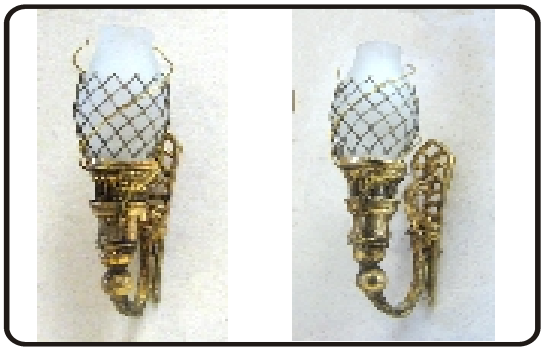
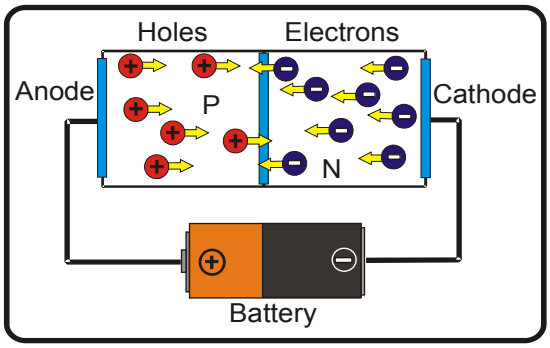
A BASIC UNDERSTANDING OF LED LIGHTING FOR MINIATURES



Why use LEDs for miniature lighting? There has been a growing interest in the use of LEDs (Light Emitting diodes) for lighting in miniatures. I feel that this interest will continue to expand and become more and more important in making miniatures. This is especially true in the smaller scales. I have used LEDs in chandeliers, ceiling lighting, sconces and on boards to light up baby houses.

One of the most desirable traits of LEDs for miniatures is that LEDs do not generate enough heat to get hot. There are no filaments in LEDs to glow and thus generate heat and light. And they are very durable. As a result, they are also very long lasting and they use very little electricity. They are lit by the movement of electrons in a semiconductor material. (For a good explanation of how diodes work, visit http://electronics.howstuffworks.com/led.htm). All I am going to say here is that the extra electrons in the N-type (negatively charged area) material have to move into the P-type (positively charged area. Thus it is important that for the electrons to flow, the electricity must be hooked up with the positive (+) connected to the positive end or anode and the negative (–) be attached to the negative end or cathode.

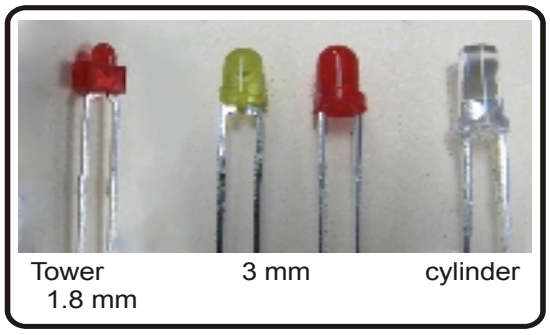


TYPES OF LEDS

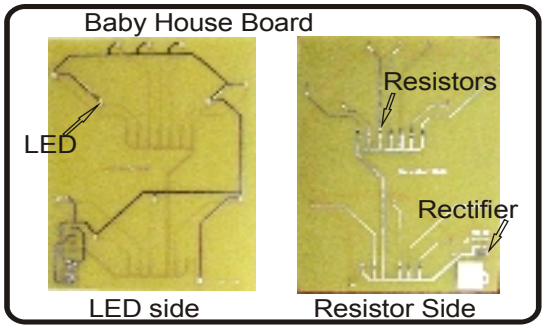
There are two types of LEDs I have used in miniature lighting. In the trade they are called “Thru-Hole” LEDs and “Surface Mount” LEDs. I will discuss each of them here and show how I have used them. For our purposes, you can choose LEDs by type, size, color, angle of light / width of beam of light, and intensity.

