Note: External web links will work in this document. For your convenience, we've attached PDF files for all technical pages which are directly available on our web site.

LED Information and Technical Data

Links to technical data, text and schematics for the beginner and the experienced LED user. These links will help you determine what to purchase, how to work with the LED products, where are some of the resources, and to provide as much in depth technical knowledge as we can to those who require more than a passing knowledge of LEDs. These links were provided by your fellow visitors and customers. If you have a link or other information source to share, or find a dead link here, please email it to info@theledlight.com.

Energy Policy Reform - Residential Solar TAX CREDIT! Read what is involved and understand how you can obtain solar power and receive year end tax credit while lowering your energy consumption.

LED Basics
An introduction for the beginner

LED Application Notes
More basics, information about color, intensity, visibility, operating life, voltage, precautions when working with LEDs

Working with LEDs
Wiring diagrams, wire and battery sizing

Color Technical Data
Chromacity charts, backlighting, and so forth

Battery Technical Data
Battery sizes and capacities

Resistors
Which Resistor???

WebEE Primers
A collection of many pdf files to learn from

LED Application Documents
Another large collection of application notes.

The Light Measurement Handbook
What is light? How does light behave? Measurement geometries and so forth.

Lighting FAQ
What does "candela" mean? Footcandle to lux conversion, beam angle, lumens, and so forth

More Color Information
Fig. 10.1 - Relative eye sensitivity and efficacy measured in lumens per watt of optical power.
Fig. 10.2 - CIE chromaticity diagram. Monochromatic colors are located on the perimeter and white light is located in the center of the diagram

What are Lumens and Foot-Candles?

More Color Information
We'd like to thank the Energy Outlet of Eugene, Oregon, and their sponsors, Eugene Water and Electric Board, Emerald People's Utility District, and Blachly-Lane Electric Co-op, for permission to use following Color Temperature and Color Rendering Index (CRI) Chart. If you are from Oregon, or nearby, please stop by and visit the Energy Outlet Resource Center, or their website. They have good, useful information, products and resources that anyone, anywhere can utilize.

[The LED Light Online Catalog]

Working With LEDs

A Few Facts about LEDs

White LEDs can be placed in abusive environments.

White LEDs do not use gas to produce light and therefore have no delicate parts to break.

White LEDs can be AC or DC powered, or powered directly off of a solar panel.

White LEDs do not produce RF to interfere with radio equipment.

White LEDs last about 100,000 hours of continuous use (11 years).

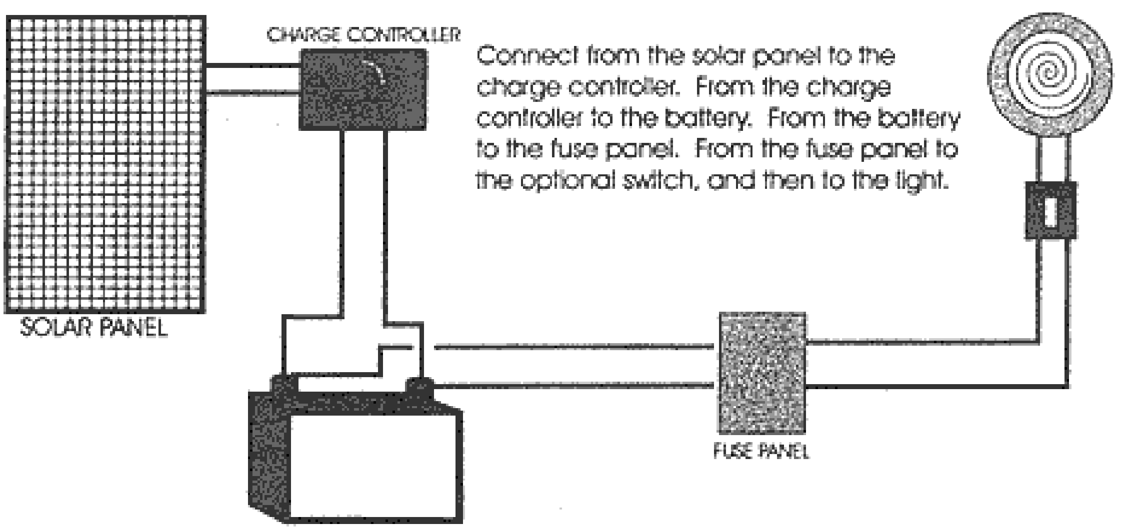
White LEDs (Light Emitting Diodes) produce almost no heat, nearly all of the energy used is converted to light.

White LEDs can be made completely waterproof for many marine applications.

White LEDs are polarity protected, so it is hard to make an installation mistake

Work/Installation Guidelines

Example: Connect from the solar panel to the charge controller. From the charge controller to the battery. From the battery to the fuse panel. From the fuse panel to the optional switch, and then to the light.



Below are basic instructions for making your own white LED light using our new LED. Figure 1 shows 4 white LEDs hooked in series using a current limiting resistor. The resistor gives protection to the LEDs from over voltage spikes. In Figure 2 we have a parallel connection of a single LED. If you are thinking of laying out a circuit, Figure 3 displays the symbol for a light emitting diode. The chart on Figure 4 will help you select the proper resistor of the proper voltage. Figures 5, 6, 7 and 8 present four different options of hooking up four LEDs in series.

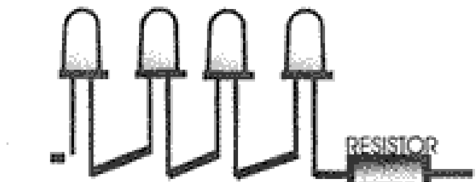


FIG.1

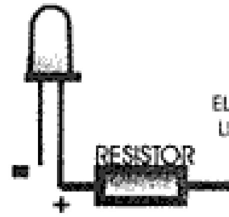


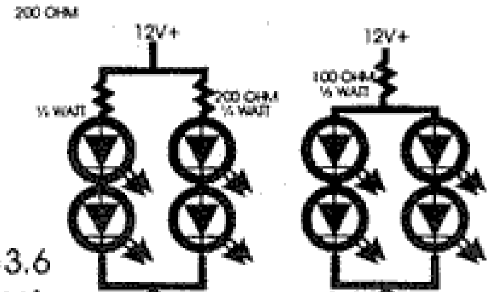
FIG.2

FIG.3

ELECTRONIC SYMBOL FOR A LIGHT EMITTING DIODE (LED)

DIRECT CURRENT VOLTAGE (DC)

FIG.4 NUMBER OF LEDs	12	24	36	48
1	330 OHM ½ WATT	820 OHM 1 WATT	1.3K 1 WATT	1.8K 2 WATT
2	200 OHM ¼ WATT	680 OHM ½ WATT	1.2K 1 WATT	1.6K 2 WATT
3	75 OHM ¼ WATT	560 OHM ½ WATT	1.0K 1 WATT	1.5K 1 WATT
4	N/A	390 OHM ½ WATT	910 ohm 1 WATT	1.3K 1 WATT



V led=3.6
I ≅ 25 MA
FIG.5
FIG.6

6 AND12 VDC WHITE LEDs OPTIONS

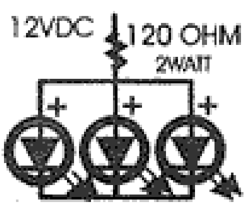


FIG.7

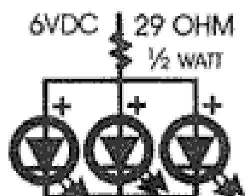
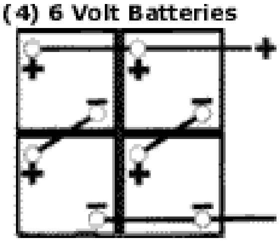


FIG.8

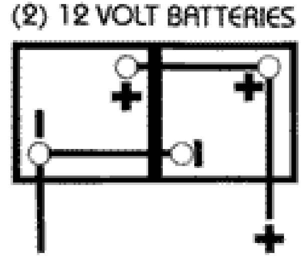
Battery and Wire Sizing Instructions

(4) 6 Volt Batteries



These are two of the most standard 12vdc battery installations. To the left there is a series-parallel battery. To the right is a standard 12v parallel hook up.

(2) 12 VOLT BATTERIES



WIRE SIZING

The following table contains a recommended wire size chart with minimum wire sizes for the system based on the amount of current capacity of different size wire. The information on the chart can be used to determine wire sizes between the array and the controller, the controller to the batteries and the batteries to the load. When the chart indicates a size between two wire sizes, always round up to the next size wire.

Note:
The wire from the controller to the battery should be as large and short as possible to reduce voltage drop between the controller and the battery. The controller senses batter voltage using these wires. Using too small or too long of a wire for this connection will cause voltage drops which will cause the regulator to oscillate in and out of charge.

The lengths in the table have already considered the factor of 2 for the distance in the hot and return wires.

