LEDs

MAINE 3 RAILERS
O-GAUGE
MODEL RAILROAD CLUB

Mark David & Rick Hills

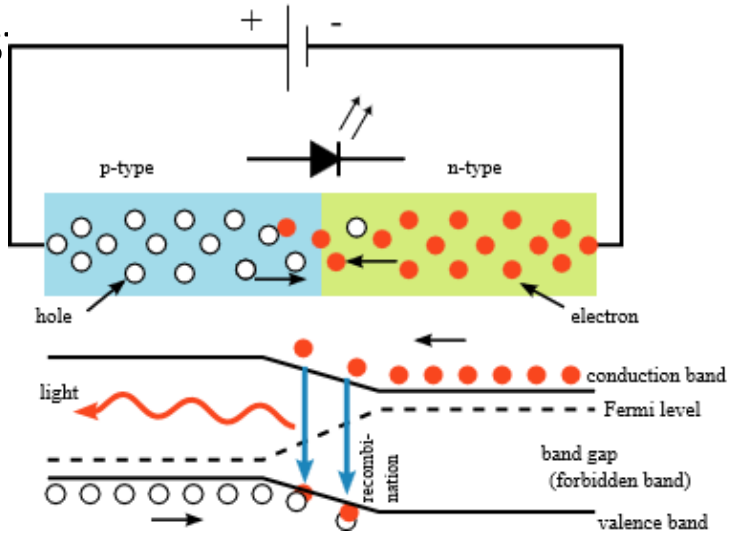
Goals for Today

- Review what an LED is and major components
- Discuss uses in O Gauge railroading
  - Why use LEDs?
  - Potential hobby uses
  - Challenges
- Modeling Examples
  - Emergency Vehicles
  - M3R Transformer car
  - Passenger Cars
  - Buildings
- Lessons Learned and Wrap Up

LED Basics

LED Basics

- An LED (Light Emitting Diode) is a semiconductor device that emits light when electric current (DC) is passed through it (but can be driven by AC)
- Light is produced when the particles that carry current known as electrons and holes combine together within the semiconductor material
- Color and brightness are determined by the semiconductor material and resis



LED Basics Cont'd

- What's the difference between an LED and your typical incandescent or fluorescent bulb?
  - A bulb uses a heated filament, a fluorescent uses gas
- LEDs are used commercially in electronics, home lighting, aerospace, automotive, medical, entertainment, gaming industries, etc and are "poised now to replace traditional incandescent bulbs"
  - The USDE hopes to reduce energy consumption for lighting by 50% by the use of LEDs…
- Some Energy stats:
  - LEDs use 75% less energy than incandescent bulbs
  - LEDs last 100 times as long as incandescent bulbs

LED’s versus typical Lionel bulbs

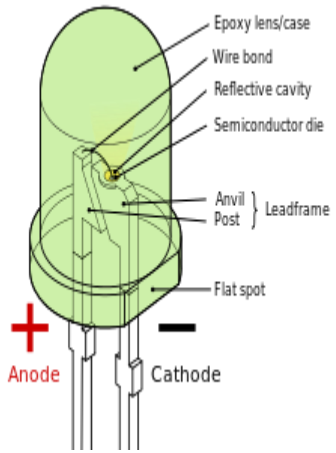
- Most LED’s draw a current of 0.02 amps (or 20 mA)
- Typical Lionel bulbs range from 0.1 to 0.25 amps each
- So, LED’s consume from 5 to 12 times less power than incandescent bulbs
  - Less power, less heat
  - larger number of bulbs on a circuit

LED basics cont'd

- Require correct voltage
  - Too much will destroy them nearly instantly
- Need a minimum voltage to create light
  - Varies with color
  - Called forward voltage
  - For a typical 5 mm white LED 3.3 volts (DC)
  - Yellow 2.1, blue 3.3, red 2.1, green 3.1 volts
- Brightness determined by voltage and current consumed
  - Most operate at 20 milliamps (mA), or 0.02 amps
  - This is very little current compared to incandescent bulbs

LED basics continued

- Have two leads, a cathode and an anode
- Cathode connects to negative power, anode to positive
- Anode lead is typically the longer lead
- Need to limit current with resistors
- Can use Ohm's law, but calculators make it easy
  - Resistance (ohms) = voltage across LED/ amperes
- With a 9 volt battery need at least a 330 ohm resistor (see next slide)



Single LED

LED calculator

This is the new version of the single LED series resistance calculator, good for when you have a single LED and need to know "**what resistor should I use with my LED?**" This calculator determines that for you.

