

# Light Emitting Diodes

## An Overview

Part 1 - For NMRA Western Heritage Division - May 5, 2018

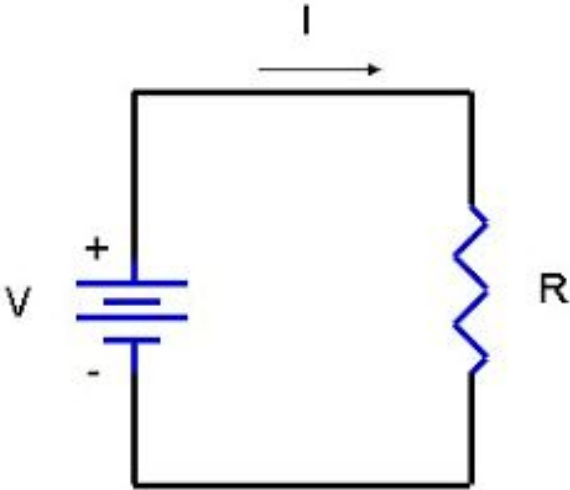
Part 2 - June 2, 2018

# Light Emitting Diodes

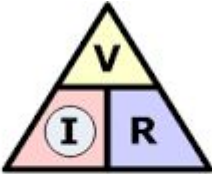
Part 1 - An Overview

# Fundamentals -

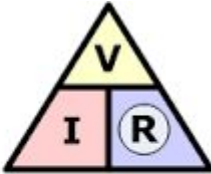
# Ohm's Law & Power



$$\textcircled{V} = I \times R$$



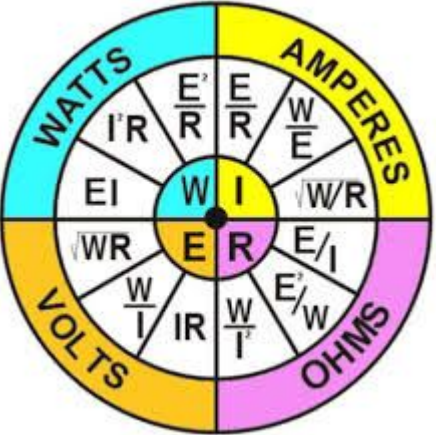
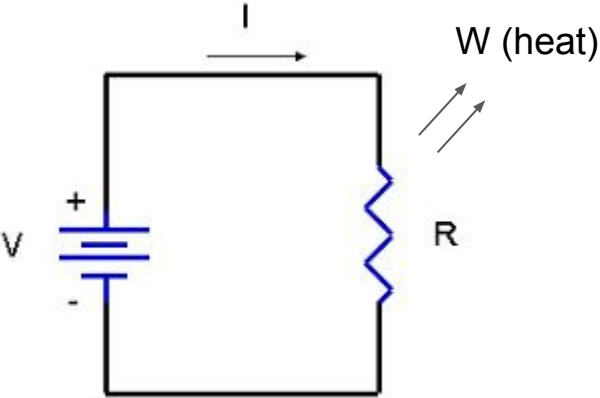
$$\textcircled{I} = \frac{V}{R}$$



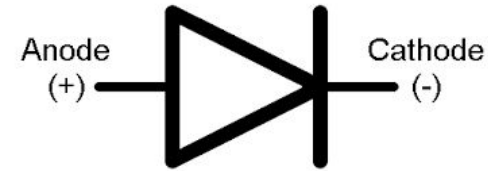
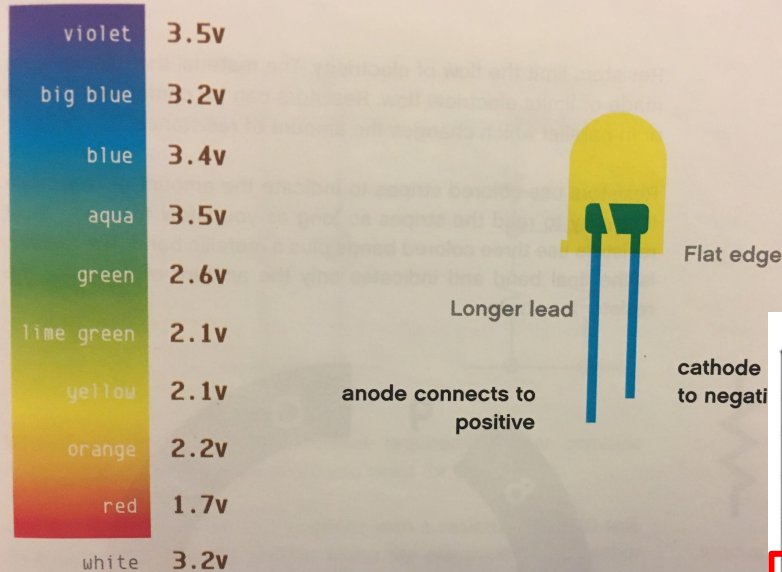
$$\textcircled{R} = \frac{V}{I}$$

# Fundamentals -

# Ohm's Law & Power



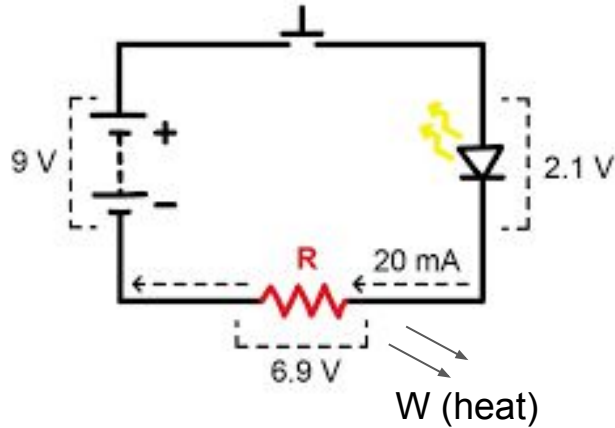
# Fundamentals - Forward Voltage & Max Current



Electrical / Optical Characteristics at TA=25°C

Symbol	Parameter	Device	Typ.	Max.	Units	Test Conditions
$\lambda_{peak}$	Peak Wavelength	Super Bright Red	660		nm	$I_f=20mA$
$\lambda_D [1]$	Dominant Wavelength	Super Bright Red	640		nm	$I_f=20mA$
$\Delta\lambda_{1/2}$	Spectral Line Half-width	Super Bright Red	20		nm	$I_f=20mA$
C	Capacitance	Super Bright Red	45		pF	$V_f=0V; f=1MHz$
$V_f [2]$	Forward Voltage	Super Bright Red	1.85	2.5	V	$I_f=20mA$
$I_R$	Reverse Current	Super Bright Red		10	$\mu A$	$V_R = 5V$

# Fundamentals - Ohm's Law & Power



Step 1

What do we know?  $V_f = 2.1\text{v}$  and  $I_{\text{max}} = 20\text{A}$

Step 2

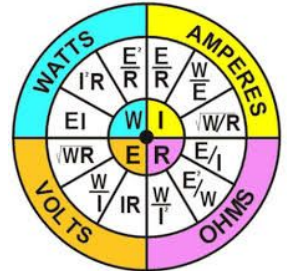
$$\begin{aligned}\text{So, } V_r &= V_{\text{batt}} - V_f \\ &= 9\text{v} - 2.1\text{v} = 6.9\text{v}\end{aligned}$$