WHAT SIZE (AWG) WIRE TO USE AND WHAT DISTANCE IT CAN RUN AT 12VDC

WIRE GAUGE	14 GA	12 GA	10 GA	8 GA	6 GA	4 GA	2 GA
1 AMP	112'	174'	274'	450'	710'	1000'	2000'
2 AMP	56'	86'	138'	224'	350'	576'	900'
4 AMP	25'	43'	68'	112'	176'	288'	450'
6 AMP	18'	30'	43'	75'	119'	188'	300'
8 AMP	14'	21'	36'	56'	88'	144'	225'
10 AMP	11'	17'	28'	45'	71'	112'	180'
15 AMP	8'	11'	17'	30'	48'	75'	120'
20 AMP		9'	14'	22'	36'	56'	90'
25 AMP		[illegible]	11'	17'	29'	45'	72'

BATTERY STATUS	% OF CHARGE
12.7	00%
12.4	75%
12.2	50%
12.0	25%
	0%

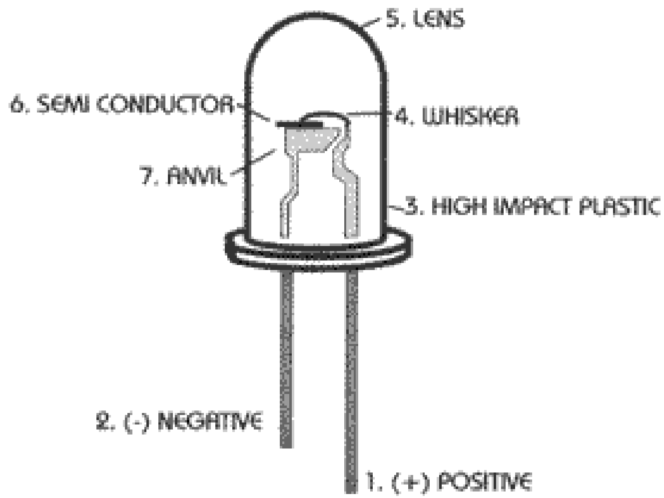
Disclaimer: The information provide herein are basics to educate one on the operating properties and user characteristics of LEDs. We do not imply that the information is accurate or applicable to every aspect of LED usage. Each application will have to be performed on its own merits and with full understanding that damages and injury are the sole responsibility of the "builder". We do not dispense engineering advice. You need to determine the specific products you will need for your specific application.

Application Notes

Eye Protection

LEDs are very bright. DO NOT look directly into the LED light!! The light can be intense enough to injure human eyes.

Basics On LEDs



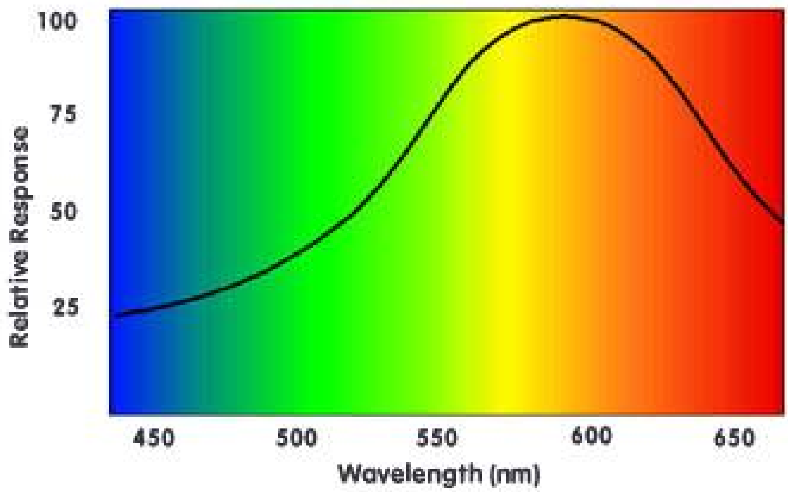
How does a LED work? This is a very simple explanation of the construction and function of LEDs. White LEDs need 3.6VDC and use approximately 30 milliamps of current, a power dissipation of 100 milliwatts. The positive power is applied to one side of the LED semiconductor through a lead (1 anode) and a whisker (4). The other side of the semiconductor is attached to the top of the anvil (7) that is the negative power lead (2 cathode). It is the chemical makeup of the LED semiconductor (6) that determines the color of the light the LED produces. The epoxy resin enclosure (3 and 5) has three functions. It is designed to allow the most light to escape from the semiconductor, it focuses the light (view angle), and it protects the LED semiconductor from the elements.

As you can see, the entire unit is totally embedded in epoxy. This is what make LEDs virtually indestructible. There are no loose or moving parts within the solid epoxy enclosure.

Therefore, a light-emitting diode (LED) is essentially a PN junction semiconductor diode that emits light when current is applied. By definition, it is a solid-state device that controls current without heated filaments and is therefore very reliable. LED performance is based on a few primary characteristics:

Color

LEDs are highly monochromatic, emitting a pure color in a narrow frequency range. The color emitted from an LED is identified by peak wavelength (lpk) and measured in nanometers (nm).



Peak wavelength is a function of the LED chip material. Although process variations are ±10 NM, the 565 to 600 NM wavelength spectral region is where the sensitivity level of the human eye is highest. Therefore, it is easier to perceive color variations in yellow and amber LEDs than other colors.

LEDs are made from gallium-based crystals that contain one or more additional materials such as phosphorous to produce a distinct color. Different LED chip technologies emit light in specific regions of the visible light spectrum and produce different intensity levels.

Comparison of chip technologies for wide-angle, non-diffused LEDs

LED Color	***Standard Brightness***				***High Brightness***			
	Chip Material	Ipk (NM)	Iv (mcd)	Viewing Angle	Chip Material	Ipk (NM)	Iv3 (mcd)	Viewing Angle
Red	GaAsP/GaP	635	120	35	AS AlInGaP	635	900	30
Orange	GaAsP/Gap	605	90	30	AS AlInGaP	609	1,300	30
Amber	GaAsP/Gap	583	100	35	AS AlInGaP	592	1,300	30
Yellow	Gap	570	160	30	--	--	--	--
Green	Gap	565	140	24	GaN	520	1,200	45
Turquoise	--	--	--	--	GaN	495	2,000	30
Blue	--	--	--	--	GaN	465	325	45

White Light

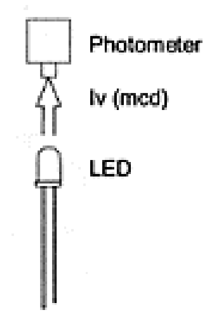
When light from all parts of the visible spectrum overlap one another, the additive mixture of colors appears white. However, the eye does not require a mixture of all the colors of the spectrum to perceive white light. Primary colors from the upper, middle, and lower parts of the spectrum (red, green, and blue), when combined, appear white. To achieve this combination with LEDs requires a sophisticated electro-optical design to control the blend and diffusion of colors. Variations in LED color and intensity further complicate this process.

Presently it is possible to produce white light with a single LED using a phosphor layer (Yttrium Aluminum Garnet) on the surface of a blue (Gallium Nitride) chip. Although this technology produces various hues, white LEDs may be appropriate to illuminate opaque lenses or backlight legends. However, using colored LEDs to illuminate similarly colored lenses produces better visibility and overall appearance.

Intensity

LED light output varies with the type of chip, encapsulation, efficiency of individual wafer lots and other variables. Several LED manufacturers use terms such as "super-bright," and "ultra-bright" to describe LED intensity. Such terminology is entirely subjective, as there is no industry standard for LED brightness.

The amount of light emitted from an LED is quantified by a single point, on-axis luminous intensity value (Iv). LED intensity is specified in terms of millicandela (mcd). This on-axis measurement is not comparable to mean spherical candlepower (MSCP) values used to quantify the light produced by incandescent lamps.



Luminous intensity is roughly proportional to the amount of current (If) supplied to the LED. The greater the current, the higher the intensity. Of course, there are design limits. Generally, LEDs are designed to operate at 20 milliamps (mA). However, operating current must be reduced relative to the amount of heat in the application. For example, 6-chip LEDs produce more heat than single-chip LEDs. 6-chip LEDs incorporate multiple wire bonds and junction points that are affected more by thermal stress than single-chip LEDs. Similarly, LEDs designed to operate at higher design voltages are subject to greater heat. LEDs are designed to provide long-life operation because of optimal design currents considering heat dissipation and other degradation factors.

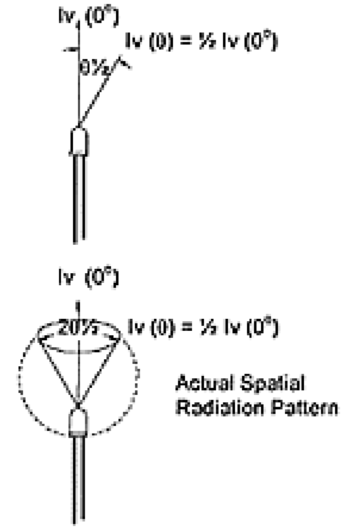
Eye Safety Information

The need to place eye safety labeling on LED products is dependent upon the product design and the application. Only a few LEDs produce sufficient intensity to require eye safety labeling. However, for eye safety, do not stare into the light beam of any LED at close range

Visibility

Luminous intensity (Iv) does not represent the total light output from an LED. Both the luminous intensity and the spatial radiation pattern (viewing angle) must be taken into account. If two LEDs have the same luminous intensity value, the lamp with the larger viewing angle will have the higher total light output.

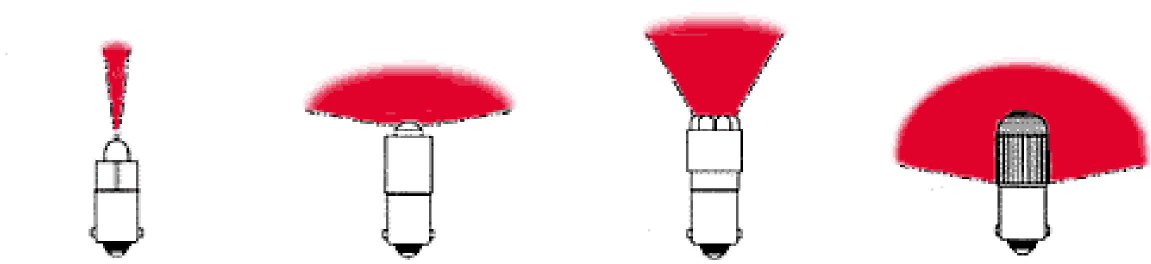
Theta one-half (q½) is the off-axis angle where the LED's luminous intensity is half the intensity at direct on-axis view. Two times q½ is the LEDs' full viewing angle; however, light emission is visible beyond the q½ point. Viewing angles listed in this catalog are identified by their full viewing angle (2q½ °).



