The Magic of Lighting

By Daniel Dawdy

When I was but a mere lad back in the 60's, we had a large layout in the basement. OK, so it was Lionel, but it was very large, and had many accessories. One of my favorite memories is going down to the layout at night, turning on our two ZW transformers, and cranking up the lights and accessories. Out went the basement lights, and the magic began. By playing with the transformer controls, I could take those number 53 bulbs inside all the stations, buildings, and signals from romantic interlude to full blown supernova.

Remembering those days was something I wanted to recreate on my current layout. Almost every building I have ever built, scratch or kit, has had well thought out lighting inside. Hanging bulbs is only half the battle, there is also all that wiring to be run and hidden inside, and a way for it to get outside. Since I started working on buildings in the late 90's, super small LED's or SMD (surface-mount device) were just beginning to find their way into products that the company I worked for made. This was way too early for most hobbyists, so I went with the standard incandescent lighting back then. I started with 12 volt GOW and GOR (grain of wheat and grain of rice) sized bulbs. My thought was to run these at 10 volts or so for longer life. I also started to use 1.5 volt bulbs for inside buildings because of the softness they portrayed. My favorite was the Miniatronics Lamp Shade w/Bulb 1.5V. Although the package said it was HO, it was really just right for O. I used them mostly inside the buildings, while using the 12V on the outside. Now mixing 1.5 and 12 volt systems in the same building can be tricky (also very dumb), but I color coded the wires coming out so as to not make a costly mistake.

In the beginning stages of the layout build, I ran a 12 volt line around as well as a 1.5 volt line. The idea was to tap off what I needed anywhere on the layout. A few years ago I started thinking about LEDs. They were larger, at 5mm or 3mm in size, but then I also thought about longevity. Incandescent lights will burn out, someday. LEDs will also, but their someday will be long after I've burned out. Unfortunately, there was that really bright white color that LEDs put out. It just did not look right for my 1947 time period. So let's take a look at a few things, and figure out that we can do.

What's a Kelvin?

Light has a color temperature, and that's measured in Kelvin (K). High color temperatures of over 5000K are said to be cool color, and often have a blue tone to them. Whereas low color temperatures of 2,500 – 3,200 are said to be warm color, and have yellow or orange tones to them. One would guess that as the color temperature (degree Kelvin) rose, it would be considered higher, but it's just the opposite. It's the color temperature that used to cause our film pictures to look green under fluorescent lighting, and orange/yellow inside without flash. In the past, most LEDs have been cool or cold. If you are modeling current times, that bright white is just fine as a headlight in a SD70, but not so good in a steam or early diesel. That bright white also does not look good in building interiors if modeling an older setting. My layout is set in 1947, so the small light bulbs worked well and looked the part. With LED bulbs, there are usually two options of white color available, and they are normally referred to as warm white or cool white. Warm white is about 3000K, and cool white is between 5000-6000K. Now, we have newer and smaller LEDs, and we can buy them in a color range that suits our needs.

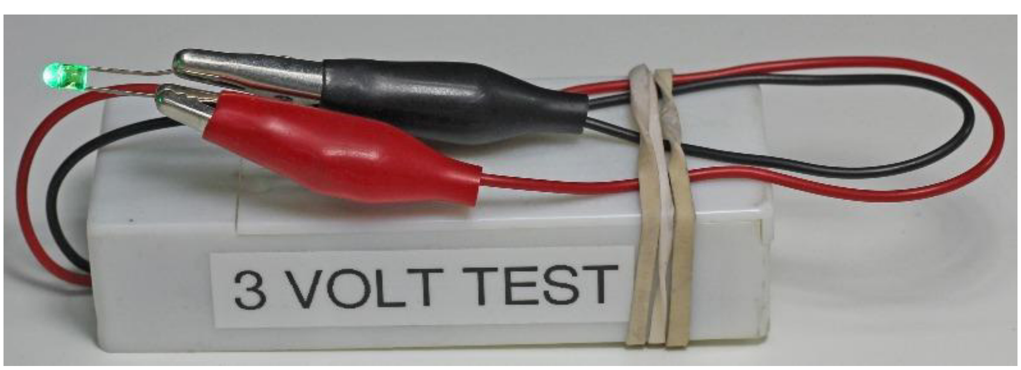
Temperature	Source
1,700 K	Match flame
1,850 K	Candle flame, sunset/sunrise
2,700–3,300 K	Incandescent lamps
3,000 K	Soft (or Warm) White compact fluorescent lamps
3,200 K	Studio lamps, photofloods, etc.
3,350 K	Studio "CP" light
4,100–4,150 K	Moonlight
5,000 K	Horizon daylight
5,000 K	Tubular fluorescent lamps or Cool white/daylight compact fluorescent lamps (CFL)
5,500–6,000 K	Vertical daylight, electronic flash
6,200 K	Xenon short-arc lamp
6,500 K	Daylight, overcast
5,500–10,500 K	LCD or CRT screen
15,000–27,000 K	Clear blue poleward sky

These temperatures are merely characteristic and considerable variation may be present.

How Do LEDs Work?

Without getting too complicated here, incandescent lights are voltage creatures; the higher the voltage, the brighter they become. LEDs are current creatures, and the current must be limited. That's where current limiting resistors comes in. It sounds complicated, but look at it this way: if I use 12 V incandescent bulbs, all my runs for lighting must be 12 V. I can't use a small plug-in transformer rated at 5 V or 7.5 V without affecting the light output for every bulb on the run. In my case, I had two wire runs under the layout, one at 12 V and one at 1.5V.

All LEDs have a forward voltage specification. That is the voltage that it turns on. On almost all the white LEDs I have worked with, the forward voltage is 3-3.2V. If you exceed that voltage, the internal resistance of the LED drops quickly causing the LED to draw more current. When that happens, it gets real bright, but for only a split second. So, what does this mean for us? Well, as long as your voltage run is greater than the the LED specification, it will work. You may need a current limiting resistor depending on the voltage. In other words, you can run an LED with 5 volts, as well as with 12 volts, but the resistor you use will be different. Hang on to that thought for now, and I'll come back that in Drawing 2. LEDs also have a Anode lead and a Cathode lead. The Anode is the positive (+) side, while the Cathode is the negative (-)



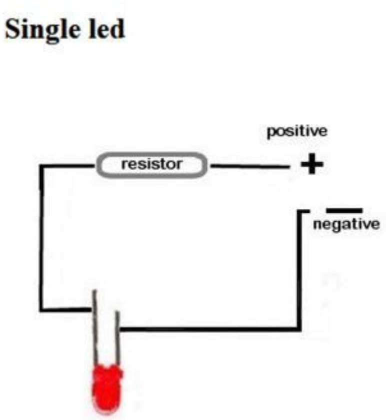
side. Larger LEDs, like the 5mm and 3mm, have a small flat spot marking the Cathode. On a SMD LED, the pad for the Cathode is rectangular, while the Anode is kind of a U shaped. The good news is if you hook one up the wrong way round, it will not light, but it won't damage anything.