Step 3

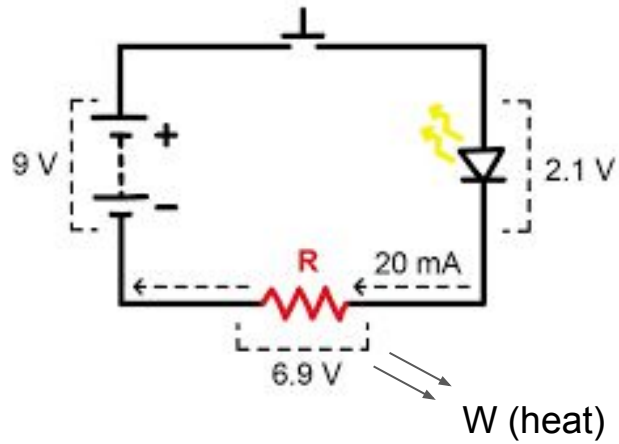
$$\begin{aligned}\text{Resistance} &= \text{Voltage} / \text{Current} \\ 6.9\text{v} / 20\text{ma} &= 345 \text{ ohms} \\ &\text{(next std value} = 360)\end{aligned}$$

Step 4

$$\begin{aligned}\text{Power in Watts} &= \text{Current Squared} * R \\ 20\text{ma} * 20\text{ma} * 360 &= 140\text{ma} \\ &\text{(use } \frac{1}{4} \text{ watt resistor)}\end{aligned}$$




# Fundamentals - The easy way



AT&T 12:07 PM 86%

Back LED Resistor



Series LED Count: 1

Supply Voltage: 9 VDC

Forward Voltage: 2.1 Vf

Forward Current: 20 mA

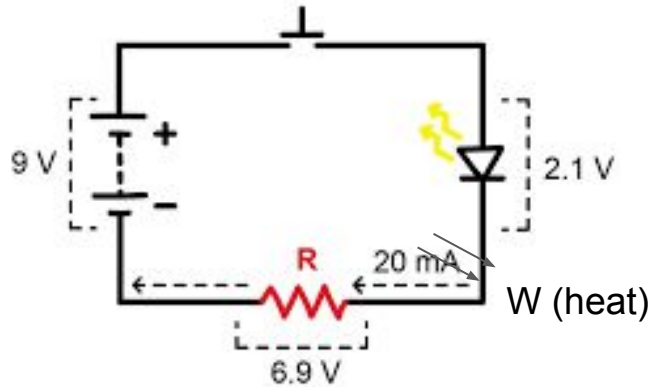
Resistance: 345  $\Omega$

Standard Value: 360  $\Omega$

Minimum Power Rating: 1/4 W

$R = (V_s - (V_f * L_c)) / A$

# Fundamentals - What if you don't know?



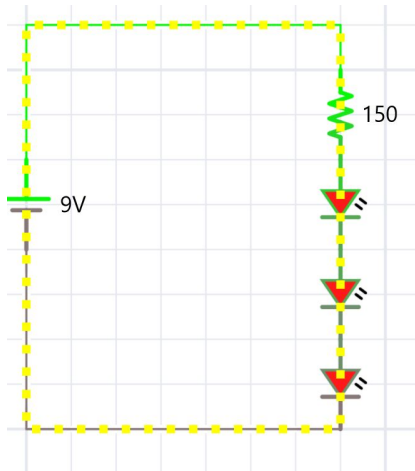
For up to 12 or 16 volts -

- 1) Plug in a 1K,  $\frac{1}{4}$  watt resistor
- 2) Reduce the resistor value until the LED lights.
- 3) Measure the diode voltage.
- 4) Do the calculations and replace the resistor.
- 5) If it smokes, your resistor was too small.

