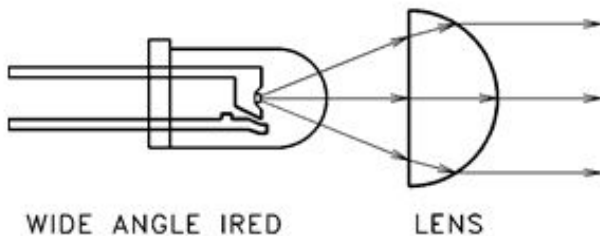
Application Notes

Rectangular Plot of Narrow Beam IRED
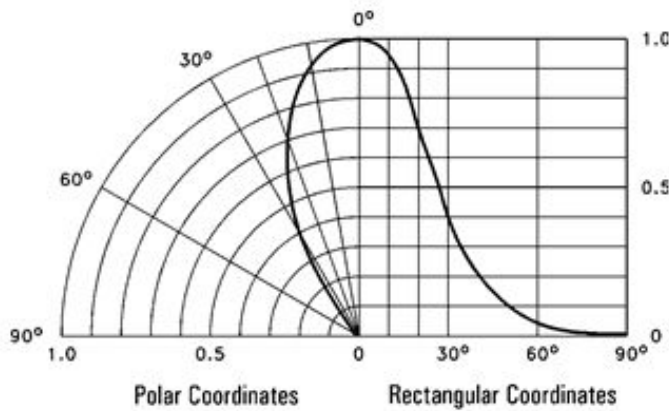
The side lobes have less peak intensity than the main beam (particularly when viewed in rectangular coordinates). However, the side lobes subtend a much larger solid angle than does the main beam. The net result is that in narrow beam IREDs, the side lobes can actually contain most of the power emitted by the narrow beam IRED. This side lobe power is lost to the main beam and is not useful in the optical system. Thus, the peak radiant intensity increases (mW/sr), but the useful main beam power decreases (mW/cm^2) as the beam width is made narrower.

MAIN BEAM HALF POWER ANGLE	APPROXIMATE FRACTION OF TOTAL POWER APPEARING IN SIDE LOBES
40 to 60*	NEGLIGIBLE
20*	10 to 20%
10*	20 to 30%
5*	40 to 60%

Applications that require maximum useful power and a narrow beam should use a wide angle LED coupled to an external lens to maximize the power coupled into the optical system.
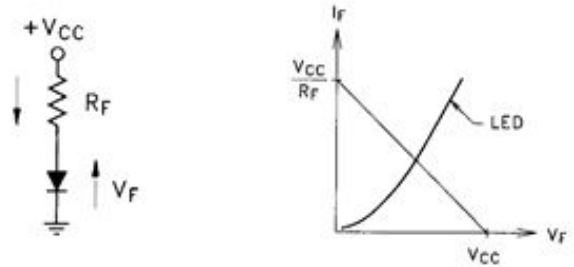

WIDE ANGLE IRED   LENS

APPLICATION NOTE #7
Biasing IREDs and Phototransistors

The light generated by an IRED is directly proportional to the forward current flowing through the device. Various biasing schemes can be used to set the value of the current. Some are illustrated below.

DC Bias

$$I_F = V_{CC} - V_F / R_F$$

$$R_F = V_{CC} - V_F / I_F$$

Example: Select R_F such that I_F = 20 mA for a GaAlAs IRED. V_{CC} = 5 V

From the data sheets:

$$V_{F\,(TYP)} @ I_F = 20\,mA: 1.25\,V$$
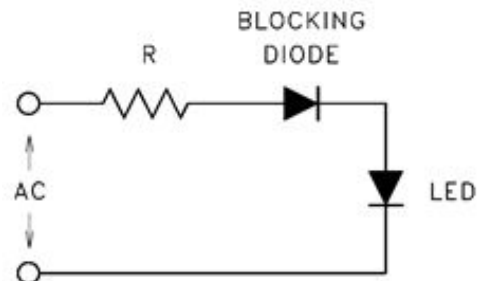
$$\therefore R = (5 - 1.25)\,V / 20\,mA = 187.5\,\Omega$$
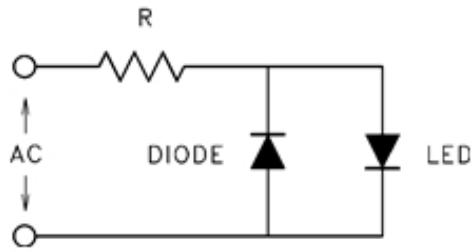
Closest standard resistor value = 180 Ω

$$\therefore I_{F\,(TYP)} = (5 - 1.25)/180 \cong 21\,mA$$ **AC**

Bias

When AC biasing an IRED, it is important to prevent the applied IRED voltage from exceeding the maximum rated reverse voltage to avoid damaging the IRED.

Application Notes

For circuit interfacing, phototransistors can be treated as any general purpose small signal transistor. The only exception being that phototransistors are driven by incident light rather than by an applied base current.

While capable of linear operation over a limited range of light intensities, phototransistors are normally used as a switch. As such, the designer is primarily concerned with the two boundary conditions; the equivalent "on" and "off" positions.
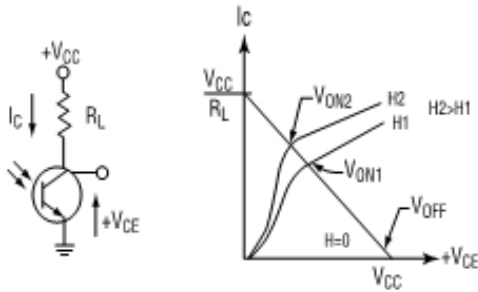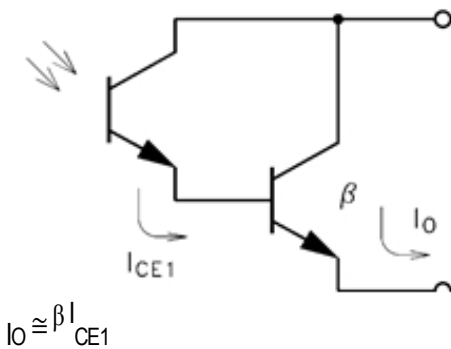

| Position	Ideal	Actual
"OFF" Position	V_{CC}	$(V_{CC} - R_L I_{DARK})$
"ON" Position	0	$V_{CE(SAT)}$

Note that $V_{CE(SAT)1} > V_{CE(SAT)2}$.

At times it may be necessary to extend the voltage or current capacity of the phototransistor.

Current capacity can be increased by using the phototransistor to drive a second transistor (Darlington arrangement).

$$I_O \cong \beta I_{CE1}$$

The following approach can be used to switch a voltage greater than the V_{BRCEO} of the phototransistor. The highest collectoremitter voltage seen by the phototransistor is the base-emitter voltage of the high voltage transistor.
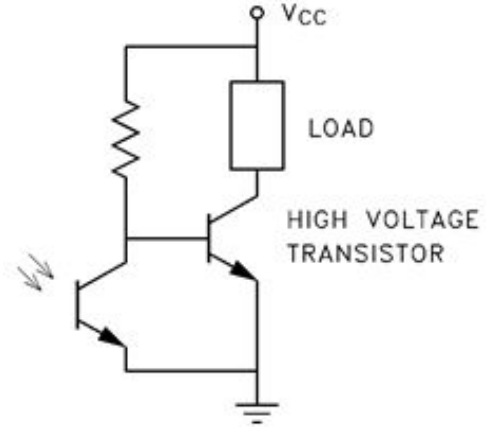
APPLICATION NOTE #8
Discrete Chips - An Alternative Solution to Space Problems

Space restrictions may preclude the use of packaged detectors or emitters in some applications. In these cases the use of discrete chips might be appropriate because of their small size. Excelitas offers IREDs and phototransistors in unpackaged die form—ready for hybrid assembly. Chips are supplied loose in vials, in waffle pack chip carriers, or as probed and inked wafers.