LED viewing angle is a function of the LED chip type and the epoxy lens that distributes the light. The highest luminous intensity (mcd rating) does not equate to the highest visibility. The light output from an LED chip is very directional. A higher light output is achieved by concentrating the light in a tight beam. Generally, the higher the mcd rating, the narrower the viewing angle.

The shape of the encapsulation acts as a lens magnifying the light from the LED chip. Additionally, the tint of the encapsulation affects the LED's visibility. If the encapsulation is diffused, the light emitted by the chip is more dispersed throughout the encapsulation. If the encapsulation is non-diffused or water clear, the light is more intense, but has a narrower viewing angle. Non-diffused and water clear LEDs have identical viewing angles; the only difference is, water clear encapsulations do not have a tint to indicate color when the LED is not illuminated.

Overall visibility can be enhanced by increasing the number of LED chips in the encapsulation, increasing the number of individual LEDs, and utilizing secondary optics to distribute light. To illustrate, consider similar red GaAlAs LED chip technology in four different configurations:



Single-Chip LED (6,500 mcd, 6°) | 6-Chip LED (58 mcd, 160°) | 7-LED Cluster (7 LEDs × 80 mcd/30° each) | Lensed LED Cluster (3 LEDs × 340 mcd/45° each)

In each case, the amount of visible light depends on how the LED is being viewed. The single chip may be appropriate for direct viewing in competition with high ambient light. The 6-chip may be better suited to backlight a switch or small legend, while the cluster or lensed LED may be best to illuminate a pilot light or larger lens.

Operating Life

Because LEDs are solid-state devices they are not subject to catastrophic failure when operated within design parameters. DDP® LEDs are designed to operate upwards of 100,000 hours at 25°C ambient temperature. Operating life is characterized by the degradation of LED intensity over time. When the LED degrades to half of its original intensity after 100,000 hours it is at the end of its useful life although the LED will continue to operate as output diminishes. Unlike standard incandescent bulbs, DDP® LEDs resist shock and vibration and can be cycled on and off without excessive degradation.

Voltage/Design Current

LEDs are current-driven devices, not voltage driven. Although drive current and light output are directly related, exceeding the maximum current rating will produce excessive heat within the LED chip due to excessive power dissipation. The result will be reduced light output and reduced operating life.

LEDs that are designed to operate at a specific voltage contain a built-in current-limiting resistor. Additional circuitry may include a protection diode for AC operation or full-bridge rectifier for bipolar operation. The operating current for a particular voltage is designed to maintain LED reliability over its operating life.

Precautions While Working With LEDs

General

We cannot assume any responsibility for any accident or damage caused when the products are used beyond the maximum ratings specified herein.

The user of these products must confirm the performance of the LEDs after they are actually assembled into the user's products/systems. It is strongly advised that he user design fail-safe products/systems. We will not be responsible for legal matters which are caused by the malfunction of these products/systems.

LED Lamps

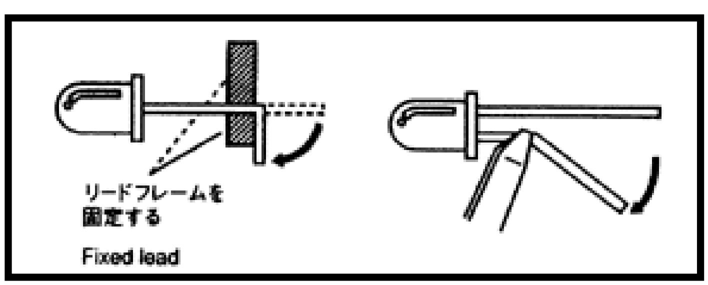
Static Electricity and Surge

Static electricity and surge damage LEDs. It is recommended to use a wrist band or anti-electrostatic glove when handling the LEDs. All devices, equipment and machinery must be electrically grounded.

Lead Forming

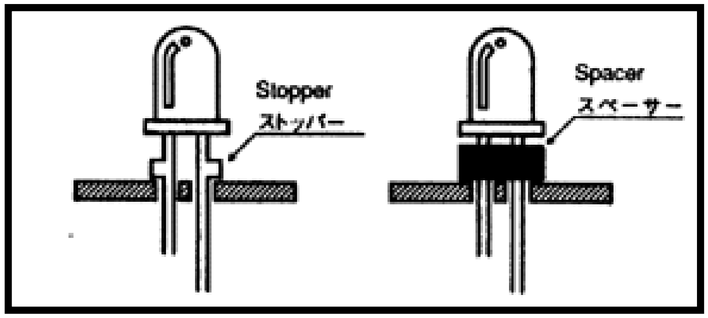
The leads should be bent at a point at least 3mm from the epoxy resin of the LEDs.

Bending should be performed with the base firmly fixed by means of a jig or radio pliers.



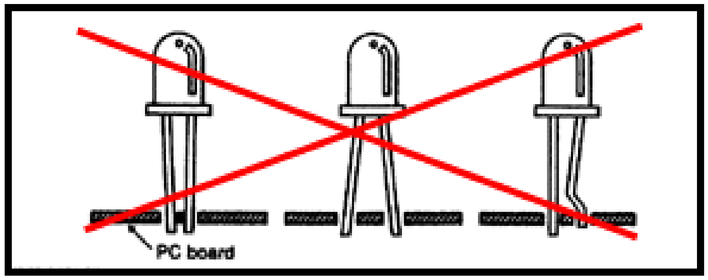
Mounting Method

The leads should be formed so they are aligned exactly with the holes on the PC board. This will eliminate any stress on the LEDs.



Use LEDs with stoppers or resin spacer to accurately position the LEDs. The epoxy resin base should not be touching the PC board when mounting the LEDs. Mechanical stress to the resin may be caused by the warping of the PC board when soldering.

The LEDs must not be designed into a product or system where the epoxy lens is pressed into a plastic or metal board. The lens part of the LED must not be glued onto plastic or metal. The mechanical stress to the leadframe must be minimized.



Soldering

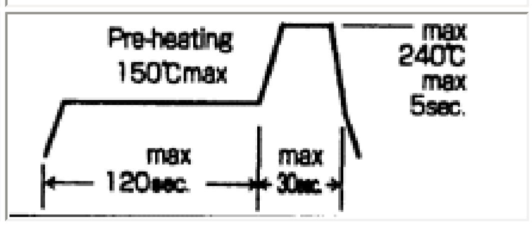
Solder the LEDs no closer than 3mm from the base of the epoxy resin.

For solder dipping, it may be necessary to fix the LEDs for correct positioning. When doing this, any mechanical stress to the LEDs must be avoided.

When soldering, do not apply any mechanical force to the leadframe while heating.

Repositioning after soldering must be avoided.

Soldering conditions:

	Soldering Iron	**Dip Soldering**	**Reflow Soldering**
Lamp LED	300degC(max), 3sec(max)	260degC(max), 5sec(max)	Not allowed.
Chip LED	300degC(max), 3sec(max) with Twin Head iron	Not allowed.	

Cleaning

Avoid exposure to chemicals as they may attack the LED surface and cause discoloration. When washing is required, "isopropyl alcohol" is to be used.

The influence of ultrasonic cleaning on the LEDs differs depending on factors such as oscillator output and the way in which the LEDs are mounted. Therefore, ultrasonic cleaning should only be performed after making certain that it will not cause any damage.

Emission color

LED emission wavelengths vary. LEDs are classified by emission color into different ranks. When a large volume of LEDs are purchased, LEDs with different color ranks will be delivered

Packaging

The leadframes of the LEDs are coated with silver. Care must be taken to maintain a clean storage atmosphere. If the LEDs are exposed to gases such as hydrogen sulfide, it may cause discoloration of the leadframes.

Moistureproof packing is used to keep moisture away from the chip type LEDs. When storing chip type LEDs, please use a sealable package with a moisture absorbent material inside.

LED Cluster Lamp and LED Dot Matrix Unit

Assembly

Please refer to the recommended distance between the leads when designing lead holes on the PC board.

Close attention must be paid on the correct positioning of O-rings and other water proof seals when assembling products/systems.

LEDs are vulnerable to static electricity. When handling the LEDs, necessary precautions regarding static electricity must always be taken into consideration.

Installation of LEDs

Make certain that the lead position and polarity are correct when installing the LEDs.

The interface cable must be as short as possible.

The power supply and ground line must be selected according to their current capacity.

Heat Dissipation

When many LEDs are mounted into a small area, heat generation must be taken into consideration. If there is a possibility that the ambient temperature may exceed 60 degrees centigrade, some kind of forced cooling system will be needed

The ambient operating temperature must be taken into consideration when a product/ system is being designed. There are certain limits to maximum current, at certain temperatures which must be kept in mind.

Handling

When the surface of the LEDs must be cleaned, the LEDs should be wiped softly with detergent. The surface may be damaged and the effect of the lens may be reduced with violent scrubbing.

Others

EMI countermeasures must be taken as a system.

When instantaneous power failure, or a current surge by lightning stops the controller at abnormal conditions, the abnormally high electric current may continue running through the LEDs for an extended period of time. This can damage the LEDs in the system. Circuit protection against abnormally high current must be built into the system to protect against this.

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Lumens, Illuminance, Foot-candles and bright shiny beads….

In defining how bright something is, we have two things to consider.

