LEDs

ECE 320 Electronics I (Digital Electronics)

Jake Glower - Lecture #7

Light Emitting Diodes (LEDs)

Light Emitting Diodes (LED's)

- Are diodes, allowing current to only flow in one direction,
- They convert current to light.(light is proportional to current flow),
- They are *very* fast, capable of over 1000 flashes per second, and
- They are a simple way to output binary data (light on / light off)

LightHouse LEDs (ebay)

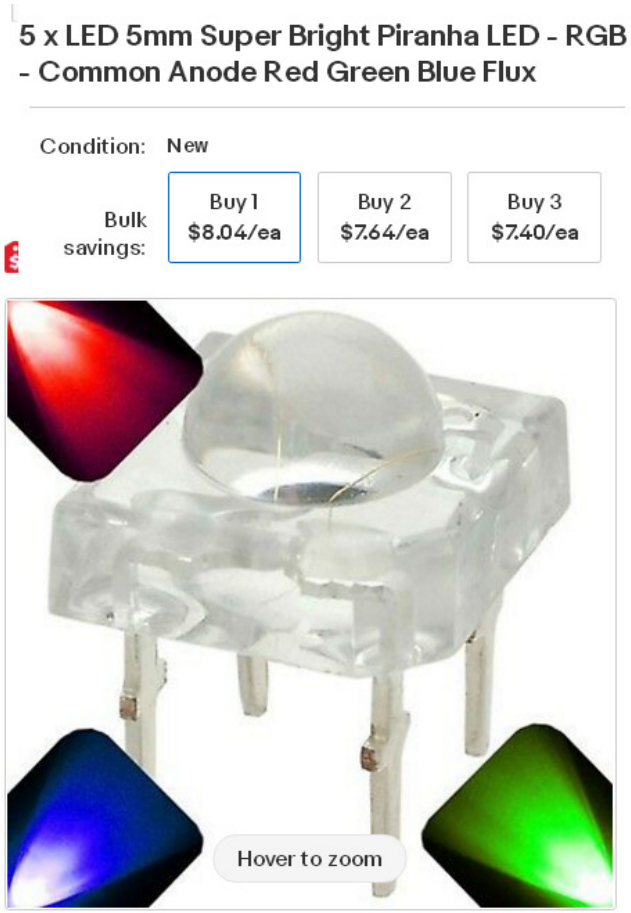
- https://www.ebay.com/str/lighthouseleds

RGB LEDs (one pixel of a street sign)

- 3.2V .. 3.6V @ 20mA
- 10,000mcd @ 20mA
- $1.68 ea (2020 price)

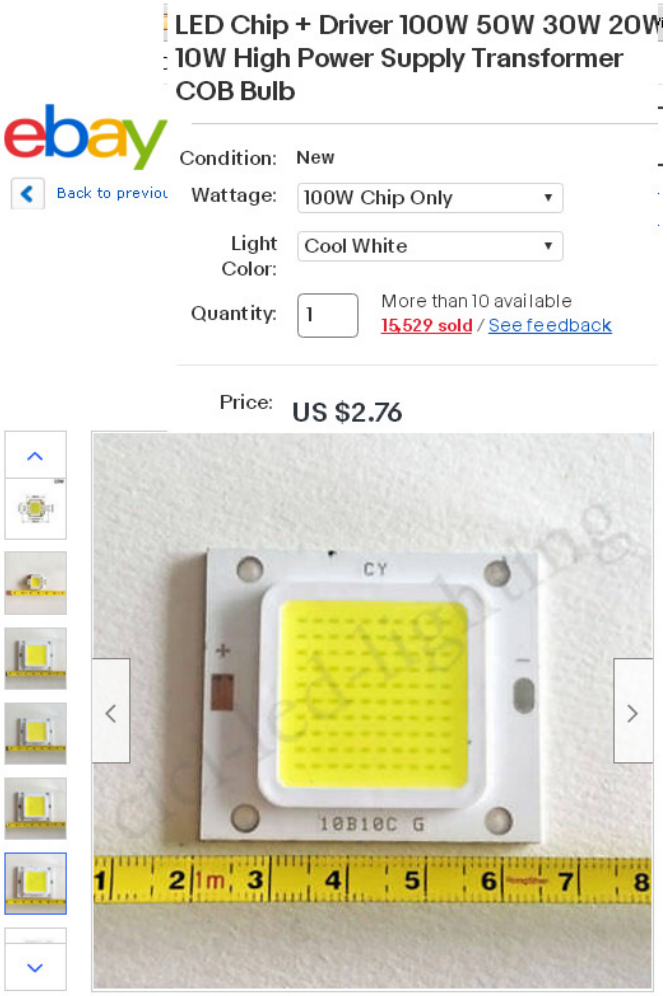
Surface Mount LEDs

- 0603 to 1206
- 0805 green LED used in ECE 376
- $0.59 each
- 3.0 to 3.2V @ 20mA
- 500mcd @ 20mA
- 521 - 527nm