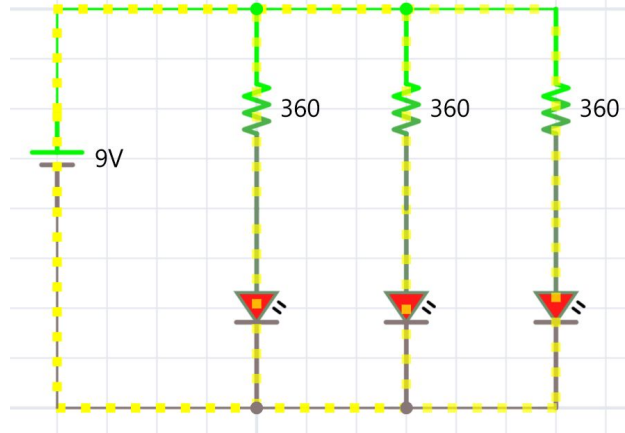


# Fundamentals - Multiple LEDs

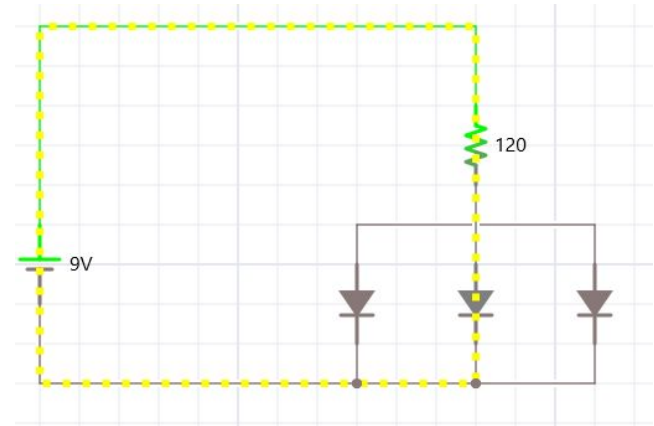
OK



OK



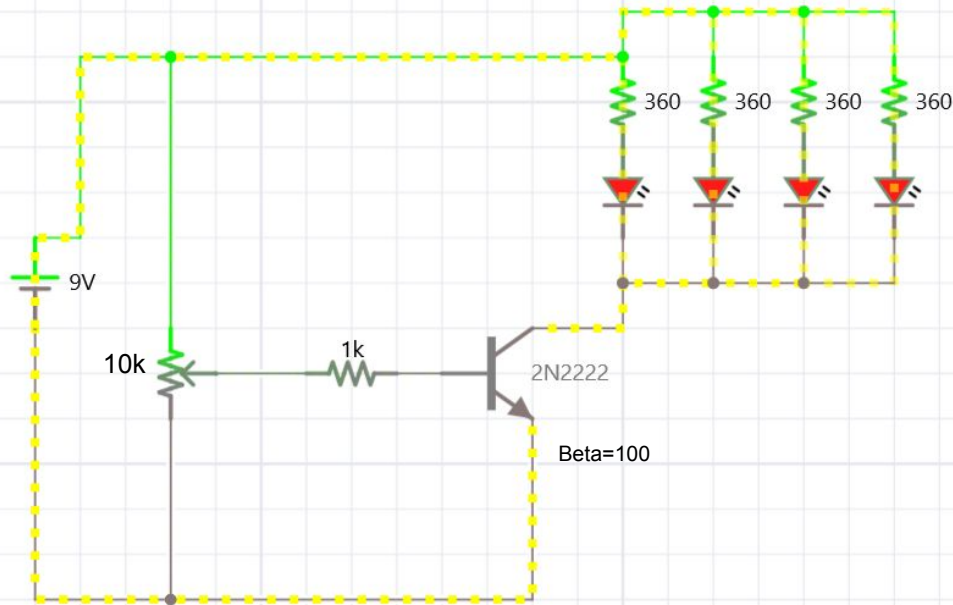
NO



# Fundamentals - Brightness Control - Multiple LEDs

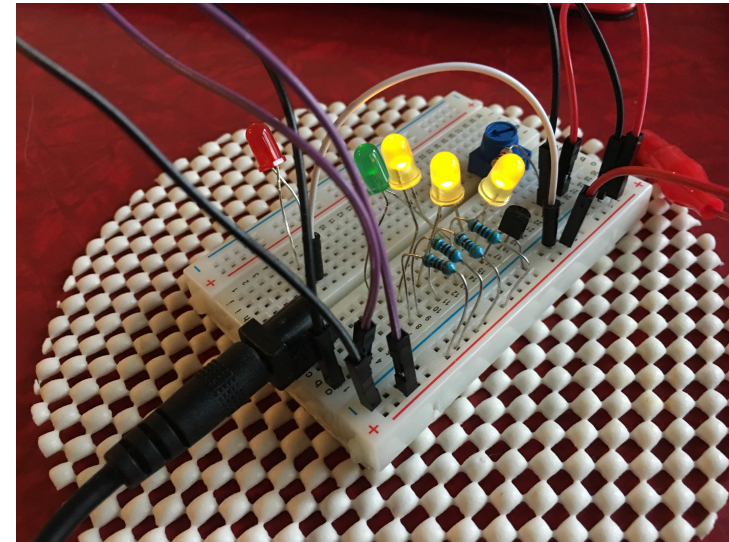
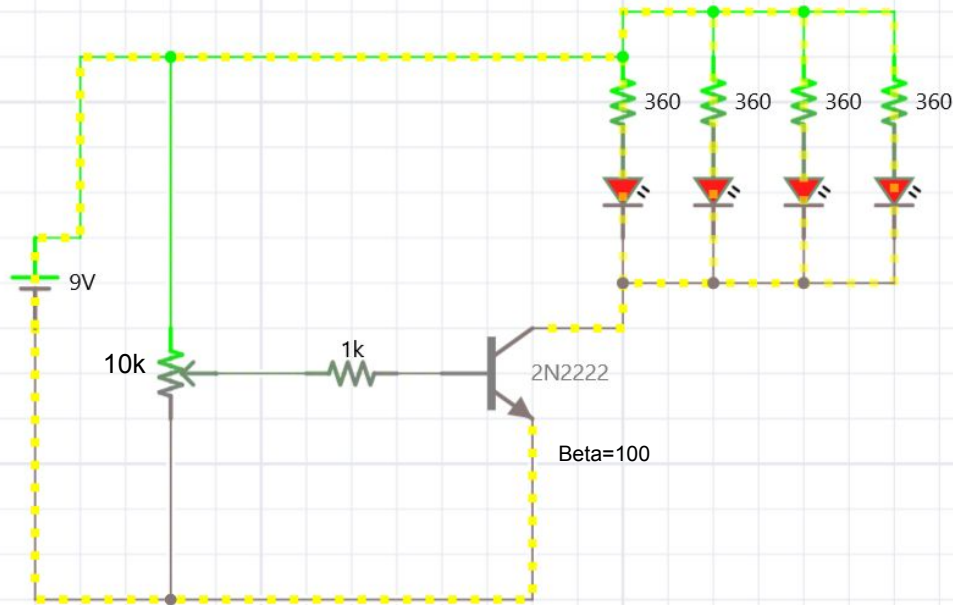
Transistor controls brightness

Woodland Scenics "Just Plug" light hub works on this design.



# Fundamentals - Brightness Control - Multiple LEDs

Transistor controls brightness



# DIY - Parts Pal and more resistors



# NCE - The Light-It and The Illuminator

An small, versatile, inexpensive LED Driver/Decoder

Use 4 Ways



For up to 3 LEDs  
5v, 30ma  
Built-in 330 Ohm Resistors

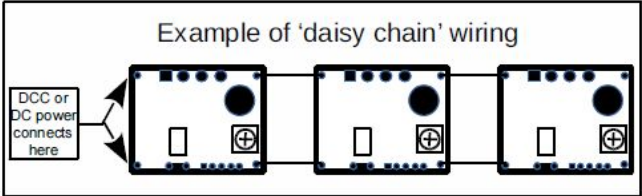
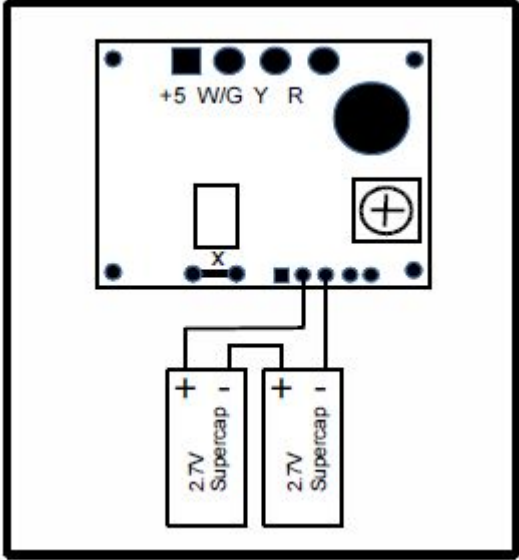
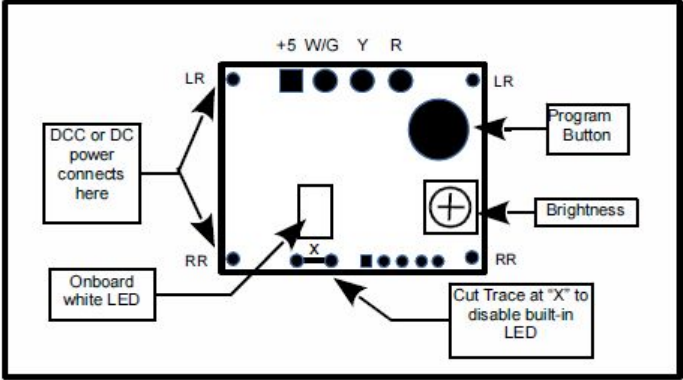
DC  
DCC Decoder with:  
Locomotive/Mobile Addr  
Accessory Addr  
Signal Head Addr



For up to 3  
Woodland Scenics LEDs  
12v, 100ma  
No Resistors

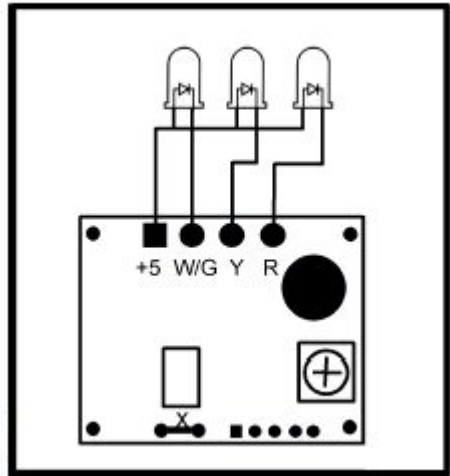
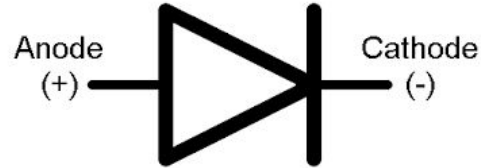
3 pack of the Light-It Universal Lighting and Signal Decoder.	19.95
6 pack of the Light-It Universal Lighting and Signal Decoder.	39.95
15 pack of the Light-It Universal Lighting and Signal Decoder.	99.95
Scenic Lighting Decoder compatible with Woodland Scenics Just Plug.	16.95
5 pack Scenic Lighting Decoder compatible with Woodland Scenics Just Plug.	79.95