1. How bright it is at the source- How Bright is that light?
2. How much light is falling on something a certain distance away from the light.

Lets' do some definitions now……

We're in America, so we are going to talk about units of measurement that concern distance in feet and inches. So, we will use some terms that folks in Europe don't use. We're going to talk about "foot-candles".

This one's simple. Get a birthday cake candle. Get a ruler. Stick the candle on one end of the ruler. Light the candle. Turn out the lights. Sing Happy Birthday to Doc. It was his 47th on the 23rd. OK, quiet down. Enough of that nonsense. One foot-candle of light is the amount of light that birthday cake candle generates one foot away.

That's a neat unit of measurement. Why? Say you have a lamp. You are told it produces 100 foot candles of light. That means at one foot from the lamp, you will receive 100 foot candles of light.

But here's where it gets tricky. The further away you move the light from what you want to illuminate, the less bright the light seems! If you measure it at the light, it's just as bright. But when you measure at the object you want illuminated, there is less light! A Physics teacher is going to tell you that light measured on an object is INVERSELY PROPORTIONAL to the distance the object is from the light source. That's a very scientific and math rich way of saying, the closer you are to the light bulb, the brighter that bulb is. Or, think of it this way. You can't change how much light comes out of your light bulb. So, to make more light on an object, you have to either move the light closer, or add more lights.

Now, lets get to LUMENS.

A LUMEN is a unit of measurement of light. It measures light much the same way. Remember, a foot-candle is how bright the light is one foot away from the source. A lumen is a way of measuring how much light gets to what you want to light! A LUMEN is equal to one foot-candle falling on one square foot of area.

So, if we take your candle and ruler, lets place a book at the opposite end from the candle. We'd have a bit of a light up if we put the book right next to the candle, you know. If that book happens to be one foot by one foot, it's one square foot. Ok, got the math done there. Now, all the light falling on that book, one foot away from your candle equals both…….1 foot candle AND one LUMEN!

Ahh, we've confused you. Let's split off from this and talk about the difference between RADIANCE and ILLUMINANCE.

RADIANCE is another way of saying how much energy is released from that light source. Again, you measure it at the source. Unless you're talking about measuring the radiance of something intensely hot, like the Sun. Then you might want to measure it at night, when it's off.

ILLUMINANCE is what results from the use of light. You turn your flashlight on in a dark room, and you light something up. That's ILLUMINANCE. Turning on a light in a dark room to make the burglar visible gives you ILLUMINANCE. It also gives you another problem when you note the burglar is pointing your duck gun at your bellybutton.

Illuminance is the intensity or degree to which something is illuminated and is therefore not the amount of light produced by the lightsource. This is measured in foot-candles again! And when people talk about LUX, it's illuminance measured in metric units rather than English units of measure. To reinforce that, LUX is the measurement of actual light available at a given distance. A lux equals one lumen incident per square meter of illuminated surface area. They're measuring the same thing, just using different measurement units.

Pretend you're an old photographer, like O. Winston Link, or Ansel Adams. These two gods of black and white photography (and a print made by either can fetch quite a hefty sum of money these days) used a device called a light meter to help them judge their exposure. (There is another way of judging exposure-that's when someone whispers in our ear at a cocktail party, "You silly twit, your fly's come undone!").

These light meters were nifty devices. You could use it to show how much light was falling on an object, light from the sun, and reflected light energy from every thing else. Or you could use it to show how much light energy was reflected off the object itself.

All this brings back two points. Well, three.

The first point is if we measure the output of a light at the source that gives us one thing.

The second point is that we use an entirely different unit of measure if we are measuring the results of that light's output.

The third point is the instructor is right off his trolley, isn't he?

Now back to the book at the end of the ruler.

We've measured two different things. We have a unit of measure for how much light is produced. We Yankees express that as a foot-candle. Being lazy, we use it all over the place.

More Confusion! Candlepower!

Candlepower is a way of measuring how much light is produced by a light bulb, LED or by striking an arc in a Carbon-Arc spotlight. Is it a measure of how much light falls upon an object some distance away?

No. That's illuminance. Is it a measure of how well we see an object that is illuminated by that light source? No. That's something all together different, and we are not going there!

Nowadays we use the term CANDELA instead of candlepower. Candlepower, or CANDELA is a measure of how much light the bulb produces, measured at the bulb, rather than how much falls upon the thing you want to light up. Further confusing the matter is beam focus. That's how much candlepower can be focused using a reflector/lens assembly. Obviously, if you project all your light bulbs intensity at a given spot, or towards something, it will be more intense, and the illuminance will be higher.

And here comes the confuser! A candlepower as a unit of measure is not the same as a foot-candle. A candlepower is a measurement of the light at the source, not at the object you light up.

And a candela is the metric equivalent of the light output of that one candle, based on metric calculations. And since using a candle is rather imprecise, the definition was amended to replace a light source using carbon filaments with a very specific light source, see the following:
The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 x 1012 hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.

The above from the National Institute of Standards Reference on Constants, Units, and Uncertainty.

Candlepower is a measure of light taken at the source-not at the target. Foot-candles tell us how much of that light is directed at an object we want to illuminate.

Now, lets convert the lumens, a metric unit of light measurement, to candlepower.

We understand a candle radiates light equally in all directions, its output, in this consideration is not focused by any mechanical means (lenses or reflectors). Pretend for a moment that a transparent sphere one meter in radius surrounds your candle. We know that there are 12.57 square meters of surface area in such a sphere. Remember your Solid Geometry classes?

That one candle (1 Candlepower/Candela) is illuminating equally the entire surface of that sphere. The amount of light energy then reflected from that surface is defined thusly:

The amount of energy emanating from one square meter of surface is one lumen. And if we decrease the size of the sphere to one foot radius, we increase the reflected energy 12.57 times of that which fell on the square meter area.

LUX is an abbreviation for Lumens per square meter.
Foot-candles equal the amount of Lumens per square feet of area.

So, that one candlepower equivalent equals 12.57 lumens.

And for you figuring out LED equivalents, first you must know how many lumens your LED's each produce. Then divide that value by 12.57 and you have candlepower of the LED. You don't have foot-candles, remember foot-candles are illuminance. And we are measuring radiance.

Summing it all up:

Candlepower is a rating of light output at the source, using English measurements.
Foot-candles are a measurement of light at an illuminated object.
Lumens are a metric equivalent to foot-candles in that they are measured at an object you want to illuminate.
Divide the number of lumens you have produced, or are capable of producing, by 12.57 and you get the candlepower equivalent of that light source.

We've now converted a measurement taken some distance from the illuminated object, converted it from a metric standard to an English unit of measure, and further converted it from a measure of illumination to a measure of radiation!

This has been an ideal proof of the superiority of the metric system. Then again, the metric system is a product of those wonderful folks that brought us:

Renault, Peugeot, Citroen, and Airbusses. Not to mention simply awful Bordeaux.

And, if you're happy with this, send those little gems to:

Robert H (Doc) Bryant
3408 Thomas Ave
Midland, Texas 79703-6240

I hope you have enjoyed this as much as I have. You ought to see me up in front of a classroom. My classes are absolute laugh riots. But people learn!

Technical Information

L.E.D Basics

Most LEDs have their characteristics specified at a current of 20 mA. If you want really good reliability and you are not certain you don't have worse-than-average heat conductivity in your mounting, heat buildup in wherever you mount them, voltage/current variations, etc. then design for 15 milliamps.

Now for how to make 15 milliamps flow through the LED:

First you need to know the LED voltage drop. It is safe enough to assume 1.7 volts for non-high-brightness red, 1.9 volts for high-brightness, high-efficiency and low-current red, and 2 volts for orange and yellow, and 2.1 volts for green. Assume 3.4 volts for bright white, bright non-yellowish green, and most blue types. Assume 4.6 volts for 430 nM bright blue types such as Everbright and Radio Shack. Design for 12 milliamps for the 3.4 volt types and 10 milliamps for the 430 NM blue.

You can design for higher current if you are adventurous or you know you will have a good lack of heat buildup. In such a case, design for 25 ma for the types with voltage near 2 volts, 18 ma for the 3.4 volt types, and 15 ma for the 430 NM blue.

Meet or exceed the maximum rated current of the LED only under favorable conditions of lack of heat buildup. Some LED current ratings assume some really favorable test conditions - such as being surrounded by air no warmer than 25 degrees Celsius and some decent thermal conduction from where the leads are mounted. Running the LED at specified laboratory conditions used for maximum current rating will make it lose half its light output after rated life expectancy (20,000 to 100,000 hours) - optimistically! You can use somewhat higher currents if you heat-sink the leads and/or can tolerate much shorter life expectancy.

Next, know your supply voltage. It should be well above the LED voltage for reliable, stable LED operation. Use at least 3 volts for the lower voltage types, 4.5 volts for the 3.4 volt types, and 6 volts for the 430 NM blue.

The voltage in most cars is 14 volts while the alternator is successfully charging the battery. A well-charged 12 volt lead-acid battery is 12.6 volts with a light load discharging it. Many "wall wart" DC power supplies provide much higher voltage than specified if the load is light, so you need to measure them under a light load that draws maybe 10-20 milliamps.

Next step is to subtract the LED voltage from the supply voltage. This gives you the voltage that must be dropped by the dropping resistor. Example: 3.4 volt LED with a 6 volt supply voltage. Subtracting these gives 2.6 volts to be dropped by the dropping resistor.

The next step is to divide the dropped voltage by the LED current to get the value of the dropping resistor. If you divide volts by amps, you get the resistor value in ohms. If you divide volts by milliamps, you get the resistor value in kilo-ohms or k.