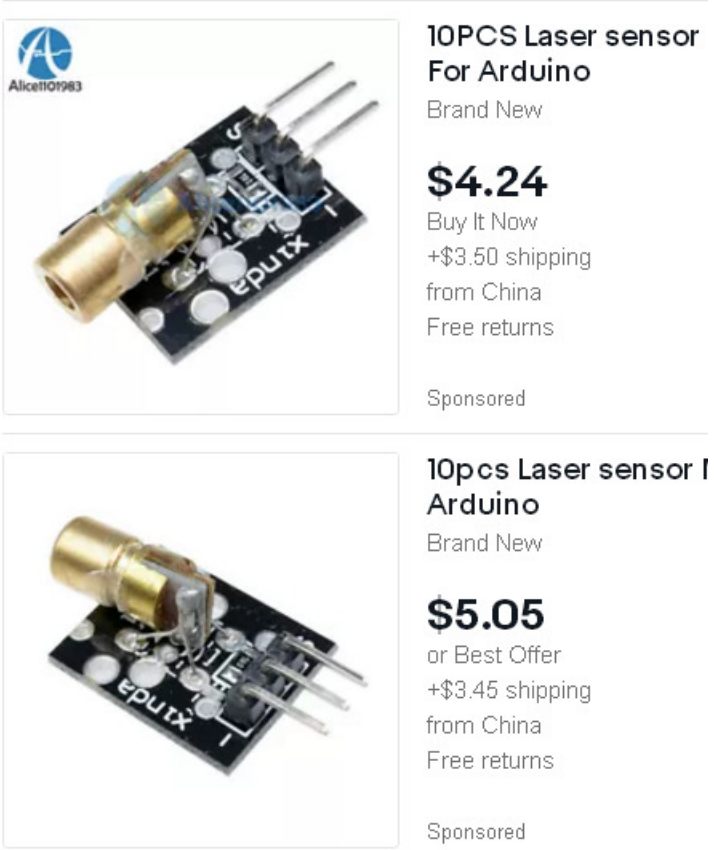
Ciciledlighting (ebay)

- https://www.ebay.com/str/ciciledlighting
- 100W LED
- Vf = 28V to 36V DC
- 3000mA
- 9000 to 10,000 lumens
- $2.76 chip (2020)
- $14.75 chip + driver