# NCE - The Light-It





# NCE - The Light-It - Common Anode



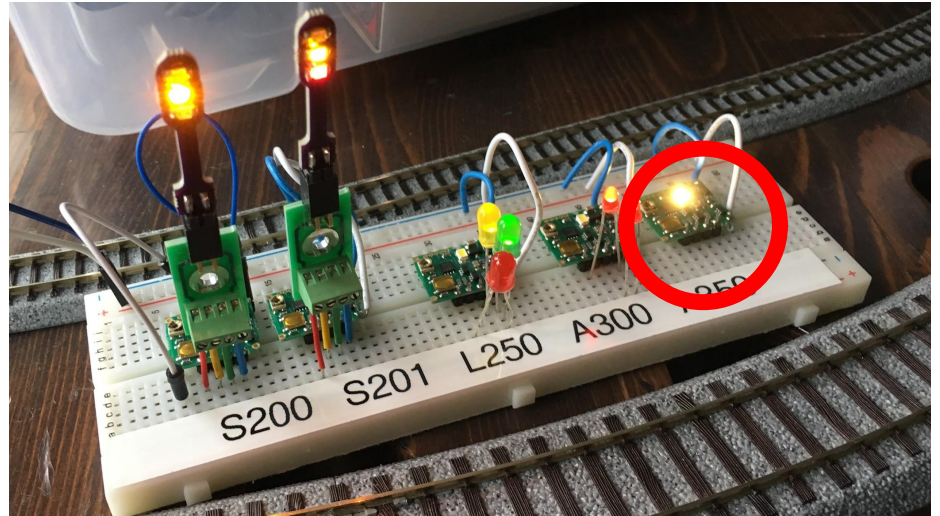
# NCE Light-It - DC



- 15 Lighting Effects
- All 3 LEDs will be the same, except 9-10
- One brightness control
- Remembers Settings after power removed

## List of lighting effects in DC operation:

- Effect 0 – off (all outputs off)
- Effect 1 – Steady on
- Effect 2 – Slow flashing
- Effect 3 – Fluorescent flicker A, more on than off
- Effect 4 – Fluorescent flicker B, more off than on
- Effect 5 – Fluorescent flicker C, a definitely dying fluorescent tube
- Effect 6 – Single strobe light (every 2 seconds)
- Effect 7 – Double strobe light (every 2 seconds)
- Effect 8 – Rotary beacon
- Effect 9 – Railroad crossing signal phase A
- Effect 10 – Railroad crossing signal phase B
- Effect 11 – Random on/off (times from 4 seconds to 1 minute)
- Effect 12 – Random on/off (times from 4 seconds to 2 minutes)
- Effect 13 – Random on/off (times from 8 seconds to 4 minutes)
- Effect 14 – Mercury vapor street light coming on (takes about 30 seconds to full brightness)
- Effect 15 – Rapid flash (lets you know this is the end of the list)





# NCE Light-It - DCC/Mobile Addr



Short or Long Addr, Consist works  
1 function per LED, map to any Function Key  
CVs for LED brightness  
Program in Ops Mode

## Controlling Brightness:

Each output has a separate brightness CV. CV140 controls the W/G output. Values of 0 to 255 are accepted with 255 being full brightness. CV141 and CV142 control the brightness of the Y and R outputs respectively.

## Lighting Effects:

Each output can have a different light effect. Values of 0 – 15 are valid. CV137 controls the effect for the W/G output. CV138 controls the Y output. CV139 controls the R output.

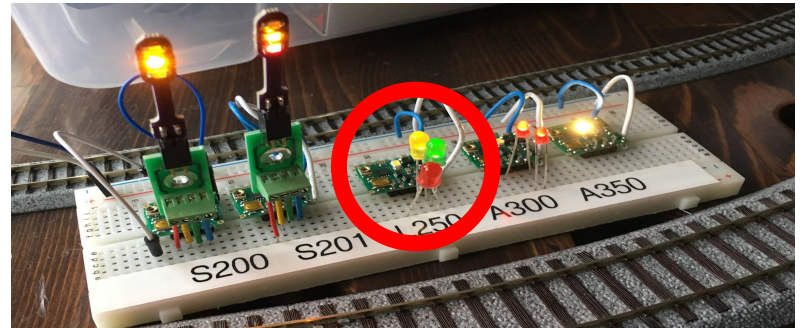
List of lighting effects in DCC operation when using a loco address:

- Effect 0 – off (all outputs off)
- Effect 1 – Steady on
- Effect 2 – Slow flashing
- Effect 3 – Fluorescent flicker A, more on than off
- Effect 4 – Fluorescent flicker B, more off than on
- Effect 5 – Fluorescent flicker C, a definitely dying fluorescent tube
- Effect 6 – Single strobe light (every 2 seconds)
- Effect 7 – Double strobe light (every 2 seconds)
- Effect 8 – Rotary beacon
- Effect 9 – RR crossing signal phase A (will not be in sync when used with loco address)
- Effect 10 – RR crossing signal phase B (will not be in sync when used with loco address)
- Effect 11 – Random on/off (times from 4 seconds to 1 minute)
- Effect 12 – Random on/off (times from 4 seconds to 2 minutes)
- Effect 13 – Random on/off (times from 8 seconds to 4 minutes)
- Effect 14 – Mercury vapor street light coming on (takes about 30 seconds to full brightness)
- Effect 15 – Rapid flash

F0

F1

F2



# NCE Light-It - DCC/Accy Addr



Accessory Address 1-2043  
1 function per LED, but single on/off switch  
CVs for LED brightness  
Program in Ops Mode

## Controlling Brightness:

Each output has a separate brightness CV. Values of 0 to 255 are accepted with 255 being full brightness.

CV140 controls the brightness of the W/G output.

CV141 controls the brightness of the Y output.

CV142 controls the brightness of the R output.

## Lighting Effects:

Each output can have a different light effect. Values of 0 through 15 are valid.

CV137 controls the effect for the W/G output.

CV138 controls the effect for the Y output.

CV139 controls the effect for the R output.

List of lighting effects in DCC operation when using an accessory address:

Effect 0 – off (all outputs off)

Effect 1 – Steady on

Effect 2 – Slow flashing

Effect 3 – Fluorescent flicker A, more on than off

Effect 4 – Fluorescent flicker B, more off than on

Effect 5 – Fluorescent flicker C, a definitely dying fluorescent tube

Effect 6 – Single strobe light (every 2 seconds)

Effect 7 – Double strobe light (every 2 seconds)

Effect 8 – Rotary beacon

Effect 9 – Railroad crossing signal phase A

Effect 10 – Railroad crossing signal phase B

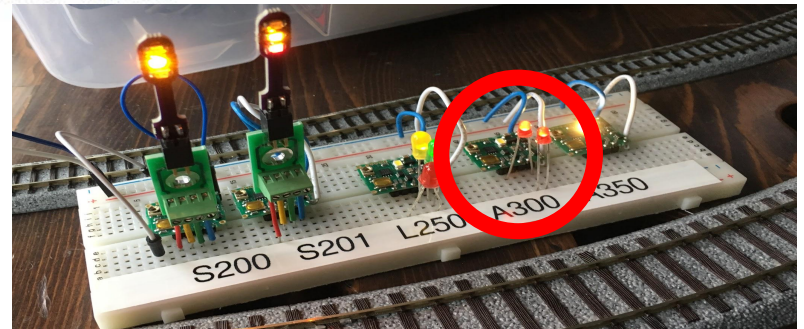
Effect 11 – Random on/off (times from 4 seconds to 1 minute)

Effect 12 – Random on/off (times from 4 seconds to 2 minutes)

Effect 13 – Random on/off (times from 8 seconds to 4 minutes)

Effect 14 – Mercury vapor street light coming on (takes about 30 seconds to full brightness)