Thru-hole Leds

The Thru-hole LEDs are probably the most familiar to many of us. They are a bulb on the end of two wire legs. One of the wires is shorter than the other wire. This is very important. As I described above, the electrons flow through the LED and set them up to glow. If the LED is not oriented in the correct direction, the electrons do not line up, but push away from each other. To get the light, the electricity must enter them at the correct end and exit at the other end. The longer leg is the anode (positive) and the shorter leg is the cathode (negative).



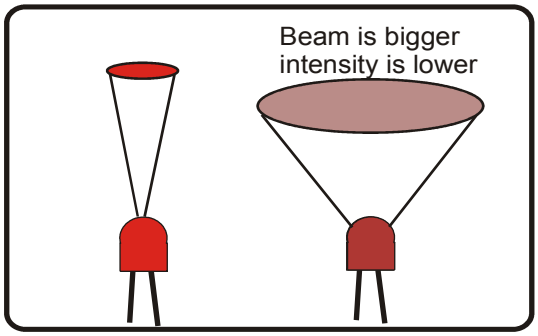
Thru-hole LEDs are customarily used with a circuit board with the traces or “wires” etched on to the board. The design of the circuit is etched onto the board and then the LEDs and the necessary components are put onto the board. I use this method to light the baby houses.



My first boards I purchased completely covered with copper. I then protected the lines I wanted on the copper and etched the rest of it off. After I perfected my design, I relegated the making of the boards to a company that makes circuit boards. I sent them a CAD design of where I wanted the lines, where the holes for the legs of the LEDs were to go, the size of the holes (to correspond with the size of the leg), resistors, junction box for the lead-in from the transformer, and the rectifier. Each company that makes circuit boards uses their own proprietary CAD program that you have use for your design. When the boards are returned to me, I then “populate” them. Each LED has its own “wire” or trace. The LEDs are soldered into the holes where they go on the LED side of the board. The resistor limits the current through the LED to avoid burning out the LED.

There are a number of **sizes** of LED lights. I have found that the “sub-mini tower” - 1.8mm and the miniature – T1 – 3mm size have worked best for me. I originally got the 1.8mm to fit in the smaller holes in the back wall of the baby house, but they have a collar around them that requires the same size hole as the 3mm – If you want them to stick through the hole in the baby house back. If this is not necessary and they do not have to stick through the thickness of the wood, then they can have a smaller hole. There are also larger ones such as standard – T1 ¾ – 5 mm and the 10mm size.

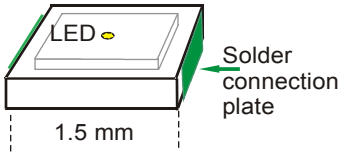
LEDs are available in several **colors** based on the length of the light wave. You will see them in red, orange, amber, yellow, green, blue and white. The color or wave length is indicated in nm (nano meters) – as a number such as 470nm (blue) to 630nm (red). The typical white is a harsh blue white. However they can be modified by the type of lens or coating that is incorporated into the surface of the LED. At this point, there is not an abundance of colored lenses over the white light LEDs, so I have used glass paints to modify the color. However, the more opaque your color or layers of paint become, the more dim the light becomes. You can also use lighting gels, or colored plastic in front of the light. Since the bulbs do not heat up, there is little danger of the color sheets burning or heating up. I experimented with many materials – even a plastic table cloth. The problem with a sheet of something was when I was putting the bulbs through the holes in the back of the baby house, the material would wrinkle and gather around the bulb, taking up more room in the hole. A better solution would be to put a flat sheet on the inside wall, but then that might interfere with the decorating of the room. While most of the LEDs come with a clear lens or water-clear lens, you can get diffused lighting, The diffused LED gives a wider angle of light, but it is less intense.



I have also altered the LEDs by sanding them to create a diffused light.

The intensity or brightness of the LED is usually rated in either mcd (milli candles per square foot) or lumens (milli candles per square meter). The basic thing you need to know here is that the higher the number the more the brightness or amount of light. The power consumption is usually around 20 mA (milli amps). The angle of the light beam also affects the intensity of the light. A very small angle will create a very intense pinpoint, while a wider beam spreads the light over a greater area, thus lowering the intensity of the light. For my purposes I try to have as large an angle beam as possible to give a more ambient light.