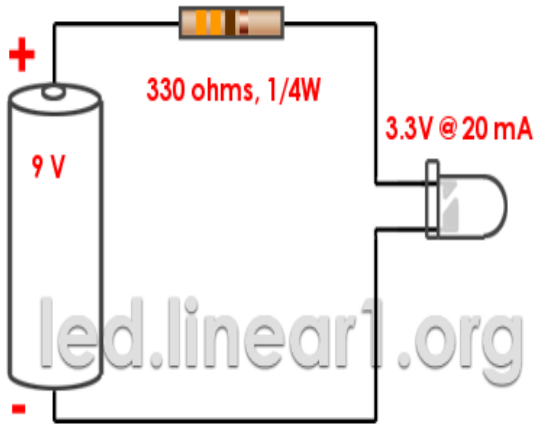
The LED series/parallel array wizard is available for those of you who need to do calculations involving more than one LED. The wizard will help you pick the resistors make the connections for **any number of LEDs**.

LED calculator: current limiting resistor value

9 Source voltage
3.3 diode forward voltage
20 diode forward current (mA)

Find R

The wizard recommends a 1/4W or greater 330 ohm resistor. The color code for 330 ohms is orange orange brown.



Link to this solution: http://led.linear1.org/1led.wiz?VS=9;VF=3.3;ID=20

*** This calculator rounds the resistance up to the next standard resistor value. You should actually be able to buy a 5% resistor with the value returned by the calculator.**

**** Power calculations assume use of the standard value current-limiting resistor shown above. Resistor power ratings are chosen based on operating within 60% of the rated value.**

Multiple LED's

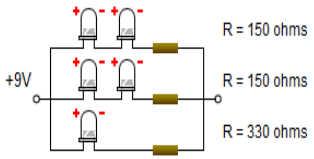
LED series/parallel array wizard

The LED series/parallel array wizard is a calculator that will help you design large arrays of LEDs. The LED calculator was great for single LEDs--but when you have several, the wizard will help you arrange them in a series or combined series/parallel configuration. The wizard determines the current limiting resistor value for each portion of the array and calculates power consumed. All you need to know are the specs of your LEDs and how many you'd like to use.

9 Source voltage
3.3 diode forward voltage
20 diode forward current (mA)
5 number of LEDs in your array
View output as: ASCII schematic wiring diagram
help with resistor color codes

design my array

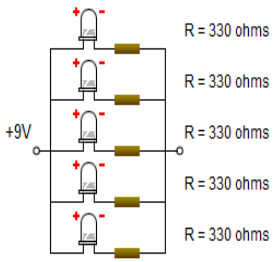
Solution 0: 2 x 2 array, 1 extra LED



The wizard says: In solution 0:

- each 150 ohm resistor dissipates 60 mW
- the wizard thinks 1/4W resistors are fine for your application
- the 330 ohm resistor dissipates 132 mW
- the wizard thinks 1/4W resistors are fine for your application
- together, all resistors dissipate 252 mW
- together, the diodes dissipate 330 mW
- total power dissipated by the array is 582 mW
- the array draws current of 60 mA from the source.

