

HyTech Racing Circuits Training

2019-2020

Dues



- If you would like to officially join HyTech Racing, you can pay dues using Venmo, PayPal, Square, or Cash.
 - Venmo: @hytechracing
 - PayPal: <u>gthytech@gmail.com</u>
 - Square: https://squareup.com/store/hytech-racing
 - Cash: See an Officer
- Paying dues gets you access to our Slack, Trello, Github, and Google Drive.
- Deadline is 9/15.

Initial Survey



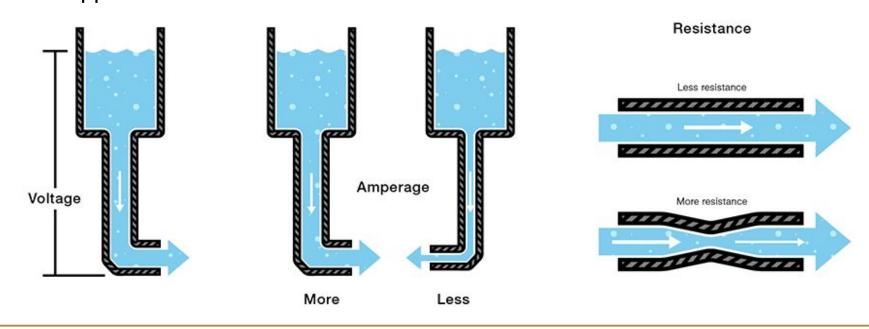
Fill out this survey here: https://tinyurl.com/2020CircuitsExperience.



Voltage, Current, and Resistance



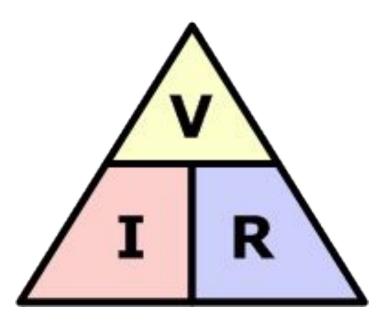
- Electricity is the flow of electrons.
- Three basic terms are voltage, current, and resistance.
- Imagine electrons as water:
 - Voltage: "Force behind electrons or pressure".
 - Current: "Number of electrons per second or flow rate".
 - Resistance: "Opposition to electron movement or flow constrictions".



Ohm's Law



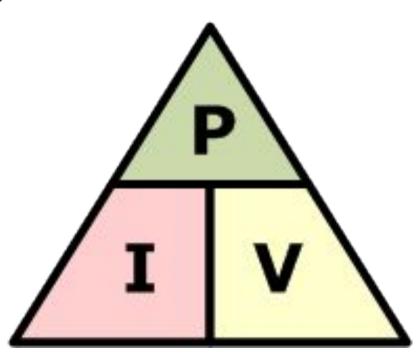
- **Ohm's Law** is the fundamental relationship between voltage, current, and resistance.
- Three Basic Units:
 - Voltage: Volts (V)
 - Current: Amps (A)
 - Resistance: Ohms (Ω)
- It is defined as $Voltage = Current \cdot Resistance$



Power



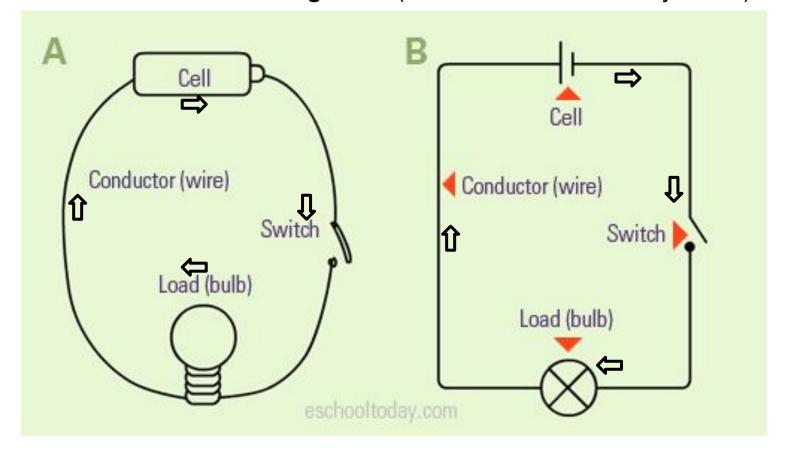
- One more aspect of electronics is power.
- Represents the work done by the electron movement.
- Usually can be considered as the heat output.
- Basic unit for power is Watt (W).
- It is defined as $Power = Voltage \cdot Current$