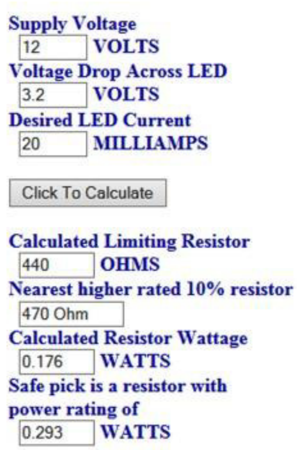
I have a battery box that came off an old Lemax light post. With two AA batteries, I can safely test the LED without the need for a resister, and be sure I know which side is Anode (positive) and which is the Cathode (negative).

Series Wiring and Figuring it Out

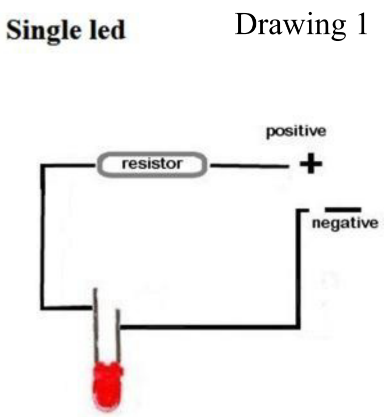
OK, now let's talk about the current limiting resistor, and how to figure it all out. I found the best Webpage for doing the calculation. And, what's even better, you can save the page to your own computer and use it anytime (see postscript). Go to http://www.quickar.com/noqbestledcalc.htm You will see three sections for doing your calculations: Single LED, LEDs in series, and LEDs in parallel.

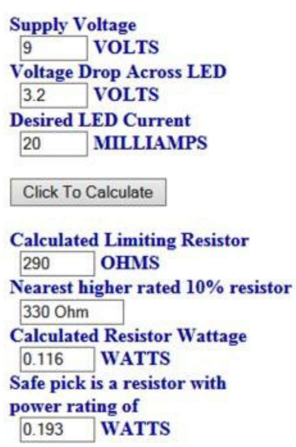
When using an LEDs, there are two specifications we must know. The first is Voltage Drop Across LED in volts. A typical white 3mm size has a forward voltage of 3.2-3.4V. The second thing we must know is the current rating in milliamps (mA). Our example is 20MA. The last piece of the puzzle is what voltage will you be using for this install? In my case, it's 12V, so we start plugging in numbers.





Drawing 1



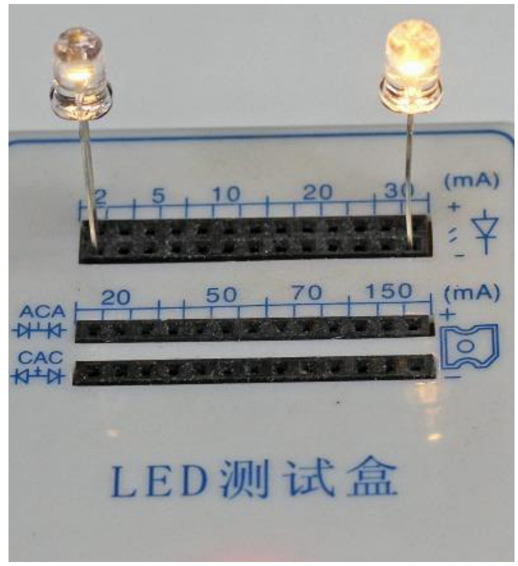


Drawing 2

Drawing 1 shows us that a 440 ohm, or closest commercial available resistor, will be 470 ohms, and we can probably use a ¼ watt without a problem. That will be easy to find at a local Radio Shack or online at such places as DigiKey.com and many others.

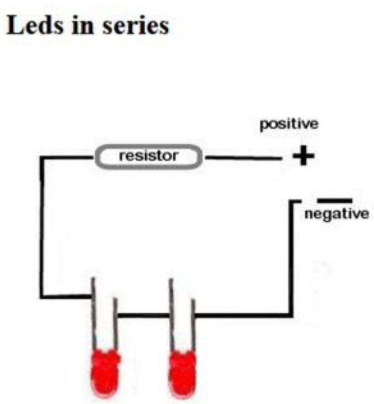
In Drawing 2, we changed the voltage to a 9 volt supply, and we now use a 330 ohm ¼ watt resistor. These calculations are based on giving us the most light output without damaging the LED. That may be way too much light for what you want to do. So, looking back at our 12V example, I may want this as a marker light on a locomotive. Those are nowhere near as bright as the headlight. Therefore, we can use a higher resistor rating. If we pick a 750 ohm resistor, our LED will be less bright. Try a 1000 Ohm (1K ohm), and it will be dimmer still. That is one of the great advantages of LEDs. Even on the same power supply, voltage can easily be varied to get the brightness you want. You can wire up a simple test bed for this using your known supply voltage, some small alligator clips, and an assortment of resistors. Clip the negative (-) side of the supply to the LED's Cathode, then clip the positive (+) side to a resistor, and then touch the resistor to the Anode. Too bright? Go to the next higher available resistor. That's kind of cumbersome, but does work. However, there is an easier way. Readily available for purchase is a 2-150 mA LED lamp tester box. If you do a search on "LED tester" you will find a bunch of them. The one I use was found on eBay for

$4.99 with a 9V battery and free shipping! What this allows you to do in simply plug in an LED to slots on the tester. The slots correspond to different milliamps. So, if the LED is too bright for your use and it's rated at 20 mA, plug it in a 10 mA slot and see if that is better. Now, doing it this way, we need to pull out Ohms law which states: R=V/I or resistance = voltage divided by current. 12/. 1 = 1200 ohms or 1.2K. Yes, we could have pulled out Ohm's law a while ago, but the Webpage I referred to is much cooler and easier to use!

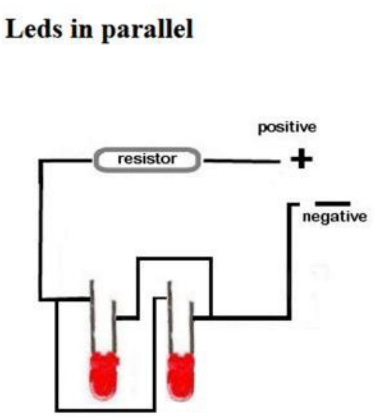


Same rated LED at 2mA and at 20mA

Back to the Webpage calculator we now have LEDs in series. It works the same way as before, but we can specify more than one LED in the circuit. Drawing 3 shows us with a 12 volt supply of 3.2 forward voltage LEDs and 20 mA using three LEDs, we need a 120 ohm resistor rated at ½ watt. For inside a building maybe three lamps is good enough and away you go. But, what if you wanted four LEDs?



Drawing 3



Drawing 4

Try that in the the calculator. Oh-O… no can do. With each LED using 3.2 forward voltage (3.2 x 4 = 12.8v) 12V will not be enough. OK, maybe in this example it will, but definitely not with 5 LEDs.