Solution 1: 1 x 5 array uses 5 LEDs exactly



The wizard says: In solution 1:

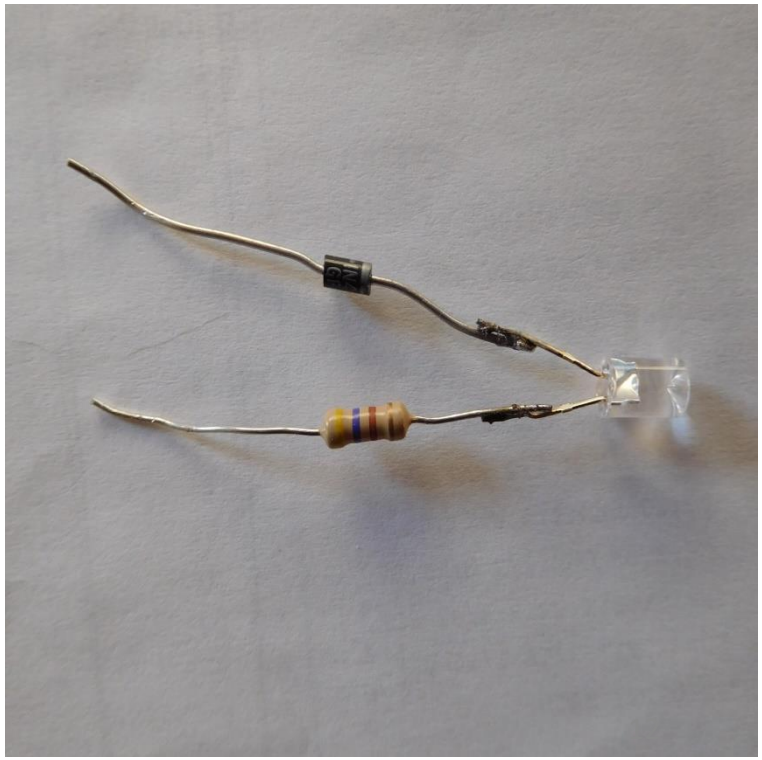
- each 330 ohm resistor dissipates 132 mW
- the wizard thinks 1/4W resistors are fine for your application
- together, all resistors dissipate 660 mW
- together, the diodes dissipate 330 mW
- total power dissipated by the array is 990 mW
- the array draws current of 100 mA from the source.

Work Shop 1: 5 minutes

- Break into six groups and make a working LED using a resistor and LED.
- Prove it works by connecting to a nine volt battery.

LED’s with AC transformers

- Can use a rectifier to convert AC to DC (but not required)
- Typical is 1N4001 (50 volt 1 Amp silicon rectifier diode)
  - $0.12 from Jameco electronics
- Solder rectifier to anode of LED and resistor to cathode
- Also can use a bridge rectifier (better)
  - Several company's make these for variable AC voltages



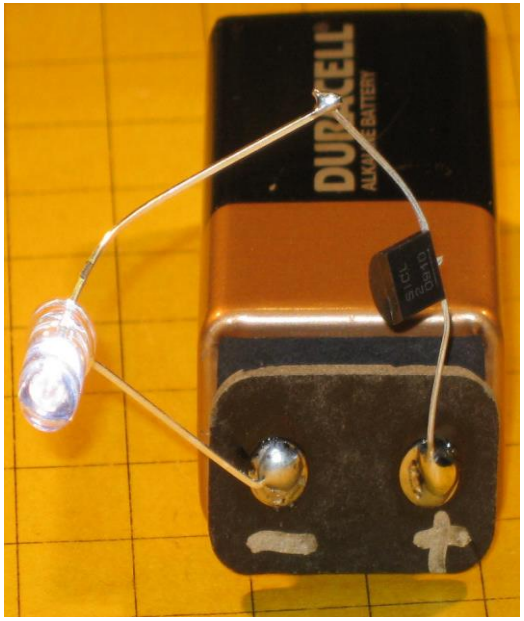
Using a LED Lighting Driver

- Does away with resistor because it provides a constant 20 mA
- $0.40 for one (Mouser electronics)
- Cut off center pin
- VA pin goes to +
- VB pin goes to anode of LED