Example: 6 volt supply, 3.4 volt LED, 12 milliamps. Divide 2.6 by .012. This gives 217 ohms. The nearest standard resistor value is 220 ohms.

If you want to operate the 3.4 volt LED from a 6 volt power supply at the LED's "typical" current of 20 ma, then 2.6 divided by .02 yields a resistor value of 130 ohms. The next higher popular standard value is 150 ohms.

If you want to run a typical 3.4 volt LED from a 6 volt supply at its maximum rated current of 30 ma, then divide 2.6 by .03. This indicates 87 ohms. The next higher popular standard resistor value is 100 ohms. Please beware that I consider the 30 ma rating for 3.4-3.5 volt LEDs to be optimistic.

One more thing to do is to check the resistor wattage. Multiply the dropped voltage by the LED current to get the wattage being dissipated in the resistor. Example: 2.6 volts times .03 amp (30 milliamps) is .078 watt. For good reliability, I recommend not exceeding 60 percent of the wattage rating of the resistor. A 1/4 watt resistor can easily handle .078 watt. In case you need a more powerful resistor, there are 1/2 watt resistors widely available in the popular values.

You can put LEDs in series with only one resistor for the whole series string. Add up the voltages of all the LEDs in the series string. This should not exceed 80 percent of the supply voltage if you want good stability and predictable current consumption. The dropped voltage will then be the supply voltage minus the total voltage of the LEDs in the series string.

Do not put LEDs in parallel with each other. Although this usually works, it is not reliable. LEDs become more conductive as they warm up, which may lead to unstable current distribution through paralleled LEDs. LEDs in parallel need their own individual dropping resistors. Series strings can be paralleled if each string has its own dropping resistor.

Disclaimer: The information provide herein are basics to educate one on the operating properties and user characteristics of LEDs. We do not imply that the information is accurate or applicable to every aspect of LED usage. Each application will have to be performed on its own merits and with full understanding that damages and injury are the sole responsibility of the "builder". We do not dispense engineering advice. You need to determine the specific products you will need for your specific application.

Senate passed, Energy Policy Reform.

SEC. 25C. RESIDENTIAL SOLAR ENERGY PROPERTY.

(a) ALLOWANCE OF CREDIT- In the case of an individual, there shall be allowed as a credit against the tax imposed by this chapter for the taxable year an amount equal to the sum of--
(1) 15 percent of the qualified photovoltaic property expenditures made by the taxpayer during such year, and
(2) 15 percent of the qualified solar water heating property expenditures made by the taxpayer during the taxable year.

(b) LIMITATIONS-
(1) MAXIMUM CREDIT- The credit allowed under subsection (a) shall not exceed--
(A) $2,000 for each system of property described in subsection (c)(1), and
(B) $2,000 for each system of property described in subsection (c)(2).
(2) SAFETY CERTIFICATIONS- No credit shall be allowed under this section for an item of property unless--
(A) in the case of solar water heating equipment, such equipment is certified for performance and safety by the non-profit Solar Rating Certification Corporation or a comparable entity endorsed by the government of the State in which such property is installed, and
(B) in the case of a photovoltaic system, such system meets appropriate fire and electric code requirements.
(3) LIMITATION BASED ON AMOUNT OF TAX- The credit allowed under subsection (a) for the taxable year shall not exceed the excess of--
(A) the sum of the regular tax liability (as defined in section 26(b)) plus the tax imposed by section 55, over
(B) the sum of the credits allowable under this subpart (other than this section and sections 23, 25D, and 25E) and section 27 for the taxable year.

(c) DEFINITIONS- For purposes of this section--
(1) QUALIFIED SOLAR WATER HEATING PROPERTY EXPENDITURE- The term `qualified solar water heating property expenditure' means an expenditure for property to heat water for use in a dwelling unit located in the United States and used as a residence if at least half of the energy used by such property for such purpose is derived from the sun.
(2) QUALIFIED PHOTOVOLTAIC PROPERTY EXPENDITURE-
The term `qualified photovoltaic property expenditure' means an expenditure for property that uses solar energy to generate electricity for use in a dwelling unit.

(3) SOLAR PANELS- No expenditure relating to a solar panel or other property installed as a roof (or portion thereof) shall fail to be treated as property described in paragraph (1) or (2) solely because it constitutes a structural component of the structure on which it is installed.
(4) LABOR COSTS- Expenditures for labor costs properly allocable to the onsite preparation, assembly, or original installation of the property described in paragraph (1) or (2) and for piping or wiring to interconnect such property to the dwelling unit shall be taken into account for purposes of this section.
(5) SWIMMING POOLS, ETC., USED AS STORAGE MEDIUM-
Expenditures which are properly allocable to a swimming pool, hot tub, or any other energy storage medium which has a function other than the function of such storage shall not be taken into account for purposes of this section.

(d) SPECIAL RULES-
(1) DOLLAR AMOUNTS IN CASE OF JOINT OCCUPANCY- In the case of any dwelling unit which is jointly occupied and used during any calendar year as a residence by 2 or more individuals the following shall
apply:
(A) The amount of the credit allowable under subsection (a) by reason of expenditures (as the case may be) made during such calendar year by any of such individuals with respect to such dwelling unit shall be determined by treating all of such individuals as 1 taxpayer whose taxable year is such calendar year.
(B) There shall be allowable with respect to such expenditures to each of such individuals, a credit under subsection
(a) for the taxable year in which such calendar year ends in an amount which bears the same ratio to the amount determined under subparagraph (A) as the amount of such expenditures made by such individual during such calendar year bears to the aggregate of such expenditures made by all of such individuals during such calendar year.
(2) TENANT-STOCKHOLDER IN COOPERATIVE HOUSING CORPORATION- In the case of an individual who is a tenant-stockholder (as defined in section 216) in a cooperative housing corporation (as defined in such section), such individual shall be treated as having made his tenant-stockholder's proportionate share (as defined in section 216(b)(3)) of any expenditures of such corporation.
(3) CONDOMINIUMS-
(A) IN GENERAL- In the case of an individual who is a member of a condominium management association with respect to a condominium which he owns, such individual shall be treated as having made his proportionate share of any expenditures of such association.
(B) CONDOMINIUM MANAGEMENT ASSOCIATION- For purposes of this paragraph, the term `condominium management association' means an organization which meets the requirements of paragraph (1) of section 528(c) (other than subparagraph (E) thereof) with respect to a condominium project substantially all of the units of which are used as residences.
(4) ALLOCATION IN CERTAIN CASES- If less than 80 percent of the use of an item is for nonbusiness purposes, only that portion of the expenditures for such item which is properly allocable to use for nonbusiness purposes shall be taken into account.
(5) WHEN EXPENDITURE MADE; AMOUNT OF EXPENDITURE-
(A) IN GENERAL- Except as provided in subparagraph (B), an expenditure with respect to an item shall be treated as made when the original installation of the item is completed.
(B) EXPENDITURES PART OF BUILDING CONSTRUCTION- In the case of an expenditure in connection with the construction or reconstruction of a structure, such expenditure shall be treated as made when the original use of the constructed or reconstructed structure by the taxpayer begins.
(C) AMOUNT- The amount of any expenditure shall be the cost thereof.
(6) PROPERTY FINANCED BY SUBSIDIZED ENERGY FINANCING- For purposes of determining the amount of expenditures made by any individual with respect to any dwelling unit, there shall not be taken in to account expenditures which are made from subsidized energy

financing (as defined in section 48(a)(4)(A)).
(e) BASIS ADJUSTMENTS- For purposes of this subtitle, if a credit is allowed under this section for any expenditure with respect to any property, the increase in the basis of such property which would (but for this subsection) result from such expenditure shall be reduced by the amount of the credit so allowed.
(f) TERMINATION- The credit allowed under this section shall not apply to taxable years beginning after December 31, 2006 (December 31, 2008, with respect to qualified photovoltaic property expenditures).'.
(b) CONFORMING AMENDMENTS-
(1) Subsection (a) of section 1016 is amended by striking `and' at the end of paragraph (27), by striking the period at the end of paragraph (28) and inserting `, and', and by adding at the end the following new paragraph:
`(29) to the extent provided in section 25C(e), in the case of amounts with respect to which a credit has been allowed under section 25C.'.
(2) The table of sections for subpart A of part IV of subchapter A of chapter 1 is amended by inserting after the item relating to section 25B the following new item: `Sec. 25C. Residential solar energy property.'.
(c) EFFECTIVE DATE- The amendments made by this section shall apply to taxable years ending after December 31, 2001.