Welcome to Parallel Wiring

Parallel wiring takes care of our voltage problems. In my roundhouse (article header photo), I used .20 piano wire and ran it through the beams. Next I used flat topped LEDs, and simply soldered them to the wire. Six LEDs per run across the roundhouse. So, let's take a look at that circuit in drawing 4. To pull this off, I needed a 82 ohm resistor rated at least 1½ watts. That is one trade off of parallel, I can still use 12 volts, but I am creating a lot of power that needs to be dissipated as heat. To be safe, I used an 82 ohm 2 watt resistor from digikey.com.

I now also use a lot of SMD LEDs mainly due to their size. If the LED is less then 2 millimeters, it can be used in marker and class lights, as well as, in the cab and even firebox flicker. These are not as easy to use as the standard 3mm and other non SMD versions, but are definitely worth looking into. You can buy these all ready wired, but they are pricey. In the next issue, we'll look at how to use these, and how it's really not difficult to solder them yourself.

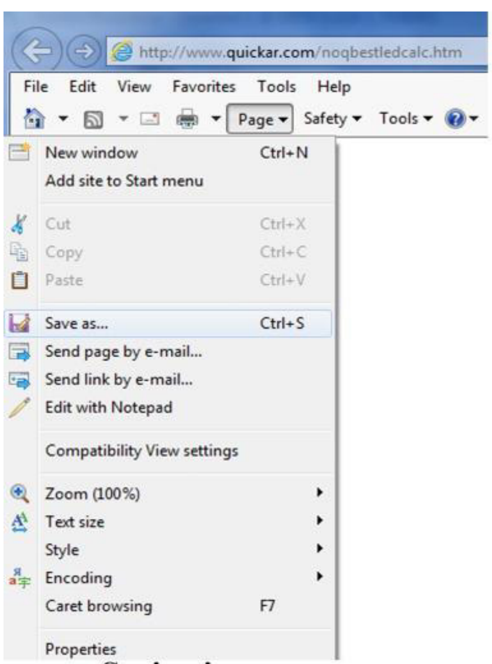
I still like bulbs for outside buildings because, well, they are bulbs. SMD LEDs don't have the glass look, and if you are using the old style gooseneck lamp, you want to see a glass bulb sticking out of it. Another problem with many LEDs is they are extremely directional, whereas an incandescent bulb will disperse light in all directions, LEDs tend to have a very narrow beam. For the roundhouse picture in the beginning of this article, I used flat top LEDs which have a much wider dispersion pattern. Of course, you pay for that in size, but in this situation, it worked.

We have many choices in lighting today. LEDs come in all shapes and sizes, as do good old incandescent bulbs. Sometimes, we can even use lighting from other scales. In the image to the left, the Walthers lamp in the small scratch built storage shed worked well, and I think it's too large for HO, but works well in O.

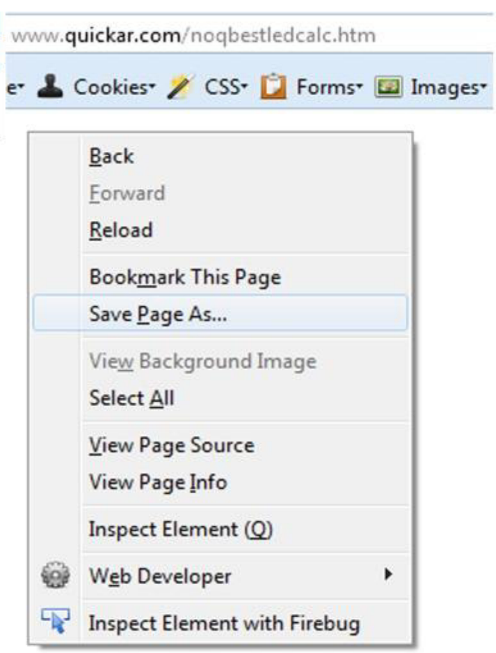
In the next issue, we'll get into some building lighting, and show just how easy (or not too hard) it can be.

Postscript:

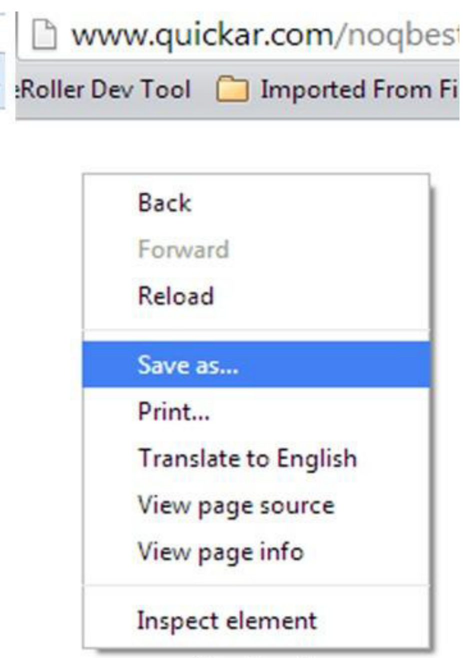
You can save many Web pages on your computer, and in the case of the LED calculation page, we used it, and it will still function. In Explorer, go to Tools / Save As. You will then will be prompted for a location to save the page called The Best Current Limiting Resistor Calculator for Led's.htm. Save that, and it will also create a new directory tied to that htm file called The Best Current Limiting Resistor Calculator for Led's_files. It's in that directory that the files to allow the page to function reside. Using Firefox, simply right click on any blank portion of the page, and select Save Page As. Using Chrome, right click and Save As. Now, this trick may not work on every Webpage, it depends on how they are coded.