MICROCHIP

Mouser Part #:	689-CL2N3-G
Manufacturer Part #:	CL2N3-G
Manufacturer:	Microchip Technology
Description:	LED Lighting Drivers 90V 20mA Temp Comp

CL2N3-G Datasheet



From: http://trainelectronics.com/LED_Articles_2007/LED_104/index.htm

LED Overview Cont'd

- So what are the benefits in using LEDs for the hobbyist?
  - Efficiency: reduced energy consumption and heat on your layout
  - Wide spectrum of colors: Whites, Red, Blue, Yellow, Orange, Green, Violet
  - Made of non-toxic materials
  - Are very bright and dimmable
  - Are durable: 10,000+ hours guaranteed by commercial vendors
  - Are configurable (size and actions) for many purposes
    - Can easily replace traditional grain of wheat, rice, bayonet/screw bulbs
    - Best train sizes are 1.8MM, 3MM and 5MM
    - Provide Blinking at various speeds
    - Some feature alternate colors in common LED

LED Challenges

- **What are some potential challenges using LEDs for O gauge trains?**
  - DC Power requirement (need a rectifier)
  - Reduction of 18 volt to a minimal voltage (need a resister)
  - Elimination of voltage drops in passenger cars (need a capacitor)
  - Dimming LEDs in passenger cars (need a adjustment circuit)
  - Blinking at slow and high rate, plus cross over (need a blinking circuit)
  - Remote control (need sender and receiver capabilities)
- **The commercially available hobby LED now available!**
  - Integrated assemblies with rectifiers to convert AC to DC, resisters to back down the voltage, capacitors to eliminate voltage fluctuations, dimming and blinking circuits, and remote controls, all at a reasonable price!

Commercial LED's for trains

Ready to Connect to Model Train and Miniatures Universal AC/DC power sources

Click to enlarge

Order Information	
Availability	Usually ships in 2-3 business days
Item #	Universal-LED
Price	$3.25
Size	◉ select size ○ 1.8mm (T3/4) ○ 3mm (T1) ○ 5mm (T1 3/4)
Color	◉ select color ○ Warm White ○ Cool White ○ Red ○ Yellow ○ Orange ○ Blue ○ Green ○ Violet
Wire Length	◉ 8 inch ○ 14 inch(+.10)

Qty 1 ADD TO CART

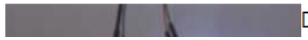
Fully Assembled LEDs for Plug and Play use

Yes! You can Connect these LEDs to any track power source.
These solid non-flashing LEDs will look great with 7-19 Volts of power input.

Guaranteed to stay lit for 2 years with free replacement. Thousands and thousands of these LEDs are now in use, on *all types* of track and transformer power supplies.

Our LED Lights can be used for Locomotive Headlights, Passenger Car Lights, Ditch Lights, Yard Lights, Building Lights, and much more. Low heat super bright LEDs only draw a tiny amount of power: 20milliamps.

Choose your colors, we have warm white, cool white, red, orange, yellow, green, blue, and violet.



Deciding which white to get?

Choose your Size and color when ordering

Save Money! *	
one light	3.25
5+ lights	3.00ea
10+ lights	2.80ea

Related Items
Flashing AC DCC LEDs
Switch Hook Up Wire

http://www.modeltrainsoftware.com/bl-212.html

Workshop 2: 5 min

- Break into six groups and implement a commercial hobby LED
- Connect the Hobby LED to a nine volt DC battery.
- This LED operates on AC as well. If you have time when you go home connect to a piece of track or transformer