Technical Stuff for the Buffs

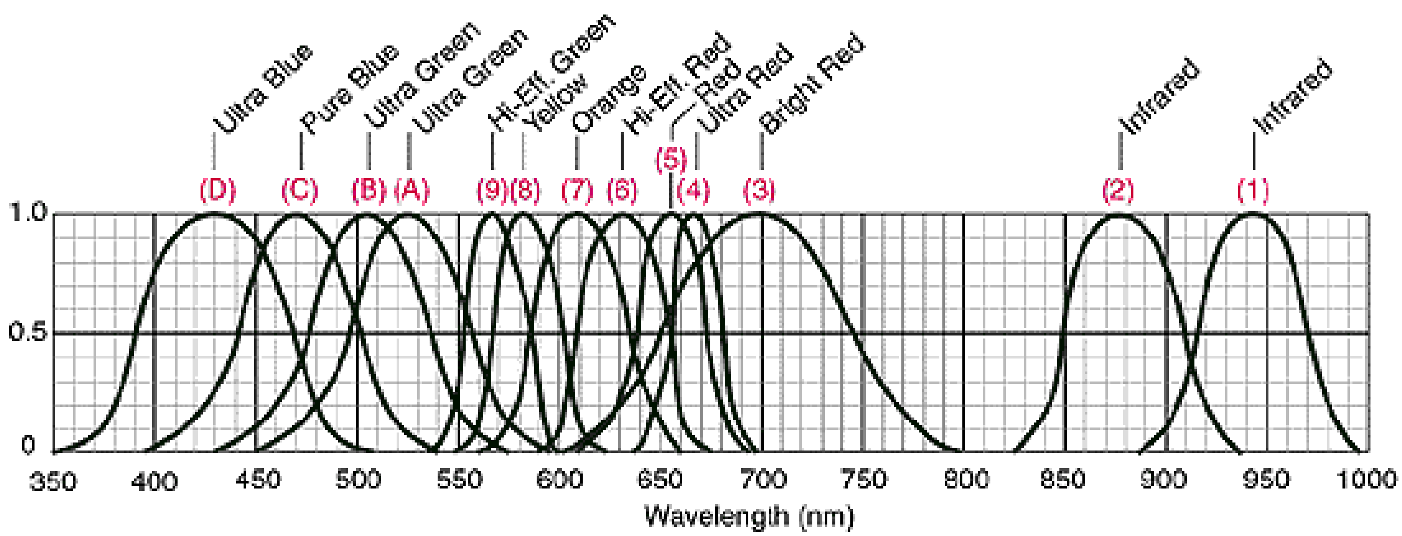
The LED color chart below does NOT represent what The LED Light carries. This chart is only to be used as reference for the various types of LEDs being manufactured today, and to show what their basic properties are.

LED Color Chart

	Wavelength (nm)	Color Name	Fwd Voltage (Vf @ 20ma)	Intensity 5mm LEDs	Viewing Angle	LED Dye Material
	940	Infrared	1.5	16mW @50mA	15°	GaAIAs/GaAs -- Gallium Aluminum Arsenide/Gallium Arsenide
	880	Infrared	1.7	18mW @50mA	15°	GaAIAs/GaAs -- Gallium Aluminum Arsenide/Gallium Arsenide
	850	Infrared	1.7	26mW @50mA	15°	GaAIAs/GaAs -- Gallium Aluminum Arsenide/Gallium Aluminum Arsenide
	660	Ultra Red	1.8	2000mcd @50mA	15°	GaAIAs/GaAs -- Gallium Aluminum Arsenide/Gallium Aluminum Arsenide
	635	High Eff. Red	2.0	200mcd @20mA	15°	GaAsP/GaP - Gallium Arsenic Phosphide / Gallium Phosphide
	633	Super Red	2.2	3500mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	620	Super Orange	2.2	4500mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	612	Super Orange	2.2	6500mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	605	Orange	2.1	160mcd @20mA	15°	GaAsP/GaP - Gallium Arsenic Phosphide / Gallium Phosphide
	595	Super Yellow	2.2	5500mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	592	Super Pure Yellow	2.1	7000mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	585	Yellow	2.1	100mcd @20mA	15°	GaAsP/GaP - Gallium Arsenic Phosphide / Gallium Phosphide
	4500K	"Incan-descent" White	3.6	2000mcd @20mA	20°	SiC/GaN -- Silicon Carbide/Gallium Nitride
	6500K	Pale White	3.6	4000mcd @20mA	20°	SiC/GaN -- Silicon Carbide/Gallium Nitride
	8000K	Cool White	3.6	6000mcd @20mA	20°	SiC/GaN - Silicon Carbide / Gallium Nitride
	574	Super Lime Yellow	2.4	1000mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	570	Super Lime Green	2.0	1000mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide

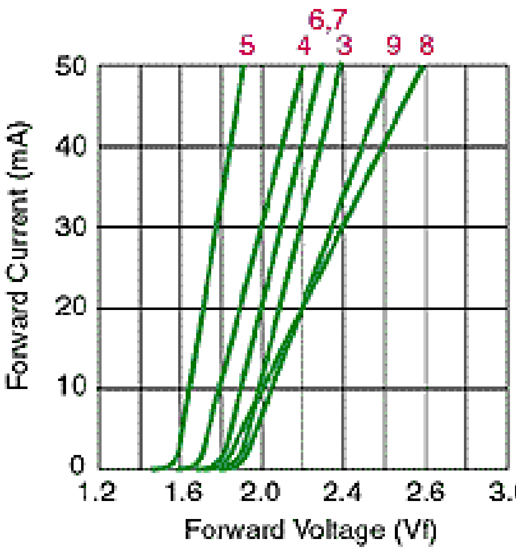
	565	High Efficiency Green	2.1	200mcd @20mA	15°	GaP/GaP - Gallium Phosphide/Gallium Phosphide
	560	Super Pure Green	2.1	350mcd @20mA	15°	InGaAIP - Indium Gallium Aluminum Phosphide
	555	Pure Green	2.1	80mcd @20mA	15°	GaP/GaP - Gallium Phosphide/ Gallium Phosphide
	525	Aqua Green	3.5	10,000mcd @20mA	15°	SiC/GaN - Silicon Carbide / Gallium Nitride
	505	Blue Green	3.5	2000mcd @20mA	45°	SiC/GaN - Silicon Carbide / Gallium Nitride
	470	Super Blue	3.6	3000mcd @20mA	15°	SiC/GaN - Silicon Carbide / Gallium Nitride
	430	Ultra Blue	3.8	100mcd @20mA	15°	SiC/GaN - Silicon Carbide / Gallium Nitride

Relative Intensity vs Wavelength (P)



Forward Current vs Forward Voltage

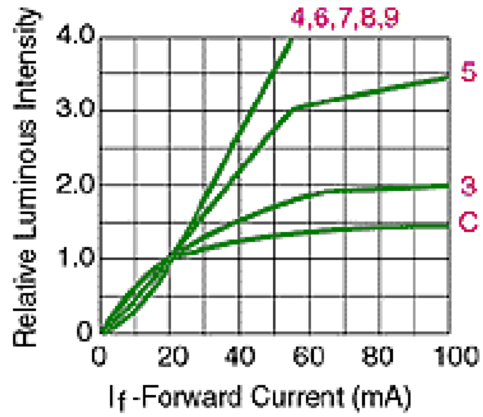
Red 5, Ultra Red 4, HE Red 6, Orange 7, Bright Red 3, HE Green 9, Yellow 8



Relative Luminous Intensity vs Forward Current

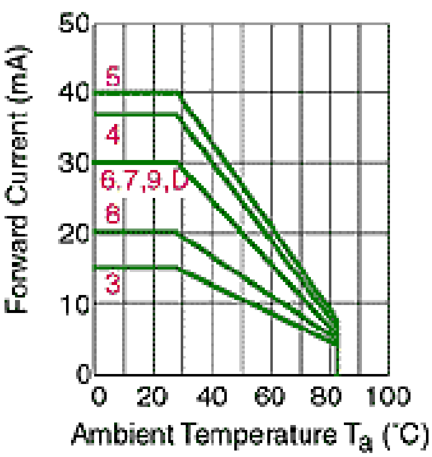
Ultra Red 4, HE Red 6, Orange 7, Yellow 8, HE Green 9

Red 5, Bright Red 3, Pure Blue C



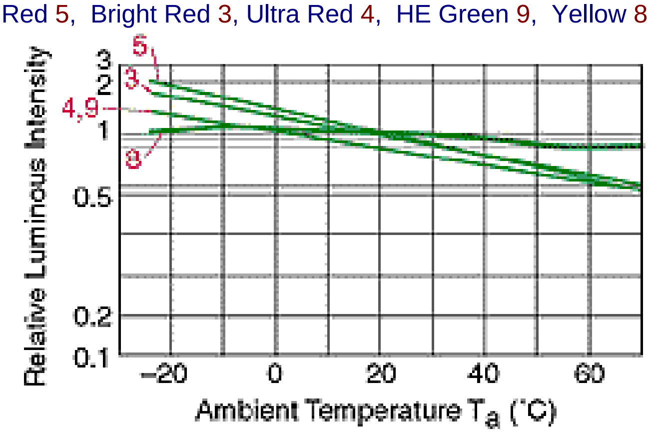
Forward Current vs Ambient Air Temperature

Red 5, Ultra Red 4, HE Red 6, Orange 7, HE Green 9, Ultra Blue D, Yellow 8, Bright Red 3



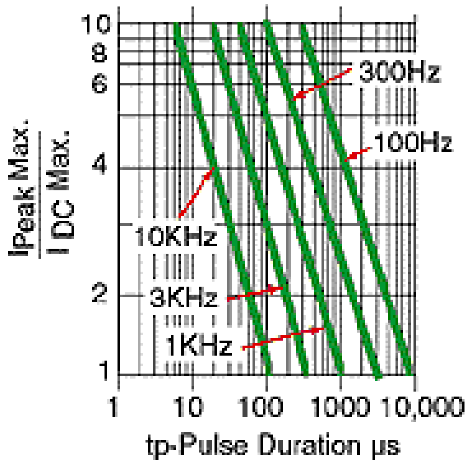
Relative Luminous Intensity vs Ambient Temperature

Red 5, Bright Red 3, Ultra Red 4, HE Green 9, Yellow 8



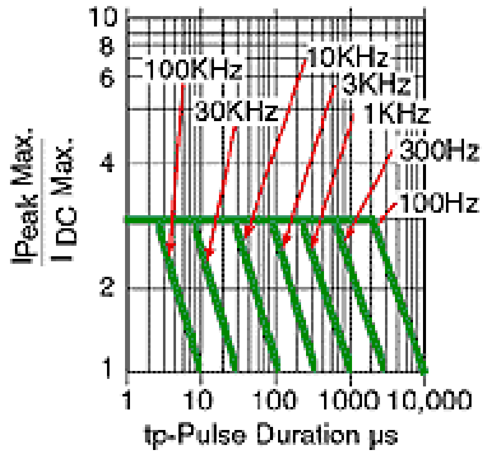
Maximum Tolerable Peak Current
vs Pulse Duration