Saving in Internet Explorer



Saving in Firefox

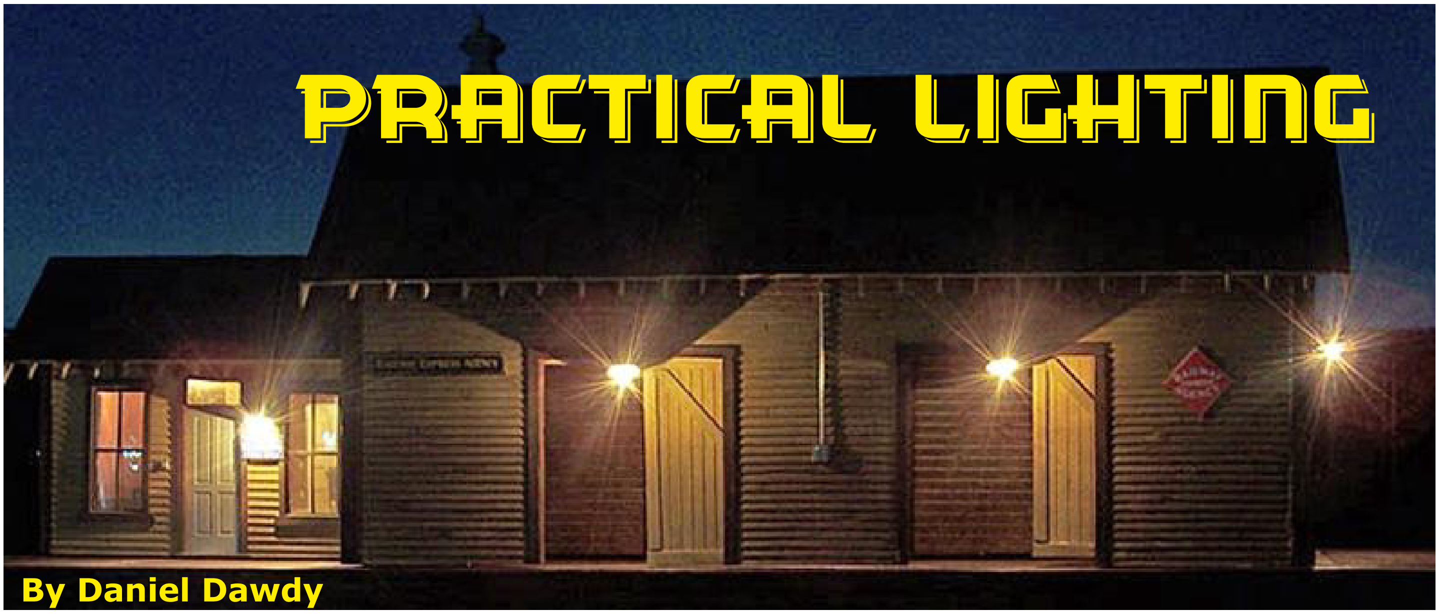


Saving in Chrome

Below is a list of common resisters. I normally use 5%, but 10% for what we are doing is just fine. You will notice that when the resistor calculator gives you a Calculated Limiting Resistor, it also shows the nearest higher rated 10% resistor that you may use. The chart shows these. Never go lower than what the resistor calculator or Ohm's Law calculates. The same goes for wattage. I try to err on the side of caution and safety, going with the higher recommendation.

SAFETY WARNING: These resistors do get hot, and using a lower rated wattage will get really hot and fail, or even worse, could generate enough heat to ignite their surroundings if enclosed in a wooden building or melt a plastic structure.

1	5.6	33	160	820	3.9K	20K	100K	510K	2.7M
1.1	6.2	36	180	910	4.3K	22K	110K	560K	3M
1.2	6.8	39	200	1K	4.7K	24K	120K	620K	3.3M
1.3	7.5	43	220	1.1K	5.1K	27K	130K	680K	3.6M
1.5	8.2	47	240	1.2K	5.6K	30K	150K	750K	3.9M
1.6	9.1	51	270	1.3K	6.2K	33K	160K	820K	4.3M
1.8	10	56	300	1.5K	6.6K	36K	180K	910K	4.7M
2	11	62	330	1.6K	7.5K	39K	200K	1M	5.1M
2.2	12	68	360	1.8K	8.2K	43K	220K	1.1M	5.6M
2.4	13	75	390	2K	9.1K	47K	240K	1.2M	6.2M
2.7	15	82	430	2.2K	10K	51K	270K	1.3M	6.8M
3	16	91	470	2.4K	11K	56K	300K	1.5M	7.5M
3.3	18	100	510	2.7K	12K	62K	330K	1.6M	8.2M
3.6	20	110	560	3K	13K	68K	360K	1.8M	9.1M
3.9	22	120	620	3.2K	15K	75K	390K	2M	10M
4.3	24	130	680	3.3K	16K	82K	430K	2.2M	15M
4.7	27	150	750	3.6K	18K	91K	470K	2.4M	22M



Practical Lighting

By Daniel Dawdy

In the previous issue of *The O Scale Resource* magazine, I talked about LED vs. incandescent lighting, as well as, how to work with LEDs. This time out, let's see some ways to wire these small SMD LEDs, as well as, wiring buildings.

To solder or not to solder…

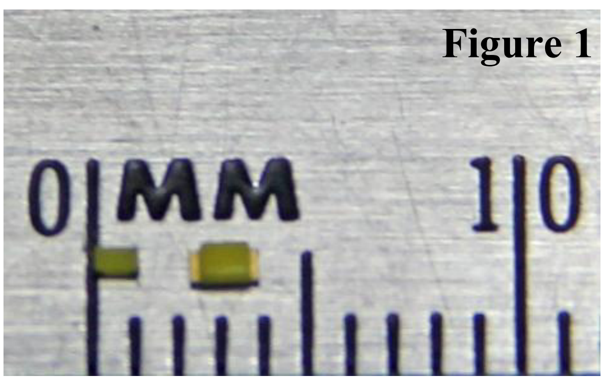


Figure 1

Soldering SMD LEDs can be a challenge. But, with some tips and your trusty Optivisor, it not very hard, and you can save a lot of money.

SMD LEDs are available in a few sizes. The two most common (and the ones I use) are the 0603 and 0402. You can see the size difference in Figure 1. You can buy them in bulk without lead wires very inexpensively, under $6.00 per hundred. Those already soldered with lead wires could cost as much as $5.00 per set. For that price difference, I'll do my own soldering.

I am a visual person. In other words, I have to see things being done in order to fully understand them. So, in the future when we have an article that I feel would benefit from a video, we'll create one. It will not replace the article, but will enhance the understanding of the article. In our first O Scale Resource Magazine Video Extra, I run through some tips I have found on the Internet along, with some of my own. I also go over tinning magnet wire, soldering 0603 LEDS, lighting ideas and painting LEDs. Although the 0402 LEDs did not arrive before I shot the video, I did solder some using the same techniques. Just crank up the Optivisor a bit, and you will do fine.

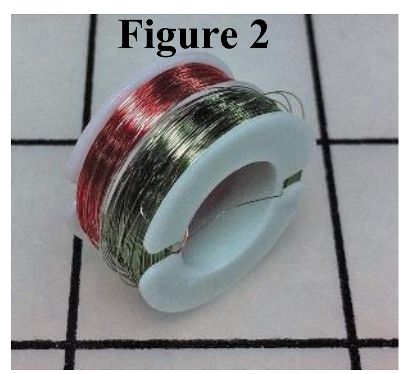


Figure 2

The two LEDs I mainly use for locomotives and buildings are the 0603 and its smaller cousin, the 0402. I start by using 3M 110 Double-Sided Foam Tape placed on my work surface. Using a tweezers, I lay the LED face down. The face is the smaller rectangular yellow colored side. I use a water-based flux to tin the

Figure 3

magnet wire, as well as, the the LED. I like to use colored magnet wire, red and green. (Figure 2) Because I'll build up a dozen or so in a single session, this helps later on so I know what is the Anode/Cathode. Once tinned, lay the small tinned magnet wire on the pad of the LED and just touch your iron or gun to the pad. (Figure 3) It only takes a quick second. We don't want to burn the pad. Depending on the use of the assembly, I like to place a dab of ACC on the pad I just soldered. This allows for a little rougher handling of the unit. It's a tedious job, but you can bang out a dozen in less then 20 minutes. Then, you will have some ready to go for your next project.