Surface Mount LEDs Surface mount LED's are tiny rectangles. One side has a tiny circle which is the LED. The ends or backs have markings showing you which end is the cathode and which is the anode The end of the resistor connects to the LED. The wires go to each of the other ends of the resistor and the LED.



This is a 0603 package Surface Mount LED


Strip of Surface Mount LEDs
These are smaller than the resistors shown next to the ruler. Size 0603. The LEDs are in the center of the black rectangles

The SMDs come in a number of sizes or “packages”. They are made for machine application, but I use them “by hand”. The sizes most often seen are: 0402, 0603, 0805, and 1206. I found that 0402 is too small to deal with by hand. (One sneeze and they are gone)! The 0805 package is a good size for small sconces. I usually use one size for the resistor.and the next smaller size for the LED - Thus there is less danger of them touching in the wrong places.

The colors are similar to Thru-holes, but there seems to be more availability for lens coating colors.

RESISTORS:

A resistor is needed for each LED to limit current through the LED to the correct amount for that particular LED. Each LED is made with a particular specification and cannot receive more current than specified or it will burn out. To find out the resistor needed for the LED and the original voltage coming in, we use a formula called Ohm's Law. So that if you know the watts and the current, you can divide the watts by the current squared to get the resistance needed. The formula is:

E= I x R E= Volts, R= Resistance or Ohms, I = Current or Amps

So for example:

Vf = forward voltage of the LED from the data sheet

A = typical current in mA (typically 10 to 30 mA)

Vs = supply voltage ex - 12V

Vd = a given – forward drop = 0.7 v (of rectifier diode)

R = Vs-Vd – Vf
A x 1000 example using a 12v transformer and a white LED → 4.0v

A = 30 mA

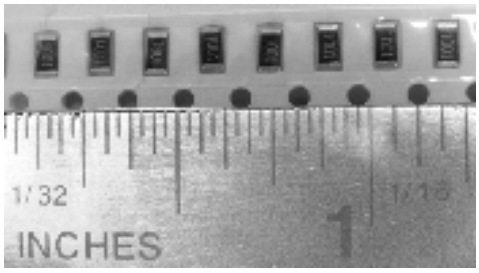
$R = \frac{12 - 0.7 - 4.0}{30} \times 1000 = \frac{7.3}{.03} = 243$ ohms

So for this LED, you would use a resistor with the closest standard value – such as a 240 ohm resistor. It is always safe to put more resistance on them rather than less, however this is not that less.There is a much greater jump to the next level up. Less than it calls for will allow too much current to flow through the LED and cause problems. If you wish to make the LED dimmer, you can add a greater value resistor. The resistor needs to be in series with the LED. It can be located on either side of the LED. LED and diode Anodes have to be closer to the power supply's positive rather than to the negative lead.

Axial Resistor

The resistors are rated for how much power they can handle. Typical power ratings are 1/8 watt or ¼ watt. To avoid burning out the resistor, the resistor must be rated for more wattage than the circuit needs. The resistor's power is calculated with another formula: P= E x I, where E is the voltage across the reistor = (E = Vs – Vd – Vf). I is the current through the resister, which is the same as the current through the LED. Using Ohm's law to replace I gives a more accurate calculation when the resistor selected is not exactly the value computed.. From this example, substituting a standard 270 ohm resistor $P = \frac{E^2}{R}$ - Thus - $P = \frac{(730)^2}{240 \text{ ohm}} = 222$ mw, so a ¼ watt (250mw) resistor is sufficient.

Resistors are also available as Thru-hole (Axial) or as Surface Mount. The Thru-hole resistors are small cylinders with the leads coming out of each end. The size of the resistor is indicated by the color rings around the cylinder. Surface Mounts are available in much the same package sizes as the LEDs. The number of ohms is printed on the top side of the resistor.