Effect 15 – Rapid flash

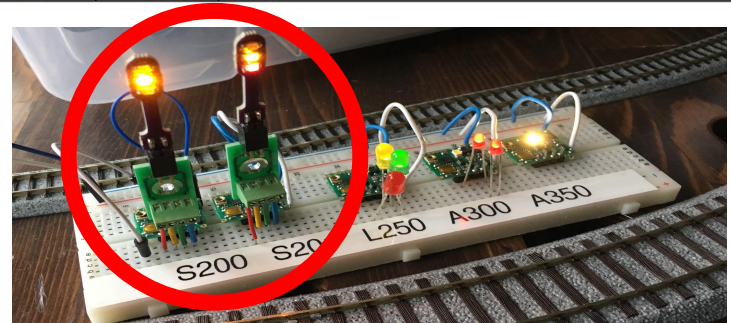


# NCE Light-It - DCC/Signal Addr



Signal Address 1-2043  
18 Signal Effects  
CVs for LED brightness  
Program in Ops Mode

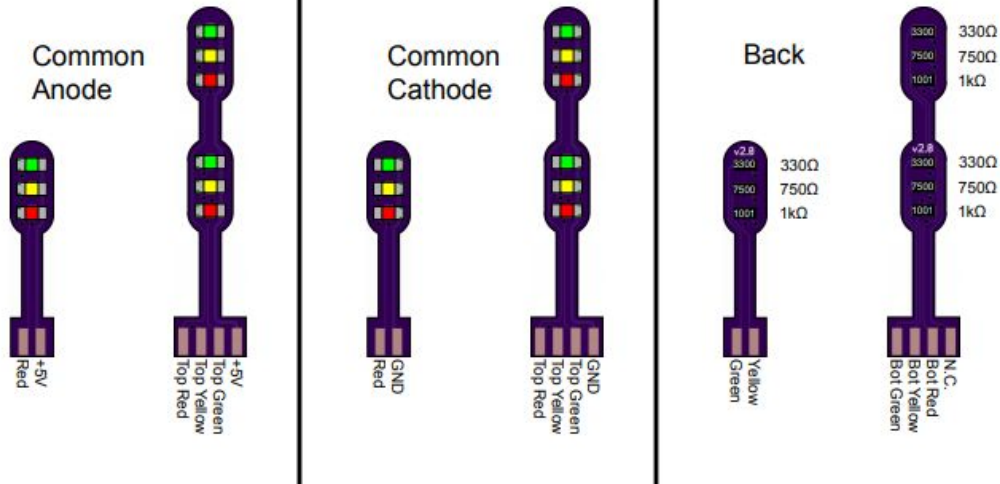
Aspect	Effect Number	Lighting effect
0	0	Red
1	1	Yellow
2	2	Green
3	3	flash red
4	4	flash yellow
5	5	flash green
6	6	red+yellow
7	7	flash red+yellow
8	8	red+flash yellow
9	9	red+green
10	10	flash red+green
11	11	red+flash green
12	12	yellow+green
13	13	flash yellow+green
14	14	yellow+flash green
15	15	effect 15=all on
30	--	all flash
31	--	all off





# ISE “Stand-in Signal Masts”

Ugly but functional



**Single Head Signal (6-Pack)**

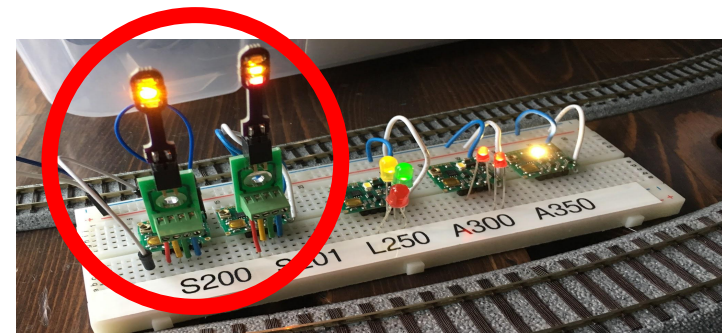
Single head signal that can be used as a stand-in for the final, prototypical signals when in the de..

\$39.00

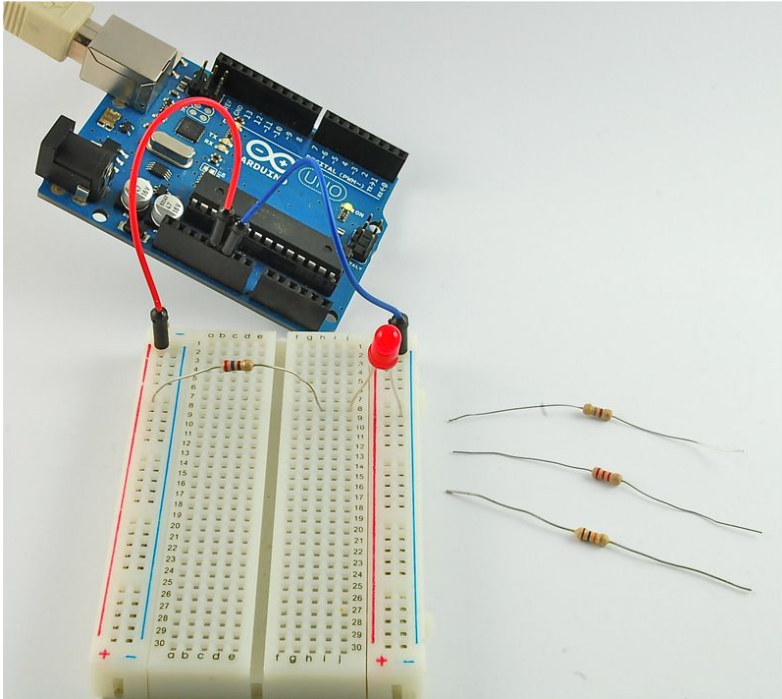
**Dual Head Signal (3-Pack)**

Dual head signal that can be used as a stand-in for the final, prototypical signals when in the desi..

\$39.00



# Using an Arduino - Why?



Resistors control current

- But, brightness doesn't vary much w/current
- Adjustment w/Resistors Tedious

Special Effects or Automated Control

Arduinos (or other controllers)