OK, we have a 0630 LED with our two wires soldered on and tested, so now what? Well, these will fit in any small lamp shade like Miniatronics Corp. Brass Lampshades. They are marked HO but look better in O. Ngineering also has a good selection of shades and sizes. These LED's are very directional, so if you are using them inside a building, you may want to use a clear bead to help diffuse the light. (Figure 4)

Figure 4

The good news is there are no municipal codes when it comes to wiring buildings on a layout. You do, however, need a plan for routing the 12 volt wire (or whatever you will be using) around the layout, keeping wire colors and sizes consistent. One of the smarter things I did when I started building was to run a 12 volt buss all around the layout on both the upper and lower sections. I chose 14 gauge for this, but depending on how far you are going, 16 gauge (and possibly even 18 gauge) will work. I also started to run a 1 ½ volt buss and extended it through most of the yard area. Later on, I thought this was a bit much, so I stopped using 1 ½ volt bulbs altogether. One of the nice things about having

Figure 5

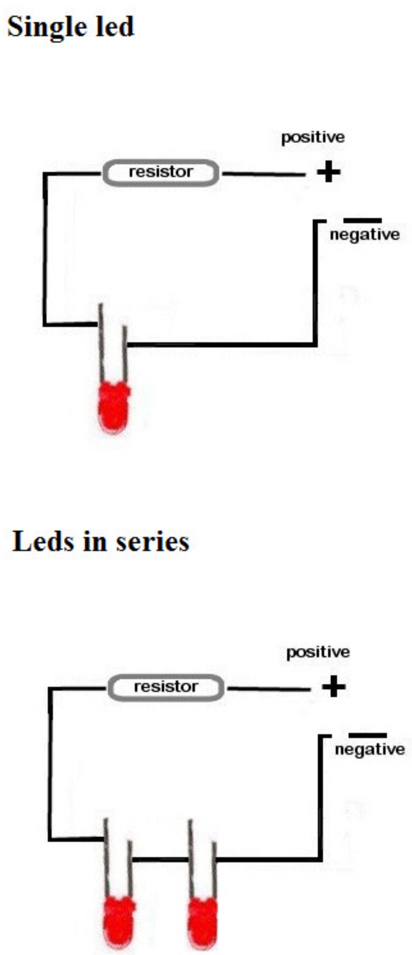
the buss in place is that you can tap off anywhere you need to. In Figure 5, I have a tap off set under a town that is still in the planing stages. This allows for many connections to go anywhere I need them within this area. Almost all of my buildings have the LED limiting resisters housed within the building knowing they would be driven at 12 volts. Most of my incandescent lighting is also 12 volts.

At this time, all of the LED lighting I have used contains the current limiting resisters inside the building based on a 12 volt feed. As I touched on in the January/February *O Scale Resource* article, the only possible danger here is using a resistor with a lower wattage rating than recommended. That will cause heat, and I have actually burned myself on a resistor in the past. Resistors can get extremely hot before they fail. Sitting inside a wood or styrene “attic” could cause problems. I just made it a habit to use the next larger wattage so I didn’t have to worry about it. We’ll see a real world example of this later on when I talk about the roundhouse lighting.

I am normally a frugal person, but when talking about resistors that can be bought at less than $3.00 per hundred, I don’t mind using them on a one to one basis. That is, if I have four LEDs lighting the inside of a building, I’ll use one resistor for each LED. I could wire in series or parallel as we talked about in the last article, but then you get into some odd resistor values. I keep a good supply on 330, 470, 750 and 1000 ohm ½ watt resistors on hand. Using a one to one system allows me to cover 99% of my needs in building wiring. When we start using series wiring, we get into some low ohms and much higher wattage, and those can be harder to find.

For example, I have a building with four hanging LED lights. With my 12 volt input, I would need four 330 ohm resistors rated at .50 watts, one for each LED. (Figure 6) Remember the calculations will give us the lowest resistor needed to produce the the highest light output safely. Conversely, stepping up to a 750 or 1000 ohm resistor will just give us a dimmer light output which, in some applications, is not a bad thing. Just taking the stock price from digikey.com we are at $.08 a piece. Yeah, I can afford $.32 for this. Even Radio Shack’s $1.49 for five I can handle. But, if we went and wired this in series it wouldn’t work because the LEDs are rated at 3.20 volts, and four of those surpassed the 12 volt buss. So, let’s try just three LEDs in series. We end up with an 80 ohm .25 watt resistor which, while available, is not that common, and you still have to go back and wire the last one by itself. Granted, there are sometimes were we have to do this (series/parallel) wiring as we’ll see later; however, for most builds, I stick with one to one.

Of course having said that, I did do one building in series because I had the resistors, and I just wanted to try it. I did not do this to save anything, definitely not money as we have seen, but just to demonstrate how it would work.