Laser Transmitter

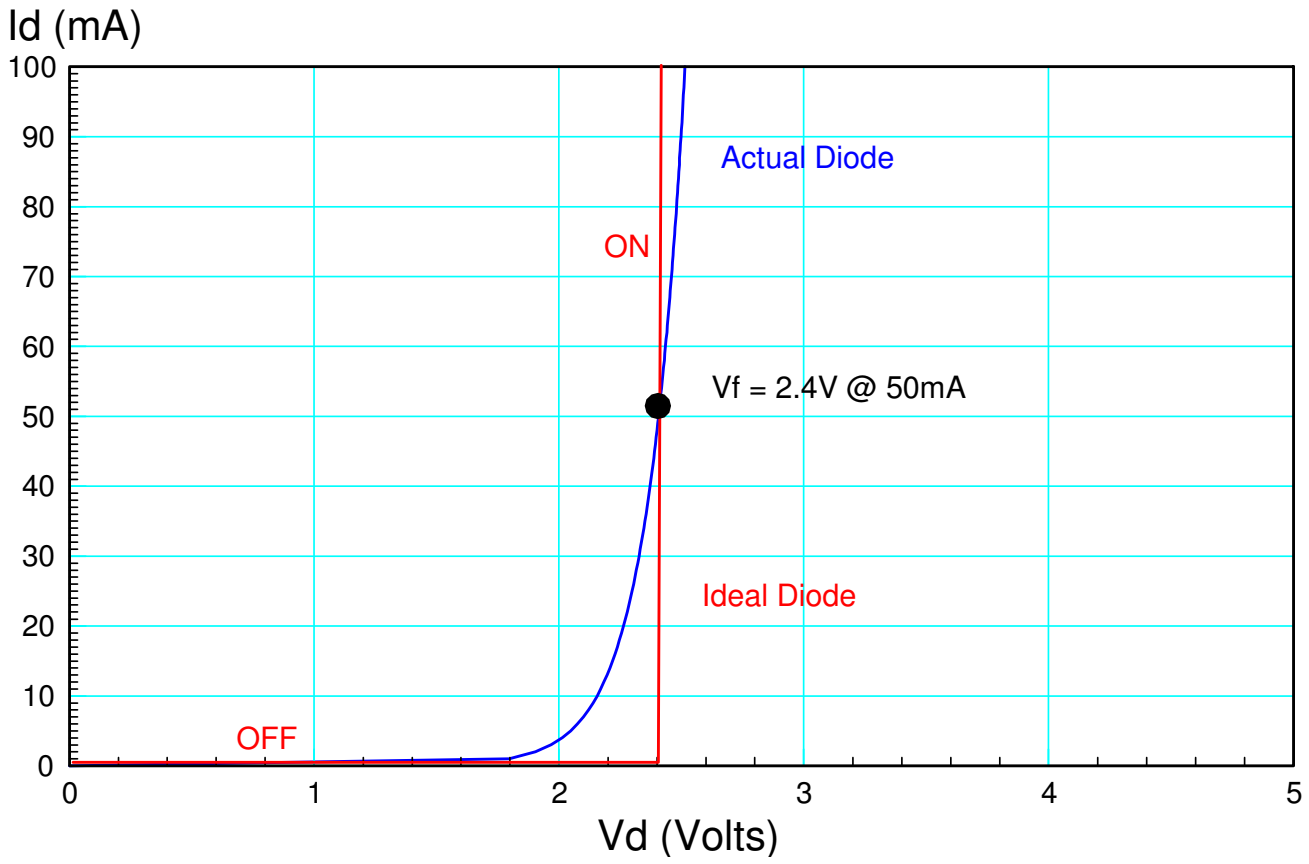
- search ebay "Arduino Laser LED"
- 5V, 5mW, 650nm
- Allow you to transmit data on a light beam



LED: VI Characteristics

Nonlinear - like all diodes

- Vd ≈ constant when on



Diode Specifications

- Vf: The voltage drop across the diode when on
- Typical mcd: The amount of light the LED outputs at a given current level
- Color: Kind of self evident
- Wavelength: A more accurate way of specifying the color of the LCD

LED	Wavelength	Imax (mA)	mcd @ 20mA	Vf @ 20mA	Price (ea)
Piranha RGB	630 nm (r)	25 mA	10,000	1.8V	$0.56
	520 nm (g)	25 mA	10,000	3.0V	
	470 nm (b)	25 mA	10,000	3.0V	
0805 Red LED	625 nm	20mA	180	2.0V	$0.19
10mm Red	625 nm	120mA	20 LM	2.15V	$0.31
10mm Yellow	592nm	120mA	15 LM	2.15V	$0.50
3W White	n/a	750mA	200 LM	3.4V	$1.90
10W White	n/a	1000mA	650 LM	11.0V	$7.62

Example 1: Determine Vd, Id, mcd

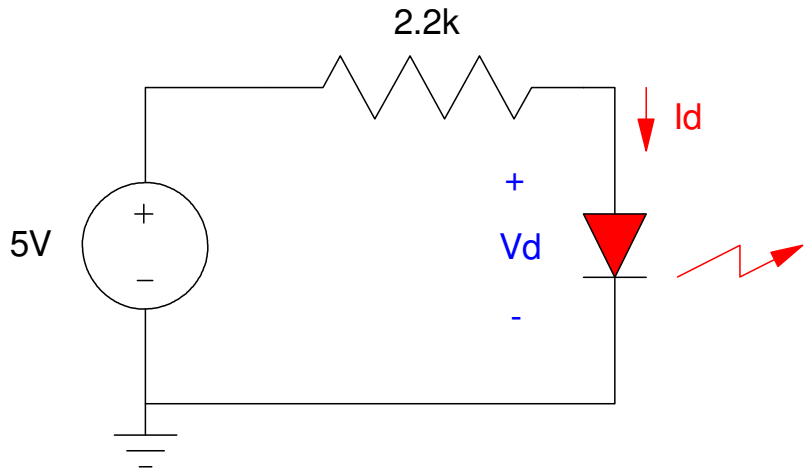
- Surface mount LEDs used in ECE 376
- 180mcd @ 20mA. 2.0V @ 20mA

Solution: Assuming ideal diodes

$$V_d = 2.0V$$

$$I_d = \left(\frac{5V - 2.0V}{2.2k}\right) = 1.3636\,mA$$

$$light = \left(\frac{180mcd}{20mA}\right) 1.3636mA = 12.27mcd$$



Example 2: Design a circuit to drive 500mA through a 3W white LED.