LED Modeling

LED Modeling

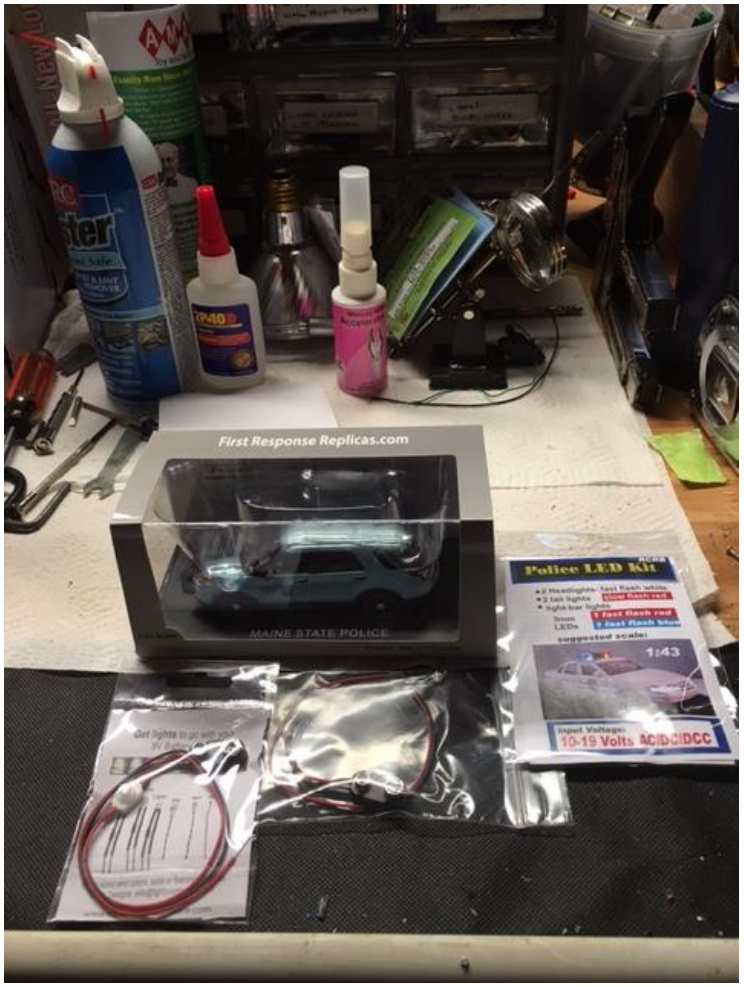
- **So lets start with some potential LED uses for O gauge trains**
  - **Autos and truck lighting …emergency vehicles**
  - **Updating train cars with lights**
    - Engines with mars lights and strobes too
  - **Improving passenger car lighting**
  - **Lighting buildings and accessories**
  - Adding end of train devices
  - Lighting/updating switches and controls
  - Adding more action to gates and cross bucks
  - Updating Super Streets vehicles
  - Add scenes, dioramas, and actions…welding, fires, robberies…
  - Tower Beacons

1) Modeling Emergency Vehicles (Cost $23-$50)

- **Step 1: Parts**
  - **Decide the type of emergency vehicle is needed and the era; modern or earlier.**
    - Plastic, Tin or Die-cast, vehicles work well. Make sure your vehicle is held together by screws that allow disassembly.
  - **Determine the lighting would you like to simulate**
    - Modern Era emergency vehicles use bright LEDs with rapid cross over blinking head/tail/header lights , sirens are appropriate for any era
    - Earlier era cars use fixed cool white head/trail lights and slow blinking header lights
    - Determine if the car will be powered by a nine volt battery, 12 volt DC source, or your 18 AC accessory volt circuit
    - 3MM LEDs are appropriate for all O Scale **vehicle** models
    - Purchase your car, on off switch, battery holder and battery if needed, and the correct hobby LED lighting harnesses. Suggested LED vendor (*Evans Designs 303-410-1118). Good 1:43 model car vendors are Die-cast Direct, Policecarmodels.com, 3000toys.com, Rite-Aid for tin models, Amazon. I really like First Response and NewRay as brands.*

Modeling Emergency Vehicles cont'd

- **Step 2: Tools:** You will need the following:
  - Small Phillips and standard mini screwdrivers
  - CA **Adhesive** and **Accelerator** to glue LEDs to the body, there is also an **LED putty** you might want to try
  - Clean work area with white paper towels on top
  - Soldering iron, shrink tubing, flux, pliers, cutters, solder
  - Work Light and magnifying glass
  - **MOST IMPORTANTLY:** New **sharp** 1.8 MM and 3MM drill bits! (Available through your local Hardware Store)
  - A hobby drill and charged battery