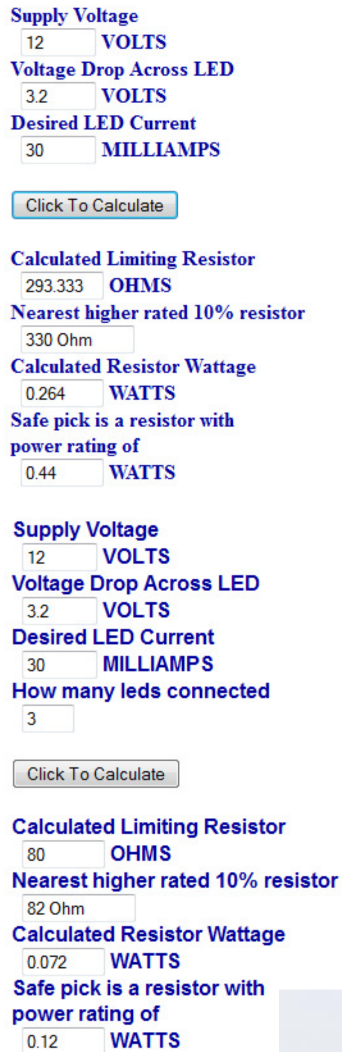


Figure 6

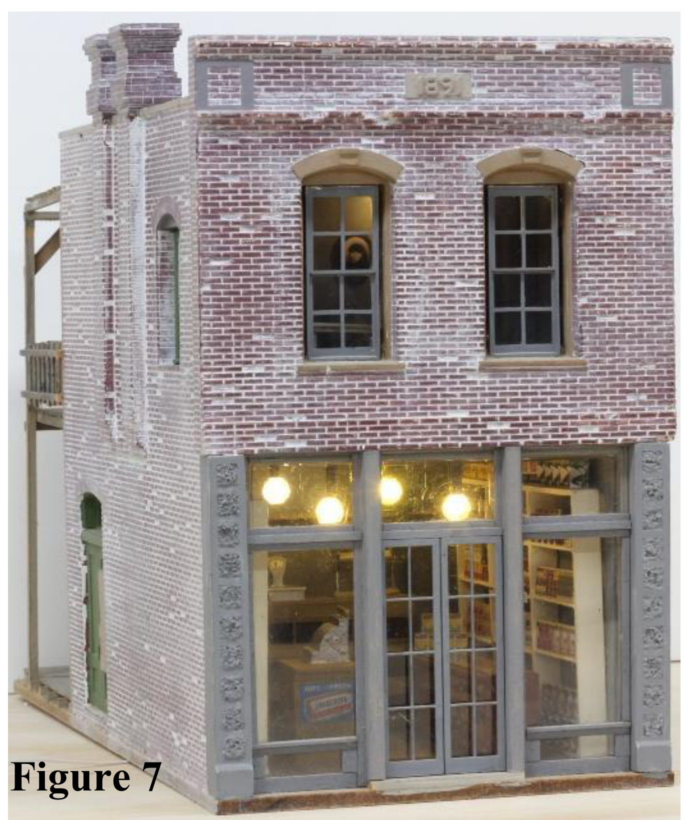


Figure 7

Figure 8

Let's start by looking at Guerra's Grocery. (Figure 7) This is a Thomas Yorke kit I bought back in the late 1970's. Living in an apartment, and chasing women (this was back in the day), I had a friend of mine build this. There was no thought to lighting or any interior. He did an OK job, and I boxed it up for use on a layout some day. Fast forward to the present. There were some problems with the building, and things I did not like. I wanted an interior and lighting because the large windows lent themselves to it. The problem was, he mounted the building on a board and there was no way to get in. This bugged me for awhile until I decided to cut into the roof. Luckily for me, it was cardboard from the original kit. Once the roof was off, a new one would be built, I found the easiest way to get two floors was to build a three sided box that could be dropped back into the building shell. (Figure 8) The first floor has four LED fixtures. I simply put a 603 LED in a bead to help diffuse the light. I did wire these in series, two sets of two with a 270 ohm resistor. The upstairs was modeled just enough to give the impression that there is something going on up there. A single 603 LED was used upstairs. Yes, the brass rod is a bit on the large side here, but stepping back and looking through the windows, it works. The lights on the main floor are nice and bright while the light in the room above is dimmer, just bright enough to give the illusion that there is something up there.

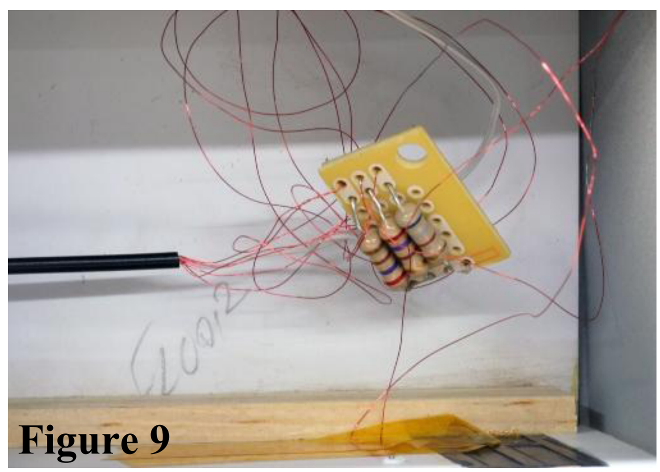


Figure 9

I tried to keep this neat by using some "project boards" from Radio Shack for soldering the resistors to along with the wiring. (Figure 9) This was housed behind the upper storeroom.

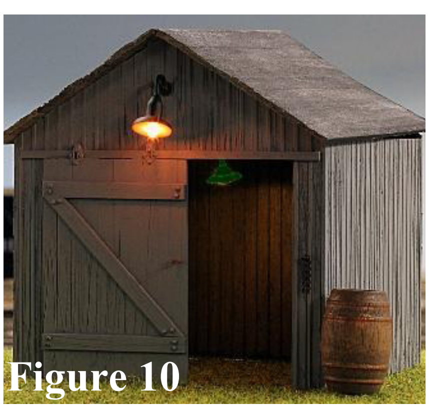


Figure 10

Because of the small amount of current, I was able to use fairly small wires going into these buildings. My wire of choice is 38 gauge magnet wire. Magnet wire (or enameled wire) is copper wire coated with a very thin, but tough layer of insulation. I buy it with green and red insulation which makes it easier to work with once soldered to the smaller SMD LEDs. For larger LEDs, such as 3mm, I use 32 gauge, 2-conductor wire such as Cir-Kit CK203. I also use that for the main feed wire.

Let's look at a few other buildings, and how they were lit. The small scratch built building in Figure 10 uses a single 0603 LED inside a brass

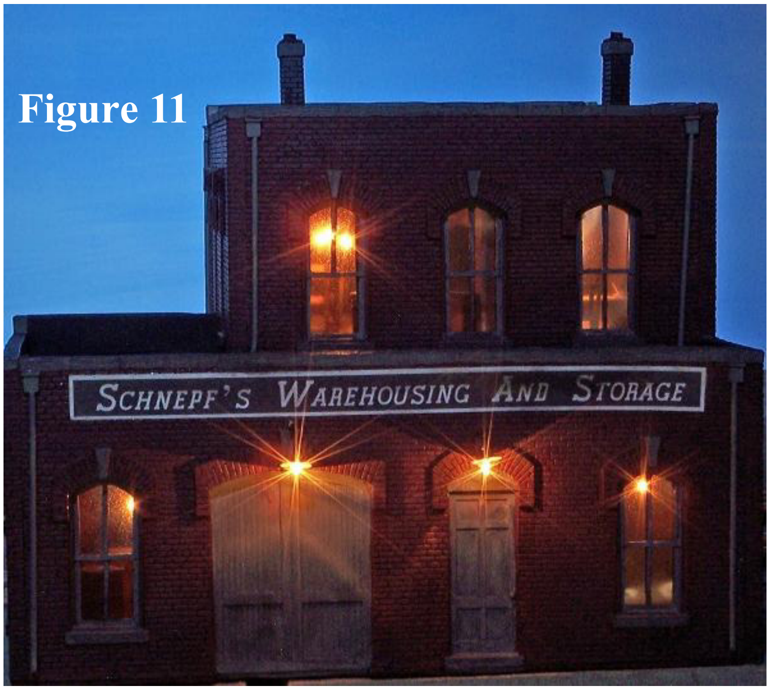


Figure 11

shade. For the outside lamp,I cheated and used a Walthers Cornerstone lamp. These were sold as HO, but are much better suited to O scale. I bought a bunch of these back when the price was low. Unfortunately, they are no longer produced.

Schnepf's Warehousing and Storage (Figure 11) was all done using 12 volt incandescent lighting. This is an old Magnuson Models kit I tried to build back in he 1980's. It had some warping problems, so I never finished it. A few years ago I pulled it out, and tried again. In Figure 12, the red stained inner ceiling for the first floor was added. All the lighting is small 12 volt bulbs and shades from Miniatronics. All I did was use small diameter tubing stuck through the inner roof with the wires fed through the bottom. A single row of bulbs was strewn across the upper floor. All the lights were tied together, fed down through a hidden wall, and brought out through the bottom of the building. I also used Miniatronics plugs, which can be fed through the layout allowing me to disconnect if I


Figure 12

have to move a building for any reason. The small dividers jutting out next to the window allow the viewer from the outside to be fooled into thinking there are rooms and more in the building than there actually is.