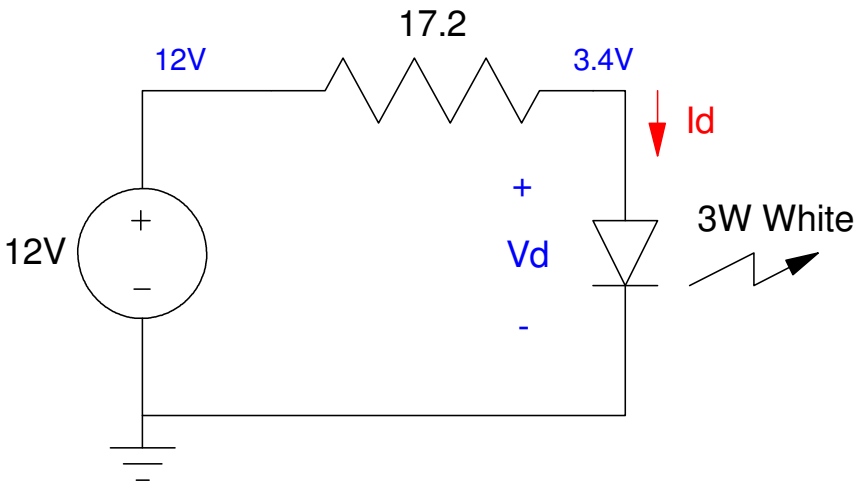
- Vf = 3.4V @ 750mA
- 200LM @ 750mA

Solution: Assume a 12V source

$$R = \left(\frac{12V - 3.4V}{500mA}\right) = 17.2\Omega$$

$$LM = \left(\frac{500mA}{750mA}\right) 200LM$$

$$= 133.3LM$$



Example 3: Build a purple LED

- 6900 mcd red
- 3100 mcd green
- 6800 mcd blue

Solution: Assume a 10V power supply.

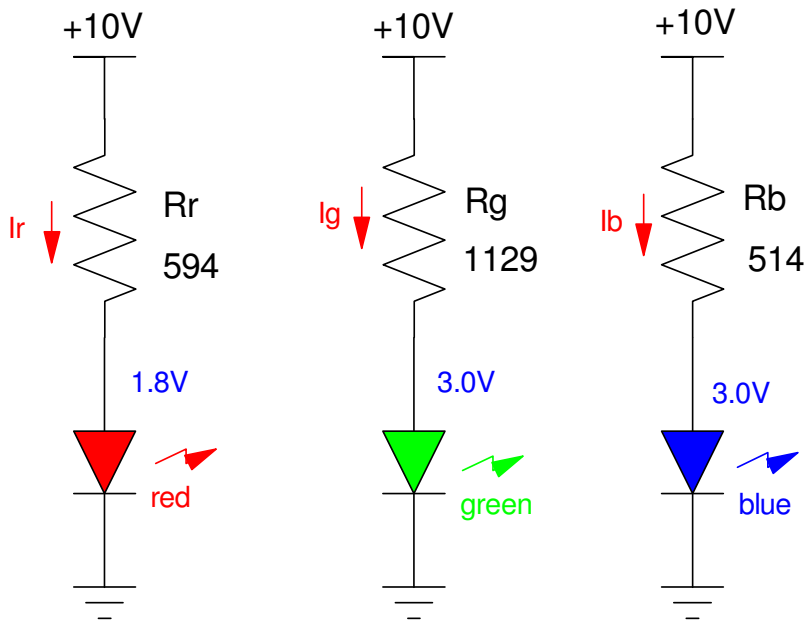
$$I_r = \left(\frac{6{,}900mcd}{10{,}000mcd}\right) 20mA = 13.8mA$$