Modeling Emergency Vehicles Cont'd

- **Step 3: Car Disassembly and Planning**
  - Remove your model from its display base by removing tie strips and screws
  - Remove the screws holding your vehicle together
    - *Hint: use your smart phone to take pictures during this process to make reassembly easier or draw a diagram!*
  - Remove the seat and passenger area to get access to the front and rear fake headlights
  - Find the fake headlights and tail lights plus review the ceiling to look for opportunities for head blinking lights
  - Take a thin sharpie marker and mark where you want to have your lights appear on the outside. Two on ceiling, two front, two rear.
  - Make sure your locations are drillable and front and rear are level

Modeling Emergency Vehicles Cont'd

- **Step 4: Drilling and LED Installation**
  - Insert your 1.8MM bit in your drill. Slowly drill your holes marked from the outside. Be very careful especially when you start each hole not to mar the finish or slip and scratch. You might want to practice on a tin or plastic model first before your higher priced die-cast model.
  - Insert your 3MM bit in your drill. Re-drill all holes.
  - Take the six LED lights you have, determine which are top, front, and rear. Install one section at a time.
    - You do this by inserting each LED in the predrilled holes from the inside of the car and applying a drop of CA glue to it. Hold the LED in place with a screwdriver and spray with accelerator. You can also use an LED putty.

Modeling Emergency Vehicles Cont'd

– Step 5: Combining the feeds

- Twist all the 6 red or + leads together, Twist all six black or - leads together. Even out by cutting off access.
- Remove insulation from all red ends, twist
- Remove insulation from all black ends, twist
- Connect red wire from switch to reds. Solder all 7 red wires.
- If you need a battery holder or clip, twist and solder leads to reds and blacks
- Apply shrink tubing to the connections
- Test with battery to ensure all lights operate

Modeling Emergency Vehicles Cont'd

– Step 6: Reassembly

- Hide your wiring as best you can in the body of your vehicle. Use CA and Accelerant to hold wires in place. Be very careful not to get CA on windows. Use sparingly.
- Reassemble the seat. If you have a seated figure, put it in the seat and glue with CA and Accelerant.
- Reassemble the car. Reference your pictures or diagram if you become lost
- Retest with a battery

2) Modeling: Update M3R Transformer Car with Warning Lights (Cost $12-$22)

- **Step 1: Parts, Ordering, Tools**
  - Determine the color of 4- 3mm blinking LEDs you would like. Suggest you try different colors that are complementary.
  - Determine if you want a switch or you would like to run the lights remotely. Order a switch and battery clip or remote control set and battery clip.
  - Order the LEDs you have chosen. (*Evans Designs 303-410-1118)*
  - Make sure you have all the tools on hand mentioned in emergency vehicle step 2.

2) Modeling: Update M3R Transformer Car with Warning Lights

- **Step 2: Drilling and LED Installation**
  - Remove your transformer box from flat car by loosening rubber bands
  - Drill four 3MM holes in the top of the transformer box
  - Position each LED in the top of the box from the inside, push into the holes with a small slotted screw driver. Use glue with accelerator or putty if needed. Take your time. Be careful.

2) Modeling: Update M3R Transformer Car cont'd

– Step 3: Twist the wires together

- Twist all the 4 red or + leads together, Twist all 4 black or - leads together.
- Remove insulation from all red ends, twist
- Remove insulation from all black ends, twist
- Connect red wire from switch to reds. Solder all 5 red wires.
- If you need a battery holder or clip, twist and solder leads to reds and blacks
- Apply shrink tubing to the connections
- Test with battery to ensure all lights operate

2) Modeling: Update M3R Transformer Car cont'd

- **Step 4: Reassembly**
  - Make a small 3mm half circle under rear of transformer with your drill. Put switch just above it, putting wires under half circle. Glue switch on transformer lower wall with CA glue and Accelerator.
  - Reattach transformer with the rubber bands and test again.