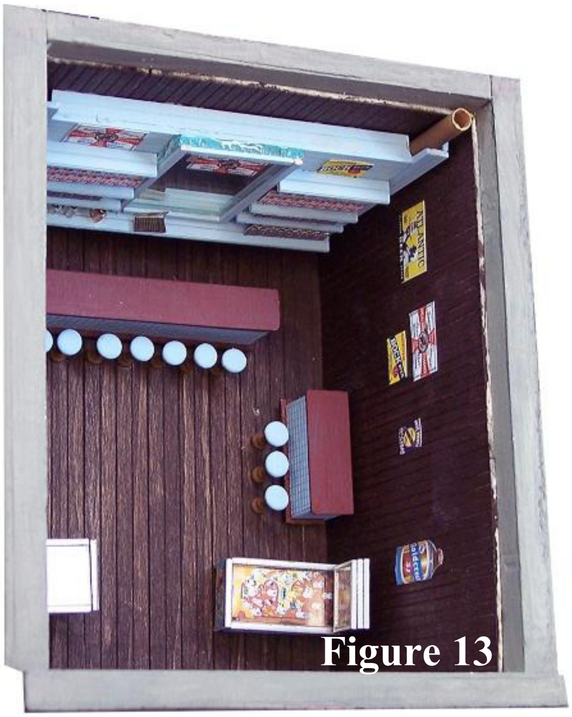


Figure 13

Balue’s Tavern (Figure 13) is typical of how I add lighting to most of my smaller cast building kits. There is a sub roof that sits just below the outer roof. This sub roof lays on top of the stained siding material I used to finish off the interior. Again, using small diameter tubing through the sub roof allows me to drop the wires down with the lamp and shade in place. There only needs to be enough room between the roof and sub roof for the wires, and in this case the resistors, to lay flat. Note the “vent pipe” in the upper right. Almost invisible from the outside, it allows all the wires to go through the building and out the bottom.

Howard’s Super Service is an Evergreen Hill wood kit. (Figure 12 and 15) The plan will be to also light the pumps, but that will have to wait for its final place on the layout. Lighting here is very simply. Again, using the bulb and shades. You have to remember that back in the 1940’s for

Figure 14


Figure 15

buildings like these there was not a great selection of fixtures. Bare bulbs hanging from wires would also work in this era.

The Roundhouse was a big challenge. This is an older Korber Models kit that I needed to shorten to fit my space. That could be a whole article in itself, so for now I'll stick with the lighting. The outside lights are not yet finished, but I'll simply make the standard old time gooseneck lamps over the doors. It was the inside that made me think. In the new instructions for the redesigned kit from Korber Models, there was a section on how someone wired their roundhouse. It was done in series, limiting the number of LEDs on a set. Although it looked nice, I used a simpler way. One thing I want to make clear here is that my buildings are not what some would call museum quality. I have seen some fantastic modeling on the forums, and some of these people go to extremes in their detailing. I love that, but it's not for me. My feeling is that if the people looking at the layout can't see it, I don't model it. Now, I know that many of you will say "but I know it's there" and that's fine. That's the great thing about this hobby, we can do as much as we feel is needed or that you are comfortable with. I don't tell anyone how to do something, I let people see what I have done, mistakes and all, and then they can use my ideas or other's ideas, or better yet, come up with new ideas of their own.

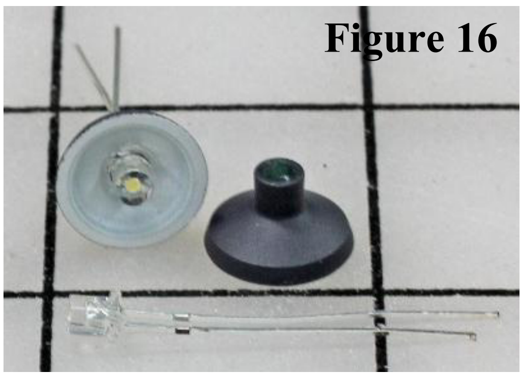


Figure 16

Let's get back to the roundhouse. The one thing I did take away from the instructions was to use 3mm flat top LEDs. They are a little larger, but the disperse the light in a much wider pattern. (Yes, I tried sanding a 3mm LED flat, and it just does not look right.) Figure 16 shows the 3mm flat top LED and the Plastruct lamp shade which is just large enough to fit the LED. I also like this set up because if you look from eye level, you see the light from the shade, but don't notice that there is no real bulb there.

The roundhouse has three stalls, and I wanted two lights for each track, one on each side. That gave me six LEDs across, and I needed three rows. Trying to wire this in series was not going to be pretty, so I looked at parallel wiring. What I decided to do was drill two small parallel holes in each beam going across the roundhouse. Then, I cut and strung .055 music (piano) wire through these holes. I simply bent the end of the LED with the shade attached and hung them where I wanted them, remembering to keep all the anode and cathodes on the same side. Once placed, I used a dab of solider and I was all set. (Figure 17) I then used a small brush and painted the wires flat black. That was the easy


Figure 17

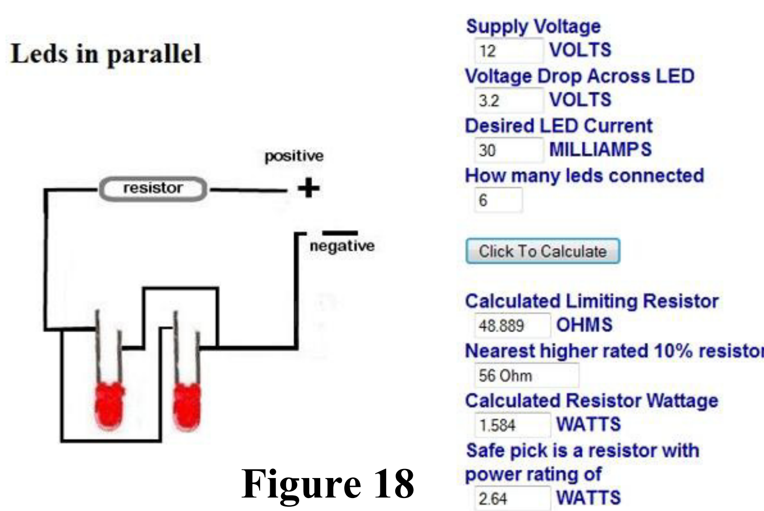


Figure 18

Figure 19

part, but how was I going to power these and where would all the wires need to go? Well, let's go back to our LED calculator. (Figure 18) I knew this was not going to use the resistors I normally have on hand. Three LEDs with a forward voltage of 3.2 volts rated at 30 milliamps with a 12 volt supply gives us one 56 ohm 2 watt resistor per set of six LEDs. You're not going to Radio Shack to find that so, back to digikey.com. They had them and in stock at $.19 each. Well, there is always something else I can add to that order, and within three days I had them. Now I needed to figure out how to wire and hide these rather large resisters.