$$R_r = \left(\frac{10V - 1.8V}{13.8mA}\right) = 594\Omega$$

$$I_g = \left(\frac{3{,}100mcd}{10{,}000mcd}\right) 20mA = 6.2mA$$

$$R_g = \left(\frac{10V - 3.0V}{6.2mA}\right) = 1129\Omega$$

$$I_b = \left(\frac{6{,}800mcd}{10{,}000mcd}\right) 20mA = 13.6mA$$

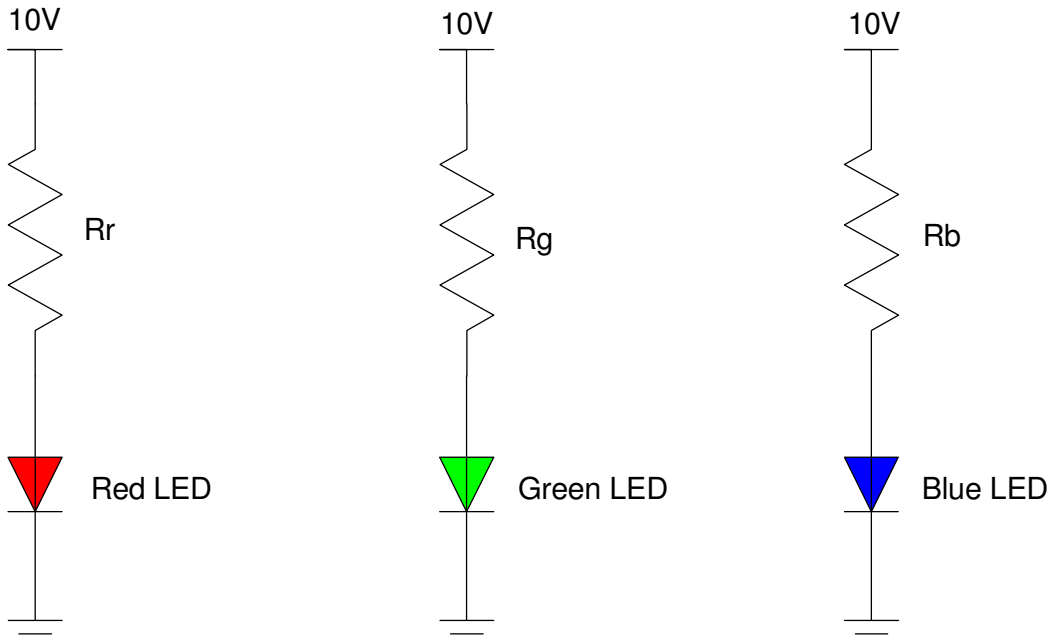


Handout

The specifications for an RGB LED are

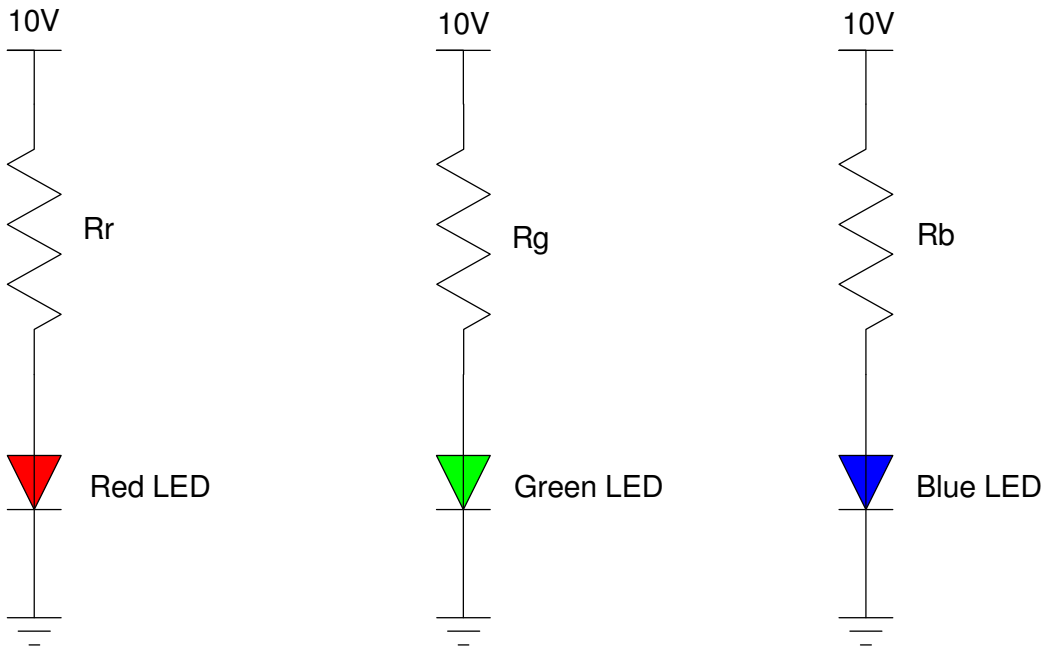
Color	Vf @ 20mA	mcd @ 20mA
Red	1.9V	10,000
Green	3.0V	10,000
Blue	3.0V	10,000