Conductive silver epoxy is commonly used for die attach. This method involves dispensing tightly controlled amounts of the epoxy either manually or with automatic equipment. The chip is placed on the epoxy which is then cured at moderate temperatures.

Connections are made to the metallized contact pads on the top surface of the chip by bonding very fine wires of aluminum or gold from these pads to the package. Typically, thermosonic ball or ultrasonic wedge wire bonding is used.

After wire bonding, the chip must be protected from the environment by either sealing it within an appropriate housing or by coating the chip with a clear epoxy or silicone designed for coating semiconductor die. This prevents moisture and contaminates from attacking the chip and wirebonds.

Excelitas offers assembly services for those customers who are not equipped for hybrid circuit manufacturing.

Application Notes

Detector Chips (Dice)

Excelitas's stock chips are 100% probed for dc current gain, dark current, collector & emitter breakdown voltages, and collector-emitter saturation voltage. Excelitas can also provide special testing to meet your custom requirements.

Emitter (E) and Base (B) aluminum metallized bond parts are provided on the top surface of every phototransistor and photodarlington chip. Some devices also have a collector bond pad on the top surface of the die. For all chips, contact to the collector can be made through the backside of the die, the entire surface of which is metallized with nickel.

Custom single and multichannel detectors can be tooled if stock devices are unable to meet the requirements of your application.

Emitter (IRED) Chips

Excelitas's stock IRED chips are sample probed for forward voltage at a given current drive, reverse leakage current, and power output. Light output cannot be measured for individual chips while they are in wafer form.

Anode contact is made through the backside (bottom) of the chip. Cathode contact is available through the bonding pad(s) on the top surface. A gold metallization system is employed on both the top and bottom surfaces.

Silver conductive epoxy is recommended for die attach. Thermosonic gold ball bonding is recommended for the top contact.

Special note on die attach epoxy "slop". Remember: all high efficiency output IR emitting dice have an electrically exposed P-N junction that appears on all four sides of the die. Conductive epoxy placed or "slopped" over the P-N junction can cause a total, partial, or even a time-varying electrical short circuit of the IRED die.
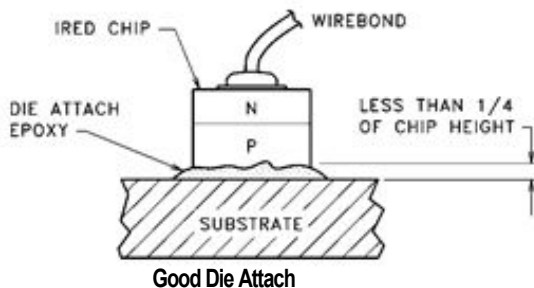
Good Die Attach
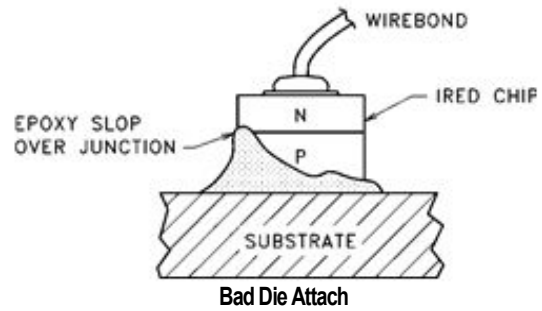
Bad Die Attach

Always use very small amounts of die attach epoxy. Keep the maximum epoxy height less than 1/4 of the height of the IRED chip.

APPLICATION NOTE #9
## 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 the familiar black plastic IC packages, clear opto epoxies have no fiberglass filler. Thus, they are not as strong as plastic IC packages. Care must by 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, producing open circuits.