Thinking about some of the old buildings I worked in back when I was a "rent-a-cop", I remembered old electrical cabinets along the walls. That would work for me. I scratch built three cabinets, complete with doors and door handles. I had three sets on six lamps, so each set needed it's own resistor and cabinet to hide in. Using brass tubing that I had on hand, I carefully drilled a hole in the sides of two of the cabinets, and one in the last. The tubing was measured, cut and added to the cabinet sides. Small tubing was then run out the roof of these cabinets up to the wires. (Figures 19 and 20) All of this was assembled on the bench after careful measuring.

Now the wiring. After testing, I used three sets of magnet wire so each light set would be fed from it's own set of wires. This allowed me to use the very thin wire to fit my conduit.

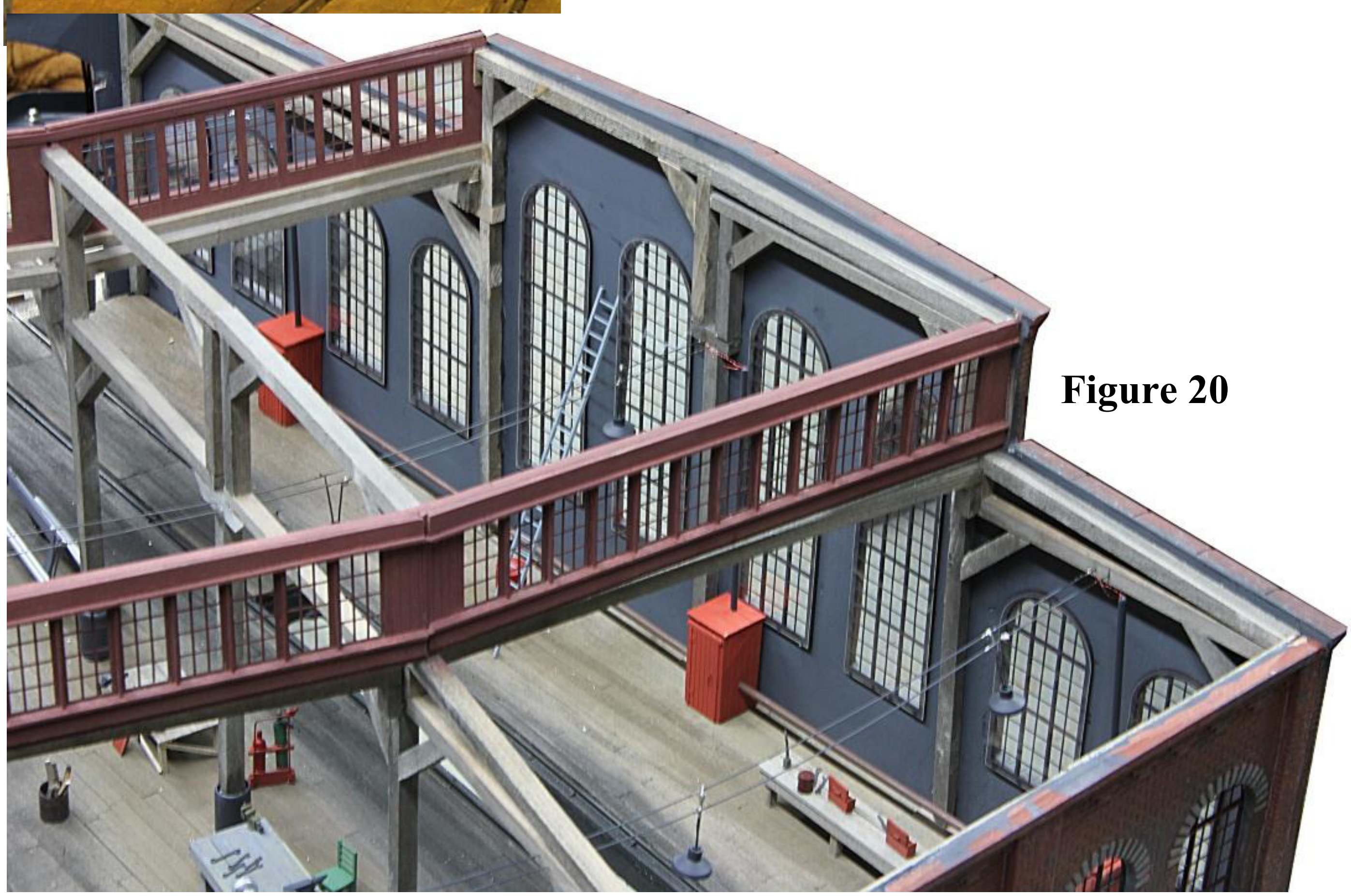
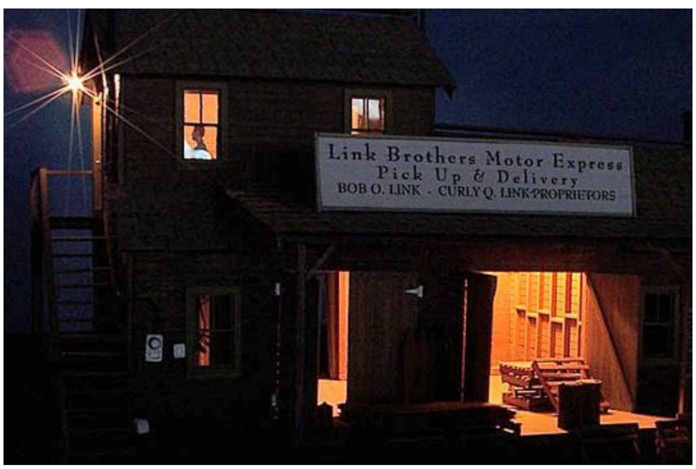


Figure 20

One set of two wires feed the resistor and then up to the the first bank of six LEDs. Then the other four wires (two sets of two) continued to the next cabinet where another pair of wires was used for the resister and then sent up to the second bank of six LEDs. The last set of two wires did the same in the third cabinet. When looking at eye level from the layout, the effect is very nice. I'll finish off with a few more pictures of my lighting. In the next issue, we'll take a quick look at using LEDs in rolling stock and locomotives.

Using incandescent outside lights with SMD 0603 LEDs inside.



Warehouse lighting looks just right using 12 volt incandescent lamps.

Sometimes things get real challenging to wire, but even in this Mullet River Model Works C&NW Crossing Tower, I was able to add lighting and run the magnet wire down a "vent stack".

Postscript:

Here is some clarification from the last article in the January/February issue. Wayne from the MTJ Forums had a few things to add, and also correct. He corrected me in that it was not color temperature that made for green pictures using film under fluorescent lighting, but rather high intensity green phosphors that made film pictures look green. I also said "You may need a current limiting resistor depending on the voltage." I came to that conclusion because, running from my 3 volt battery pack and my 3 volt transformer, I did not not need a resistor. Wayne's point is that you always need a resistor. In my case, the internal resistance of the batteries inside, and the test lead resistance read high enough to limit current to safe levels. I sometimes try and keep things too simple, but at least people are reading!