1) Assume Rr = 1k. Determine how bright the red LED is.



2) Find {Rr, Rg, Rb} so that the RGB LED outputs orange

- Red = 8000 mcd
- Green = 3000 mcd
- Blue = 750 mcd



1000W LED (90,000 lumens)

- When 900 Watts isn't enough
- https://youtu.be/-JVqRy0sWWY

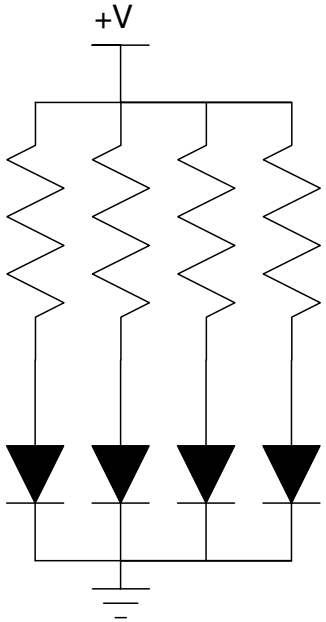
Powering Multiple LEDs

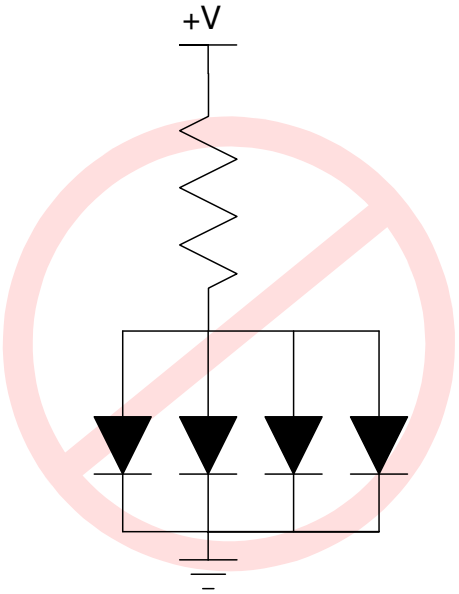
Placing in series works

Placing in parallel with separate resitors works

Placing in parallel does not work

- The LED with the lowest Vd takes most of the load and burns out





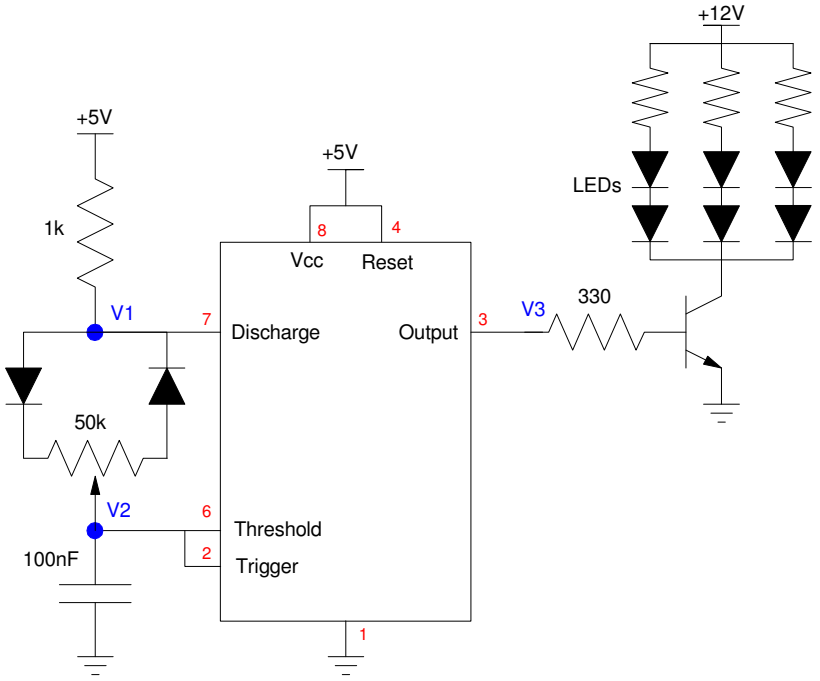
LED Driver

LEDs are current devices

- Light is proportional to current, not voltage

To vary the light output

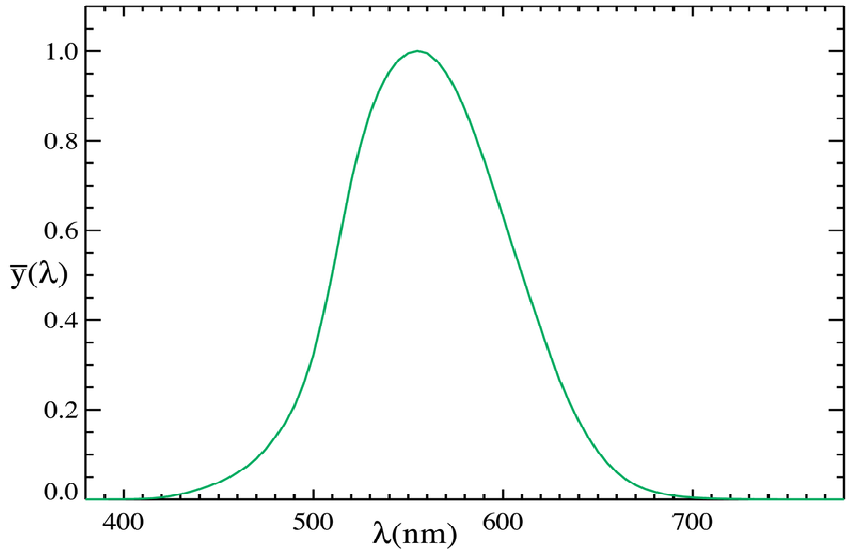
- Vary the resistance
  - MOSFET: Voltage Controlled Resistor
- Vary the duty cycle
  - 10% on = 10% brightness
  - 555 timer can be used
  - A microcontroller can be used
- Use a voltage-controlled current source
  - ECE 321: Analog Elecronics topic



Sidelight: What's the efficiency of LED light bulbs?

Depends upon how you define 100% efficient.

- The human eye is most sensitive to green light. If you limit yourself to green light, 100% efficiency is 683 lm/W.
- If you want white light, that depends upon how much energy goes into each color.
  - Assume an ideal black body radiating at 5800K, band limited to (400nm - 700nm).