3) Modeling: Update a Passenger car with interior LED Lighting (cost $4-$45)

- **Step 1: Determine your approach**
  - There are three approaches I have used:
    - Replacement of screw or bayonet bulbs with LED replacement (Simplest) (Cheapest) (Least functional) ~$2.00 per *Bulb (Town and Country Hobbies 973-942-5176)* Works great for O Scale 022 type switches, buildings and accessories too.
    - Adding a four 5MM LED harness to an existing car (warm white, bright white, or amber) ~$10 (*Evans Designs 303-410-1118)*
    - Installing an LED strip with dimmable LEDs and resistant to flickering warm white, bright white, amber. (Expensive, Most Functional) (Used for See Thru Windows and Expensive collector cars with passengers) ~$34 - $45 (Dallee Electronics 717-661-7041)
  - Note your passenger car must have trucks that have power pickups. If not upgrade the trucks first, work with your local train store to obtain the correct parts

3) Modeling: Update a Passenger car with interior LED Lighting

- Instructions: Adding a Four 5MM LED Harness
  - Remove screws or bend tabs to remove roof or walls and roof. If you get stuck, call your local hobby store or watch Eric's Trains.com "add Passengers to Passenger cars" video for help.
  - Solder the red lead to the passenger car center pick up wire, the black lead to the ground.
  - Decide where you want your LEDs in the ceiling and use CA glue and Accelerator to adhere. You might position the LEDs first and see how you like them with two sided tape, then glue permanently.
  - Reassemble the car. If you can see the interior from the outside, add some people using the Eric.com method.
  - Test

3) Modeling: Update a Passenger car with interior LED Lighting

- Instructions: Adding an LED dimmable strip
  - Remove screws or bend tabs to remove roof or walls and roof. If you get stuck, call your local hobby store or watch Eric's Trains.com "add Passengers to Passenger cars" video for help.
  - Solder the passenger car center pick up wire to the proper red wire on the harness, ground to the black wire. Connect the plug to the board. Read the directions carefully that are provided by Dallee.
  - You can add a super capacitor to the strip to eliminate flickering and a light to your drumhead. Read the instructions!
  - Decide where you want your LEDs in the ceiling and use the two sided tape supplied to adhere. If you can see the interior from the outside, add some people using the Eric's Trains.com method.
  - You might want to adjust the dimming pot on the strip. Be careful. Follow the instructions! Test
  - Reassemble the car and test again.

4) Modeling: Light a Building or a City

- **Determine your approach**
  - There are many approaches I have used but suggest the following two:
  - **Approach A)** Add Commercial Hobby LEDs to a Building
    - This is very simple. Select several 5MM LEDs that take 12-18 volts and position them inside your building and wire to your AC transformer. Fasten to the building with CA glue and Accelerator.
    - Call Evans Designs *303-410-1118* to order your Hobby LEDs or make your own.
    - Don't forget the DC to AC rectifier if you make your own.
    - Cost is~ $3.00 per Commercial LED, less if you make your own which is cheaper

4) Modeling: Light a Building or a City

- **Approach B**:
  - Add a Woodland Scenics *Just Plug Lighting System* to Your Layout.
  - This system requires no electrical knowledge, is quick and easy and very expandable. Individual Room or building brightness can be controlled. There are great street lights and exterior building lights available as well.
  - The best way to get familiar with the system is to watch the 7 videos at Woodland Scenics.com:
    - » https://www.youtube.com/watch?v=YqHZ34-9VAY
    - » Ray Dellovo 603-554-1543 and Richard Ridolfo 603-929-1441, club members with train stores, stock these systems and components.
    - » System costs ~$50 to start, call the above dealers

Wrap Up

- Adding LEDs to your layout is an excellent, creative, and evolving part of the hobby
  - Make sure to take your time
  - Practice on inexpensive models, first

- Feel free to reach out to us anytime for help
  - Mark David 207-273-0185
  - Rick Hills 603-673-9262