Relatively Inexpensive

Very Versatile

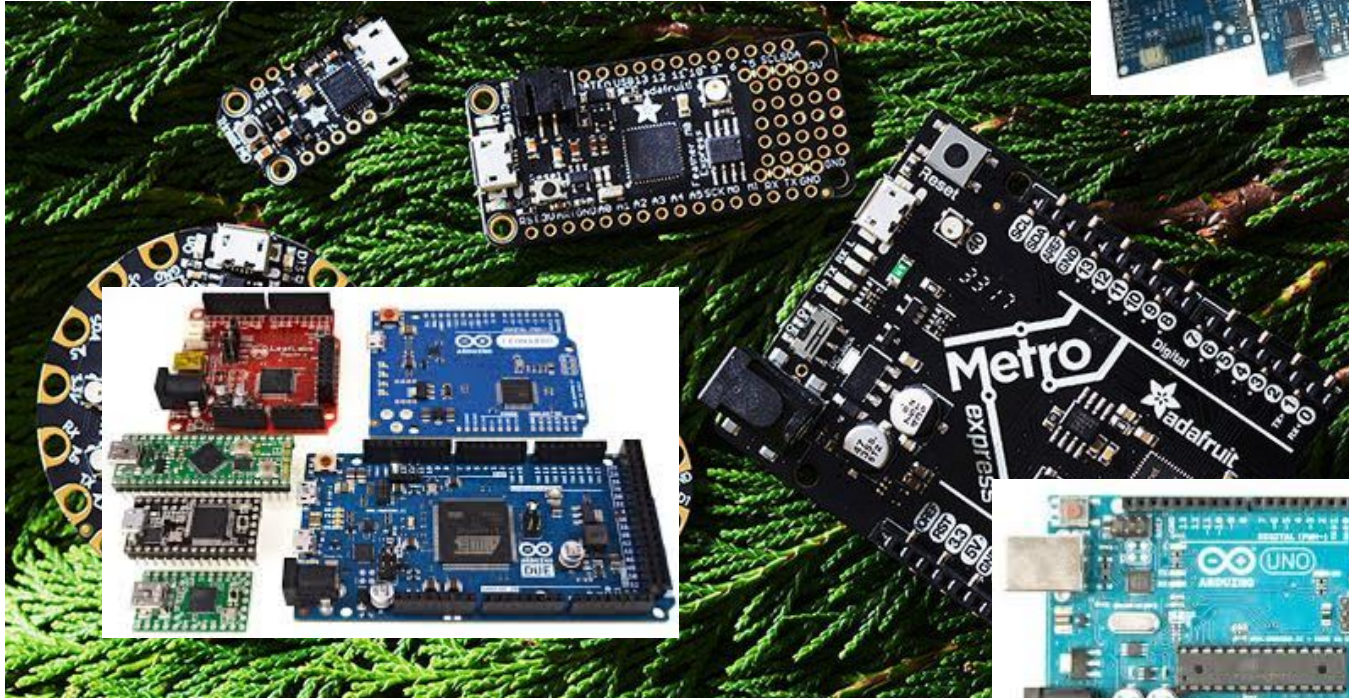
Many Code Libraries Available

Easy to learn

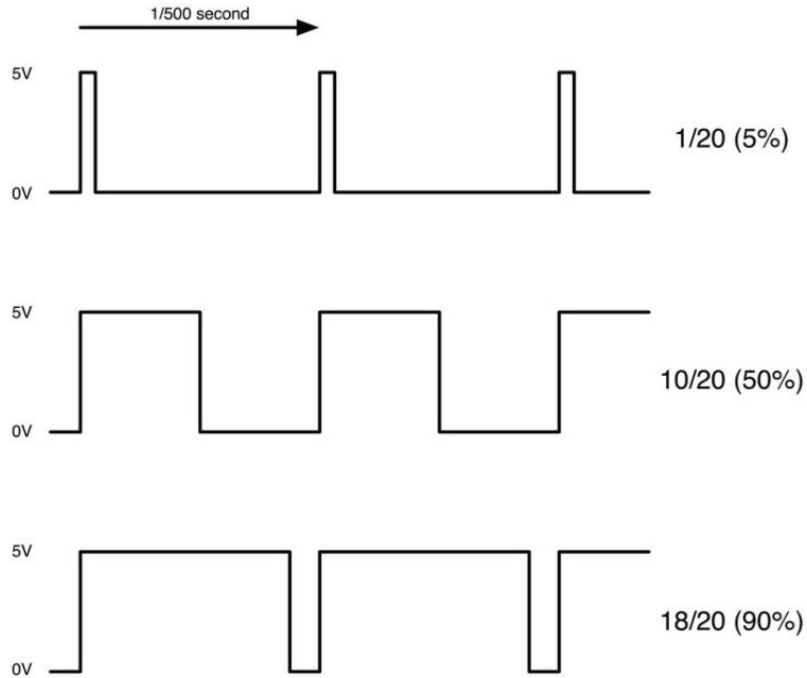




# DIY - Arduino Sizes

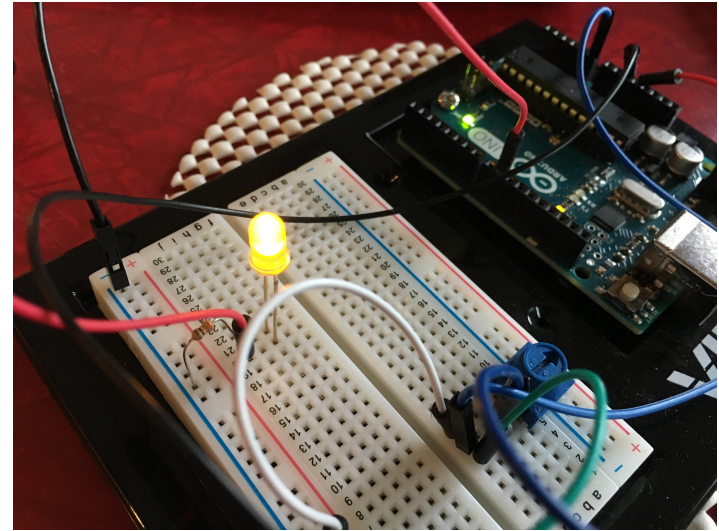


# Using an Arduino - PWM



LED is always at full power

Brightness is adjusted by changing the Duty Cycle

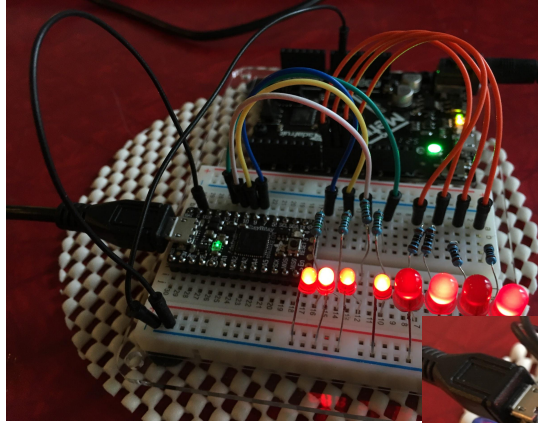
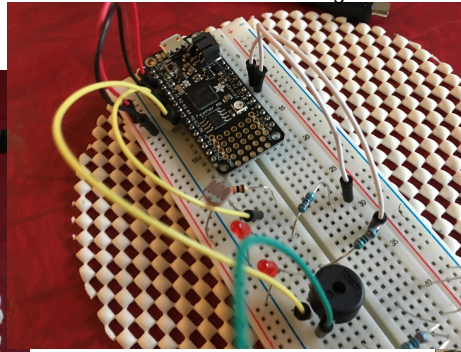


Arduino Uno

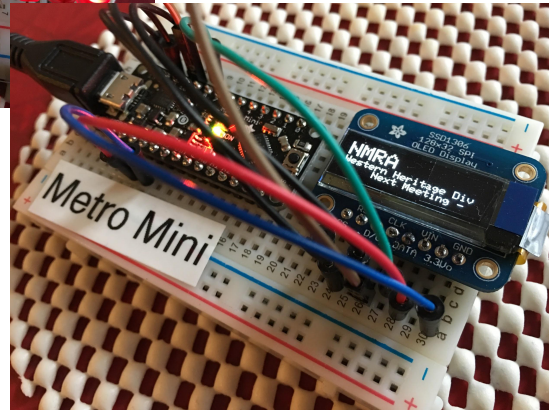


# Beacons, Strobes, Crossing Warning and OLED

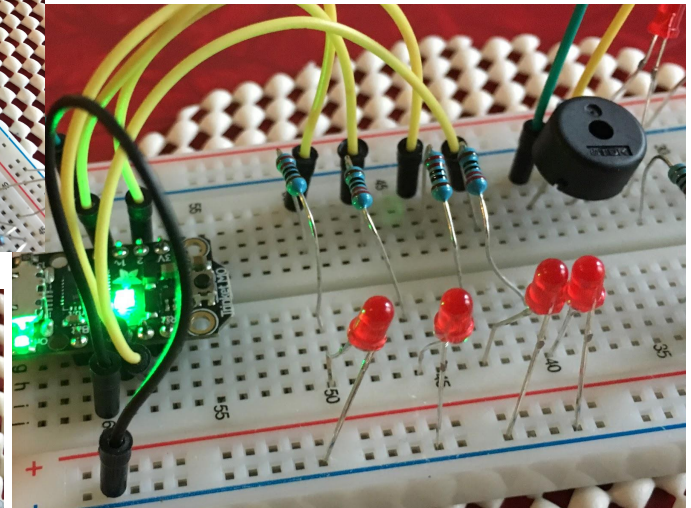
Feather with basics of RR Crossing



Metro and Itsy Bitsy  
With 4 Rotary Beacons each



Metro Mini with OLED Display



Trinket with 4 Strobe Lights

# Resources

LED Tutorials - <https://learn.adafruit.com/all-about-leds?view=all>  
<https://sites.google.com/site/markgurries/home/part-sources/led-s/resistors-for-leds-bulbs>