  - 215 lm / W = 100%



Sensitivity of the human eye to light: (www.wikipedia.com)

Efficiency of Light Bulbs

	W, Lumens	Price		lm / W	eff
		new	@ 1000 hr		
Incandescent (c. 2000)	60W, 300 Lm	-	-	5.27	2.1%
Incancescent: GE 66247 (3)	43W, 620 Lm	$1.36	$1.38	14.4	5.7%
Halogen: Phillips 60W (3)	43W, 750 Lm	$1.46	$1.48	17.4	6.9%
CFL: Philips 823031 CFL (3)	13W, 860Lm	$3.50	$0.36	66.2	26.4%
LED: Sylvania 74765 (3)	8.5W, 800 Lm	$0.83	$0.075	94.1	37.5%
Street Lights:					
Mercury: GE 175W Street (3)	175W / 7850 Lm	$11.29		36	14%
Sodium: BulBrite (3)	70W / 6000 Lm	$8.95		86	34%
100W LED (4)	100W / 9000 Lm	$8.29		90	36%
LED Light (theory)				201	80%
Ideal Black Body	-	-		251	100%

3): www.Amazon.com (4) www.ebay.com

Implications:

- 1990: About 20% of the electricity produced in the U.S. went to lighting[1]
- 2021: About 5% of the electricity produced in the U.S. goes to lighting[2].

This reduction means

- Less coal needs to be burned and less CO2 is put into the atmosphere,
- Fewer power plants need to be built,
- Older, less efficient power plants can be retired, and
- Brown outs and blackouts are avoided - situations where energy demand exceeds supply.

This is why the less efficient lights were banned in Europe. You can still buy them in the U.S.

[1] www.lighting.sandia.gov

[2] https://www.eia.gov/tools/faqs/faq.php?id=99&t=3