Ultra Red, Red, HE Red, Orange, Yellow, HE Green,
Ultra Green (523nm), Ultra Green (502nm), Pure Blue, Ultra Blue



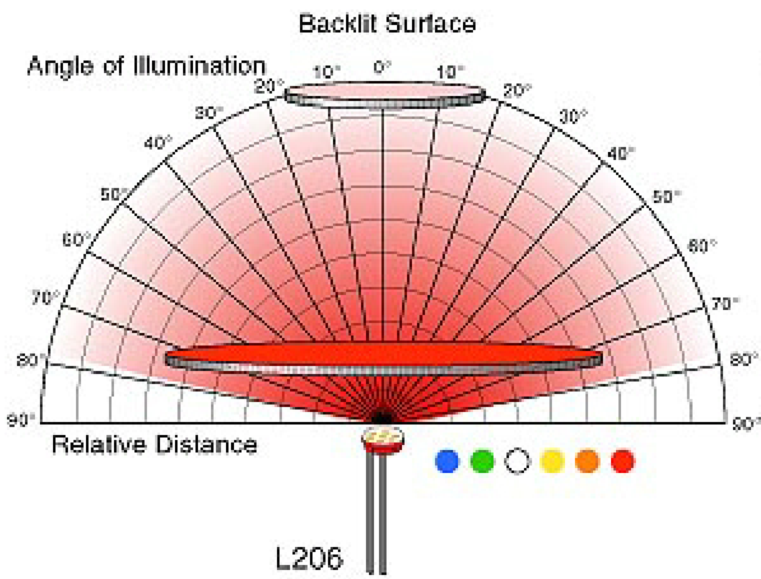
(4,5,6,7,8,9,A,C,J,K)

Bright Red

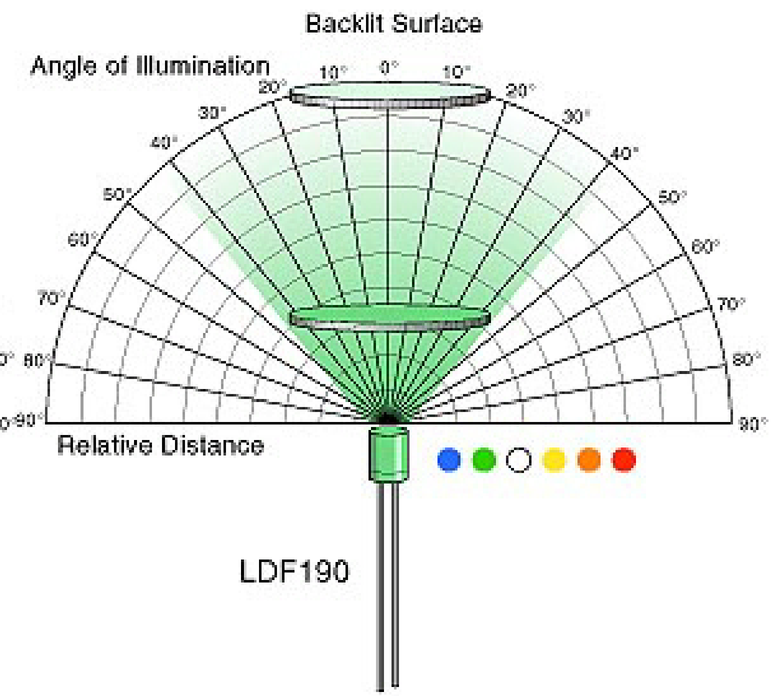


(3)