In order to form leads safely, 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.

Application Notes

Examples of Tooling Fixtures Used to Form Leads
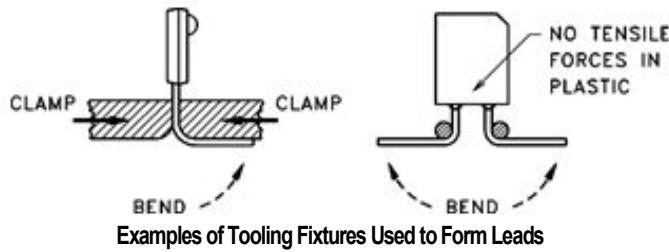
For highest reliability, avoid flush mounting the plastic body of the printed circuit board. This minimizes mechanical stresses set up between the circuit board and the plastic packages. it also reduces solder heat damage to the plastic package.

BAD   GOOD
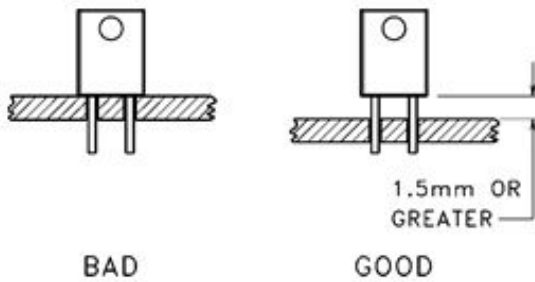
Good printed circuit board layout avoids putting spreading (plastic under tension) force of the leads of a plastic package.

BAD   GOOD
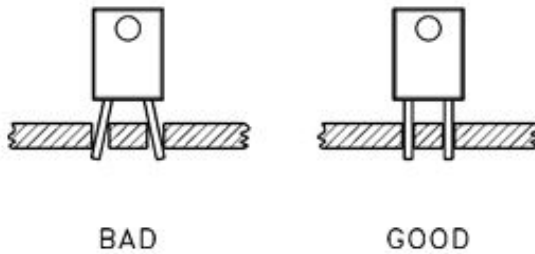
When hand soldering, it is important to limit the maximum temperature of the iron by controlling the power. It is best if a 15W or 25W iron is used. The maximum recommended lead soldering temperature (1/16" from the case for 5 seconds) is 260°C. An RMA rosin core solder is recommended.

Sn60 (60% tin/40% lead) solder is recommended for wave soldering opto components into printed circuit boards, other alternatives are Sn62 and Sn63. The maximum recommended soldering temperature is 260°C with a maximum duration of 5 seconds. The amount of tarnish on the leads determines the type of flux to use when soldering devices with silver plated leads

Condition of Leads	Recommended Flux
Clear Bright Finish (Tarnish Free) Dull	RMA - Mildly Activated
Finish (Minimal Tarnish)	RMA - Mildly Activated RA
Light Yellow Tint (Mild Tarnish)	- 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 to immersion time as short as possible (less than 2 seconds) and to immediately wash all devices thoroughly in ten rinses of deionized 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 of 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 # 10.

APPLICATION NOTE #10
Recommended Cleaning Agents

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

1. hermetically sealed glass/metal packages

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 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.

Application Notes

RECOMMENDED	NOT RECOMMENDED
ARKLONE A	ACETONE
ARKLONE K	CARBON TETRACHLORIDE
ARKLONE F	METHYL ETHYL KETONE
BLACO-TRON DE-15	METHYLENE CHLORIDE
BLACO-TRON DI-15	TRICHLOROETHYLENE (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 DA
ISOPROPYL ALCOHOL	GENESOLV DM
WATER	GENESOLV DMS

In many cases the devices 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.

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 short as possible.
2. The exact requirement of the cleaning process will vary from customer to customer and application to application.
3. Additives and concentrations will vary from supplier to supplier.

Because of these uncertainties, our recommendation is that all customers 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.