Resistor/LED apps - Circuit Playground App by Adafruit  
Digi-key App by Digi-Key  
For the desktop - just Google it, there are several

Resistor Substitution Box - Source: Amazon Maker: Elenco and others

Resistor Assortment - Source: Amazon - “Joe Knows” and others

Parts Pal - <https://www.adafruit.com/product/2975>

NCE Light-it, Illuminator, Mini-Panel - <https://www.ncedcc.com/> or just ask Dave

Free Circuit Emulator - <https://www.tinkercad.com/circuits>

Inexpensive circuit emulator - ICircuits (Google it)

Arduino - I’ve used kits from Vilros, Adafruit (metro), MonoPrice.

Learning Resources: Arduino.org, Adafruit.com

“Stand-in Signals”-

Iowa Scaled Engineering - <https://www.iascaled.com/store/ModelRailroad/Signals>

Digitrax - <http://www.digitrax.com/products/detection-signaling/>

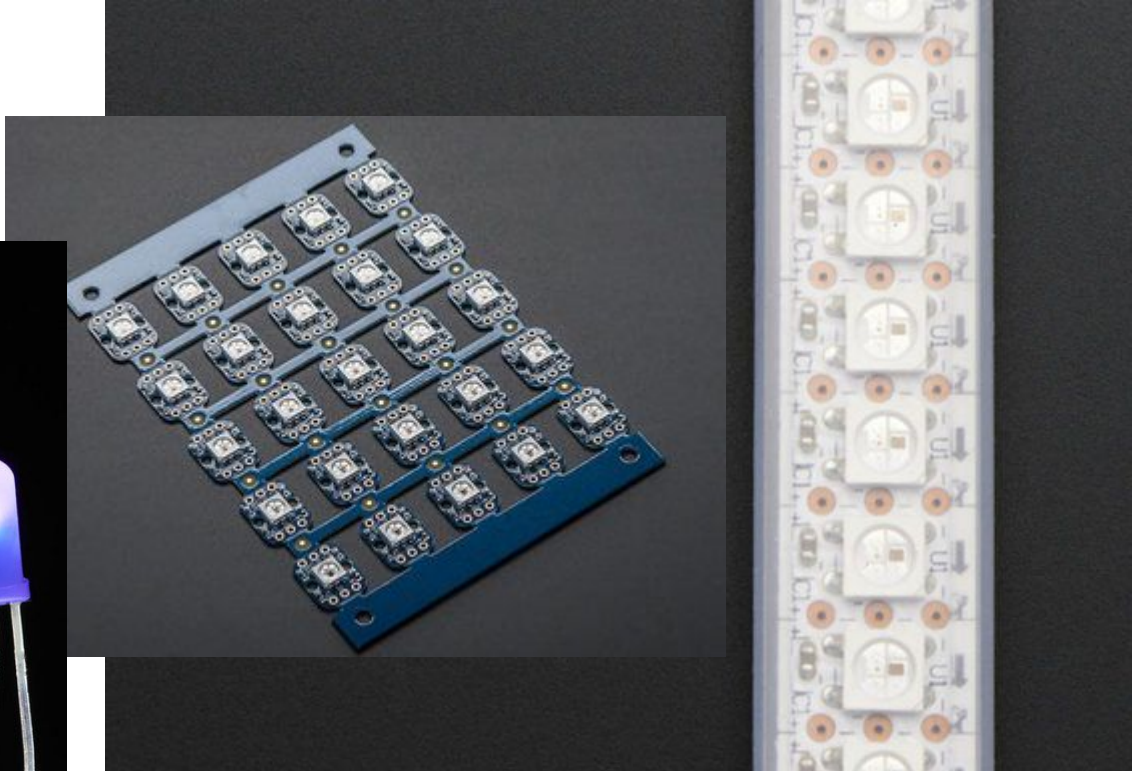
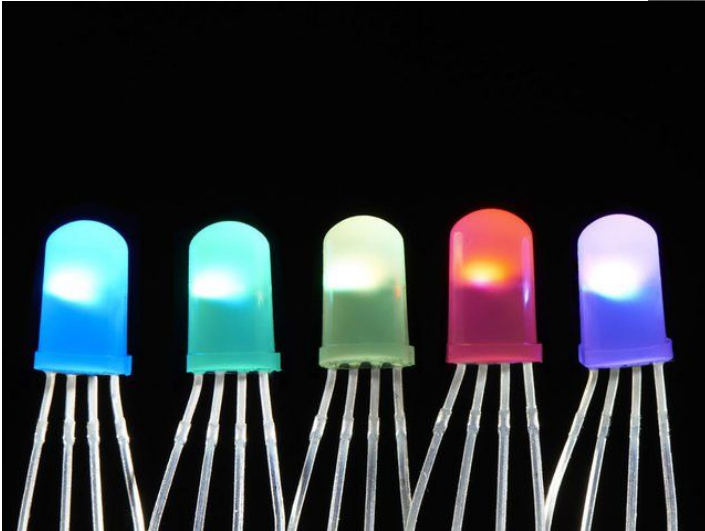
# Light Emitting Diodes

Part 2 - Addressable LEDs - NeoPixels

# Part 2 - Addressable LEDs

AKA - “NeoPixels” or “WS2812”

- Must be used with a micro-controller
- Very bright and power hungry
- Available in many forms
- No very small forms available
- RGB and RGBW versions





# Addressable LEDs - OMRA video

[Overview](#)

[Color Demo](#)