1 K ohms Surface Mount Resistors

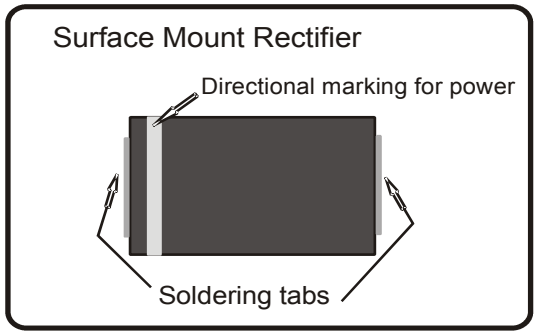
I use mostly the surface mount resistors – the thick film chip, ¼ watt. in size 1206 or 0805 package. I use them on the back side of the board where I mount my baby house Thru-hole LED's and also coupled with smd LEDs for sconces and other lighting.

RECTIFIERS:

Rectifiers are used to make sure that the current is flowing in the correct direction. However they should be used with transformers or any Alternating Current source. Although they are not absolutely necessary with a battery, since the battery delivers Direct Current, it is also a good idea for battery operated LEDs as the rectifier protects the LED against inadvertently connecting the battery backwards.

Axial Rectifiers

Like the LEDs and resistors, the Rectifiers can be Axial (Thru-hole) or Surface Mount. An Axial rectifier is a round cylinder with a leg coming out of each end. There is a marking on one end of the rectifier. A surface mount rectifier has the line on the top flat area., the Axial rectifier has the mark around the body at one end. The rectifier is placed on only one line of the power; either the positive or the negative line. If it is on the positive line, then the marking should be placed away from the power supply. If it is on the negative line, then the mark is placed toward the power supply.

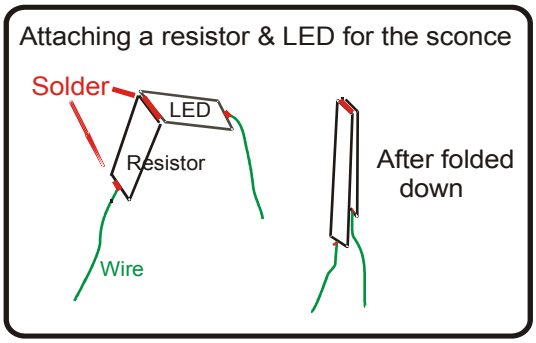


On my baby house boards, I have been using surface mounted "Fast Recovery 1A 50V" rectifiers. They are surface mounted on the lower right hand side of the board just above where the lead-in from the transformer comes in. If you are putting the rectifier in a doll house or room box circuit, using wiring or tape wiring, then the Axial rectifiers are better to use. Usually, only one rectifier is needed for our projects. One rectifier will work for about 75 LEDs. I solder a piece of wire to each leg. This wire makes it easier to attach the rectifier to either the wires or to the tape-wire. In either case, I use a bit of solder to secure the joint and then insulate it.

Other considerations:

Connections must be soldered for permanence and good performance. Use a small size solder.

To solder smds together, I put a strip of double stick tape down on my desk and lay the smds on it. I first solder the wires to the one end of each of the resistor and LED. Then I place them on the tape so that the two ends without wire are next to each other and solder them. If they are going to fit into a very small space, then I place and solder them so that they are back to back without the wired ends touching. To ensure this distance, I usually use two different sizes of SMD. After the soldering is done, I insulate it with clear nail polish as a precaution against a short circuit.



Since the LEDs use very little electricity, you can use a small transformer size. A three watt transformer is adequate for a 12 LED baby house board. The lights themselves add up to 2.5 watts.

I have presented this information to show how I use LEDs and what has worked for me. The information on the characteristics and specifications is needed to have them work. Much of the end results have been a result of testing, and retesting and trying various components to get the results I want. There were also lots of questions to several electrical engineers (my children, Ray who first put the thought in my head and really convinced me that LEDs were a good answer to miniature lighting and Chuck who helped me with the CAD program to get the circuit boards made – (both of whom I have constantly called with questions). And I will have more as I am constantly trying new configurations and uses.

Baby House by LadyBug
LED Lighting by Acorns By Oak

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