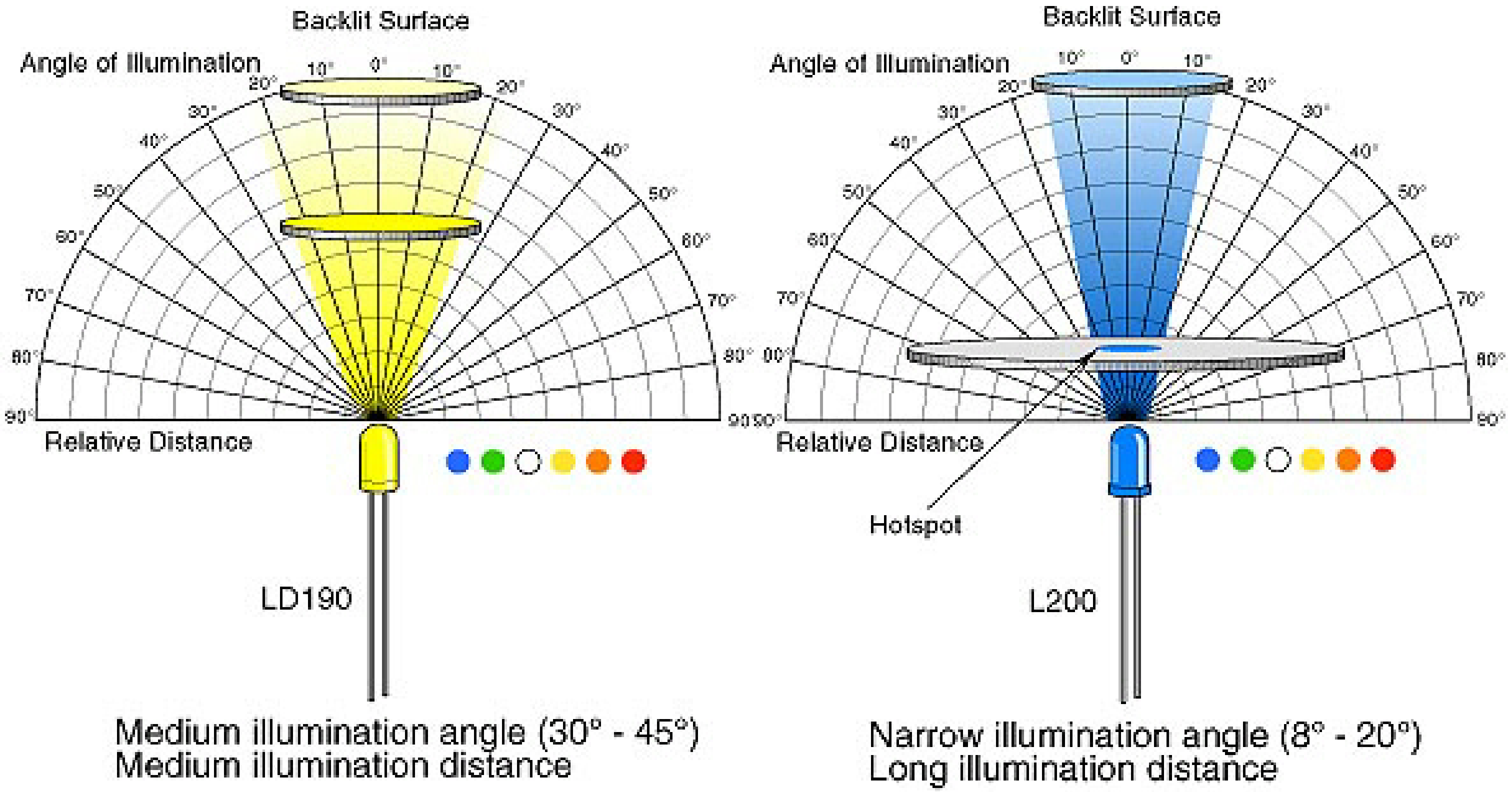
Backlighting Surfaces Using LEDs



Extra wide illumination angle (160°)
Very short illumination distance

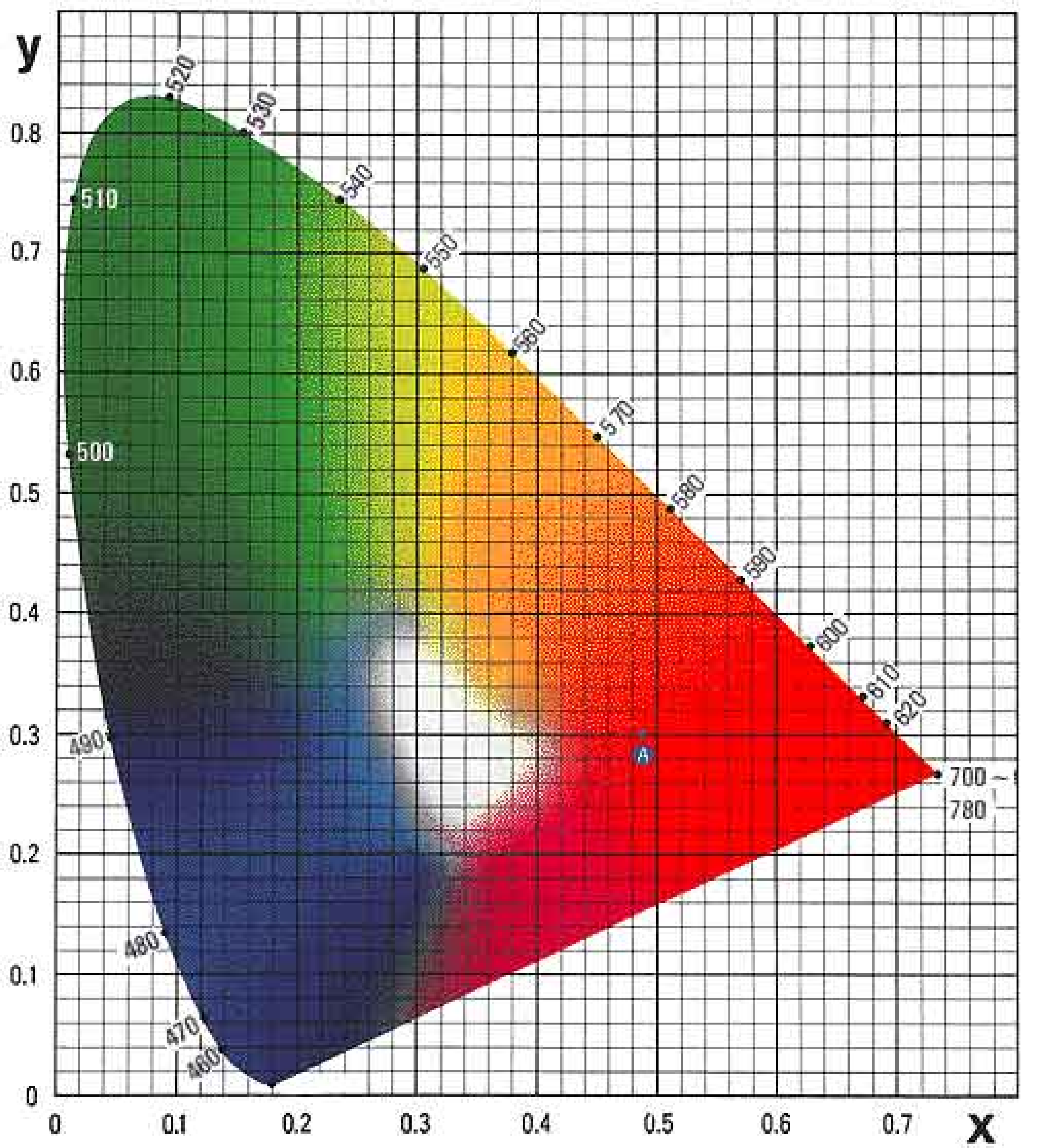


Wide illumination angle (120°)
Short illumination distance



Tables, Graphs and Images are through the courtesy of LEDtronics 07/10/00

Disclaimer: The information provide herein are basics to educate one on the operating properties and user characteristics of LEDs. We do not imply that the information is accurate or applicable to every aspect of LED usage. Each application will have to be performed on its own merits and with full understanding that damages and injury are the sole responsibility of the "builder". We do not dispense engineering advice. You need to determine the specific products you will need for your specific application.



y
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Note: The links on this PDF file will not work. This is just to give you an idea of the kinds of products we stock. Visit us on the web at www.TheLEDLight.com. Our web site is updated almost daily.

Online Catalog Customer Service Search Commercial Accounts Mailing List

The LED Light.com Online Catalog

The LED Light stocks white LED flashlights, White LED clusters/assemblies, discrete (loose) Light Emitting Diodes, 120vac LED bulbs, Solar Power Stations and Solar fans. We also stock LED desk and table lamps, LED ceiling and wall fixtures, White LED 12vdc replacement bulbs, LED lanterns, controllers, disconnects and light dimmers, and many more energy saving lighting products. We have a LED product to fit your personal needs, and for residential and commercial lighting applications.

General Information

What are Lumens and Foot-Candles? We are often asked to compare how bright are a number of LEDs against foot-candles and watts. We are not able to do that but a good friend of The LED Light has offered some explanations in the way he teaches his students. Fun and very educational.

Technical Information Get the Facts! Color spectrum graphs, CRI, LED types, which resistor to use, L.E.D. information and technical how-to.

Clusters, Arrays, Assemblies or Strings are names that refer to the same thing...a grouping of LEDs soldered to a circuit board with the appropriate resistor to operate it at the desired voltage. In the case of our products, they are all set up for 12vdc unless stated otherwise.

"LEDs DO NOT generate RF wavelengths or emit UV, Ultra-Violet light." Therefore, radio interference will not occur with the use of ANY product shown here. Furthermore, LEDs do not emit UV light so it will not readily attract bugs and other insects.

The Catalog

This IS The LED Light's product catalog and price list! Visitors are free to printout or download any of the pages on this website. We are not able to publish a printed catalog at this time as we add new products constantly.

LED - Light Emitting Diode Index in all colors including RGB and U-V diodes. *If an LED is NOT listed here, we do not handle it!* Printable data sheets are provided, and we strongly suggest that you print them out prior to ordering.

White LED

T1 3mm white, 25 degree, 3200mcd, clear lens
T1-3/4 5mm white, 20 degree, 6400mcd, clear lens
T1-3/4 5mm white 35 degree, 4500mcd, clear lens from Asia
T1-3/4 5mm white, 50 degree, 1800mcd, clear lens
T1 3mm white, 70 degree, 780mcd, milky lens
T1-3/4 5mm white, 70 degree, 480mcd, milky lens
T1-3/4 5mm Warm white, 20 degree, 2000mcd, clear lens

RGB LED

T1-3/4 RGB, 5mm Full Spectrum (Red, Green, Blue), milky lens

Blue, Green, Turquoise LED, clear lens

T1-3/4 5mm Blue, 15 degree, 3460mcd, clear lens
T1-3/4 5mm Blue, 15 degree, 1700mcd, clear lens from Asia
T1-3/4 5mm Green, 15 degree, 11,600mcd, clear lens
T1-3/4 5mm Turquoise (Blue-Green), 15 degree, 4300mcd, clear lens

Red, Yellow, Orange LED

T1-3/4 5mm Yellow, 8 degree, 8000mcd, clear lens
T1-3/4 5mm Red, 8 degree, 8000mcd, clear lens
T1-3/4 5mm Orange, 8 degree, 8000mcd, clear lens
T1-3/4 5mm Red-Orange, 8 degree, 8000mcd, clear lens
T1-3/4 5mm Red, 23 degree, 8300mcd, clear lens from Agilent, formerly Hewlett-Packard
T1-3/4 5mm Yellow, 30 degree, 2200mcd, clear lens
T1-3/4 5mm Red, 30 degree, 2200mcd, clear lens
T1-3/4 5mm Orange, 30 degree, 2200mcd, clear lens

Ultra-Violet LED

T1-3/4-110UV, 5mm Ultra-Violet, 100 degree 1000 microW, clear lens
T1-3/4-10UV, 5mm Ultra-Violet, 10 degree, 750 microW, clear lens

Luxeon Star LEDs

Clusters, Arrays and Assemblies from Do-It-Yourself DIY-3 3 LED clusters to DIY-36 36 LED clusters. We also have Flexible LED Boards, MicroStar LEDs and the Versalux 10 LED Module here.

LED Fixtures Index - are completely finished and ready for installation. We stock wall, ceiling, undercounter and soffit lights, or fixtures for use anywhere the imagination takes you. Most are available in 12vdc to 48vdc, and more than a few in 120vac.

Table and Desk Lamps

Interior Fixtures
Exterior Fixtures
Special Use Fixtures
Lanterns and Utility Lights

LED Flashlights! for general utility or special use such as Ultra-Violet Lights; Micro lights, small lights and BIG lights; special microprocessor controlled lights; colored lights for a variety of user applications; the BEST of the headlamps. Keep tuned to this category as it frequently changes!

"NEW" - eternaLight ELITE X-Rays!
"NEW" - INOVA X5 Flood Lights!

120vac Light Bulbs and Fixtures From the 3 LED AC-3 to an AC-144 bulb. We have Street Lights and BillBoard/Sign illimination fixtures, as well as other 120vac and a few DC products for the home, farm or commercial property.

Replacement Bulbs for flashlights; 12vdc models for vehicles, and other applications.

Safety and Security Equipment from traffic batons to flashers to emergency utility lamps. We have USCG Xenon Strobes, red LED safety flashers, boating navigation lights, and portable Power Stations.

Solar Powered Fans, from the 4 inch Outhouse type to our huge 16 inch Attic Vent Fans. These will run at 12vdc or 24vdc for the 12" and 16" models.

US Senate passed Energy Policy Reform!

Get the latest policy revision that affects those who have bought or are contemplating purchase of solar powered lights and fans for residential and condominium applications. If you have been delaying the purchase of either lights or fans to be solar powered, now is the time to do it. Check out the facts here: **Senate Passed Energy Policy Reform Sec 25C Residential Solar Energy Property.**

Solar Powered Lights that can be installed permamnently, semi-permanently or be portable. Use for sheds, barns, garages, as a portable emergency light, or for night security lighting. We also stock 12vdc Trickle Chargers for vehicles, boats, farm equipment and RVs.

Controls and Switches for our solar powered lights and fans, or LED arrays. We also stock 12vdc dimmer/on-off switches and AC to DC voltage step-down transformers.

Accessories from batteries to holsters. We have lanyards, clips, shields, lenses, boots, and the hard to buy batteries that fit the flashlights we sell.

Un-Solicited Testimonials from 'you'! These are unsolicited feedback we receive from customers who get to "experience the LED Light", the product line and our support and service.

What's New and "Coming Soon"! is our way of keeping you all up to date with new products and LED Technology offered at The LED Light. Bookmark this page for sure!

SPECIALS! are those rare occasions where we will discontinue a product. All new merchandise unless specifically stated otherwise.We also have customer returns, demos and damaged goods that are in good operable condition, many of which are almost brand new.

LEDs in model trains See how some of our customers are using LEDs as locomotive headlights and accessory lights.

If there is a specific question you have that has not been answered on this website, e-mail us at **info@theledlight.com**

There are more links to help you navigate this website in the yellow boxes with drop-down menus at the bottom of this and every page on the website.