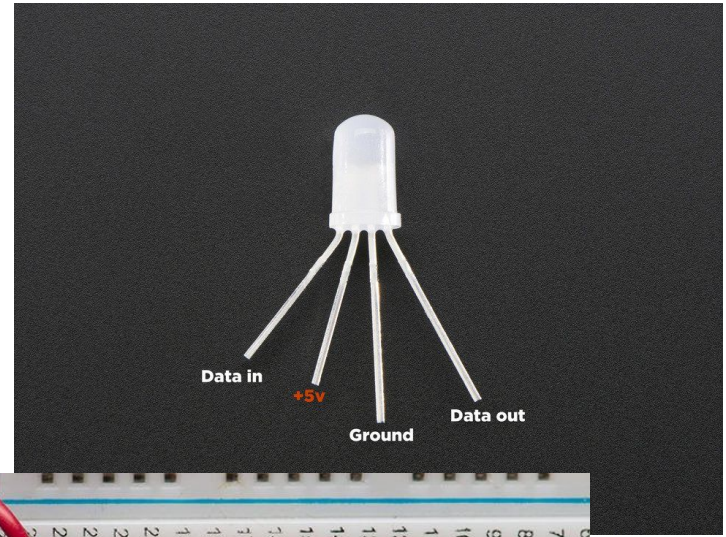
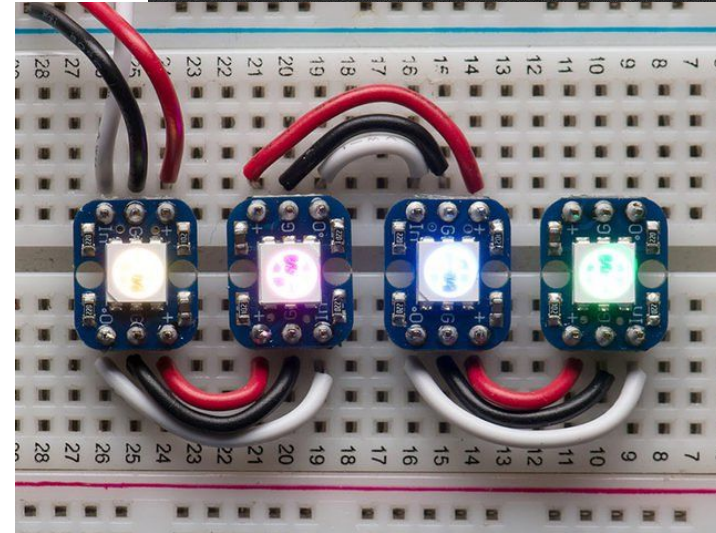
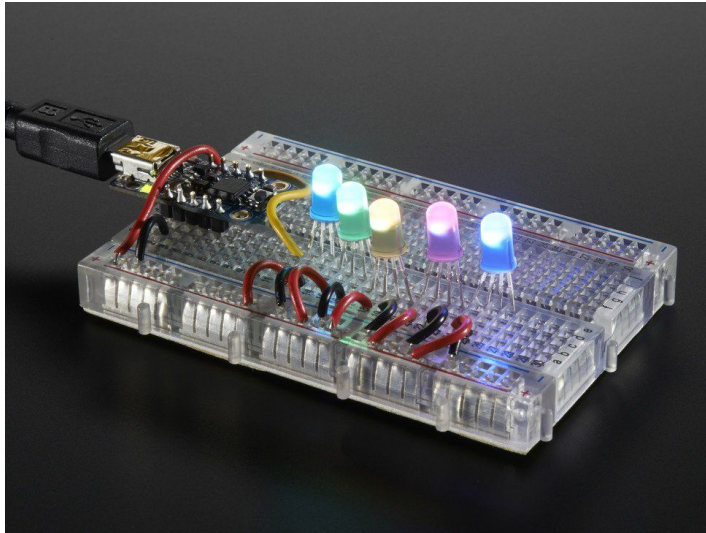


# Addressable LEDs

Reduced wiring

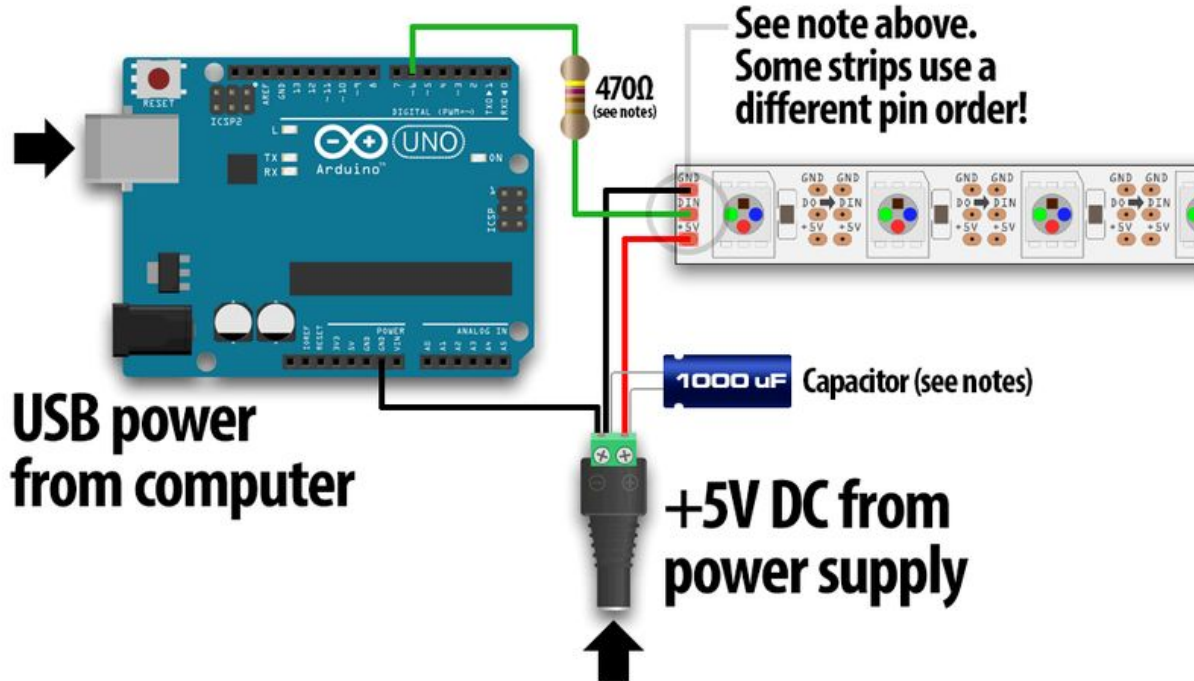
4 pins

Data in and Data out  
+5 and Ground



# Addressable LEDs

Connected in a serial chain



# Addressable LEDs - defining colors

RED = (0, 255, 0)

YELLOW = (150, 255, 0)

GREEN = (255, 0, 0)

BLUE = (0, 0, 255)

PURPLE = (0, 180, 255)

candle\_1900 = (132,255,0)

sunrise\_or\_set\_2500 = (159,255,70)

tungsten\_2900 = (174, 255, 103)

flourescent\_4200 = (211,255,175)

noon\_5200 = (252,255,213)

cloudy\_9000 = (223, 210,255)

OFF = (0,0,0)



# Addressable LEDs - sending data

“Make all pixels in the string glow as fluorescent lightbulbs”

```
pixels.fill(flourescent_4200)  
pixels.show()
```

“Make pixel number 4 glow red”

```
pixels.setpixel(3, RED)  
pixels.show()
```

“Turn off pixel number 5”

```
pixels.setpixel(4, OFF)  
pixels.show()
```

*Many software languages start counting at 0*

# Resources - Part 2

Addressable LED Tutorial - <https://learn.adafruit.com/adafruit-neopixel-uberguide?view=all>

OMRA full video - <https://youtu.be/k8iCOa0sIXo>

WS2812 Sample Data Sheet - <https://cdn-shop.adafruit.com/datasheets/WS2812.pdf>

Digikey Product Page - <https://www.digikey.com/catalog/en/partgroup/ws2812-and-ws2812b-rgb-led-module/50496>

Jameco Product Page - [https://www.jameco.com/z/WS2812-SMD-WS2812-Surface-Mount-RGB-LED\\_2245239.html](https://www.jameco.com/z/WS2812-SMD-WS2812-Surface-Mount-RGB-LED_2245239.html)

Book Reference - Electronics Cookbook by Simon Monk (Amazon Link) -

[https://www.amazon.com/Electronics-Cookbook-Practical-Electronic-Raspberry/dp/1491953403/ref=sr\\_1\\_1?ie=UTF8&qid=1527794840&sr=8-1&keywords=electronics+cookbook](https://www.amazon.com/Electronics-Cookbook-Practical-Electronic-Raspberry/dp/1491953403/ref=sr_1_1?ie=UTF8&qid=1527794840&sr=8-1&keywords=electronics+cookbook)

Color temp to RGB conversion calculator - <https://academo.org/demos/colour-temperature-relationship/>