Electrical Circuits



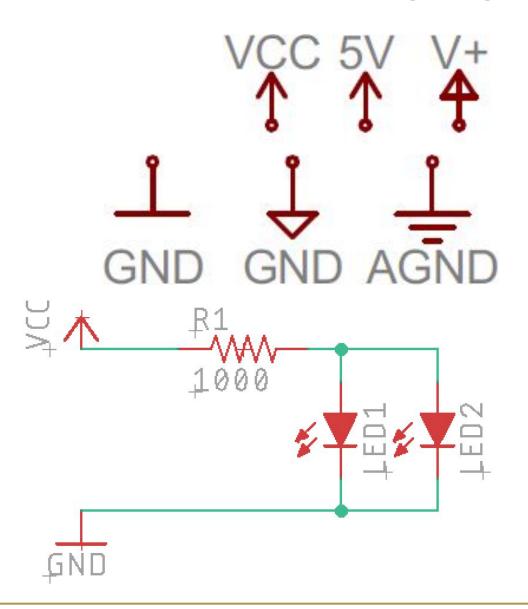
- An electric circuit is a path in which electrons from a voltage or current source flow.
- Electrons enter a circuit at the **source** (the right side of the battery below).
- Electrons leave a circuit at the return or earth ground (the left side of the battery below).



Power and Ground Symbols

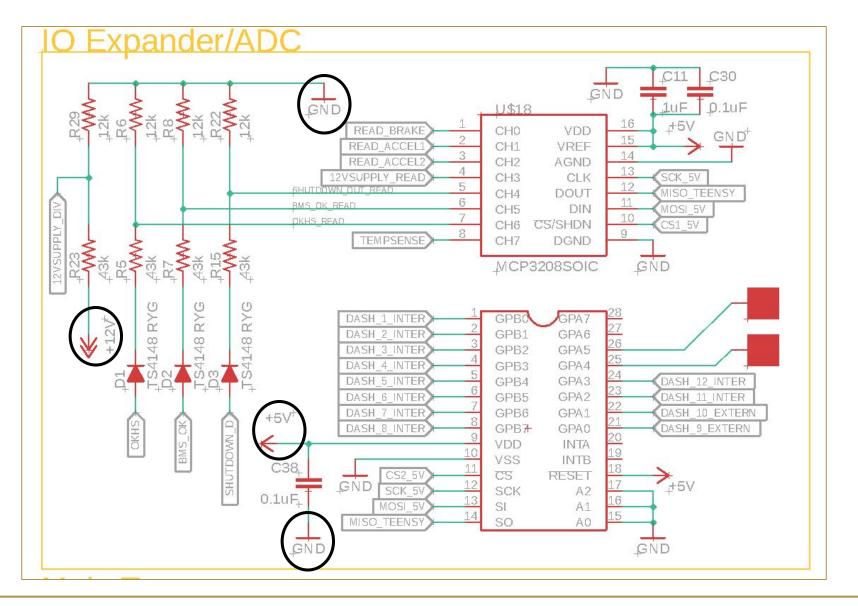
HYTECH

- Instead of drawing circuits as a big loop, we use power and ground symbols.
- Labeling is important for readability:
 - We label power symbols with specific voltages.
 - We label ground symbols with types of grounds.



Power and Ground Symbols (Schematic Example)



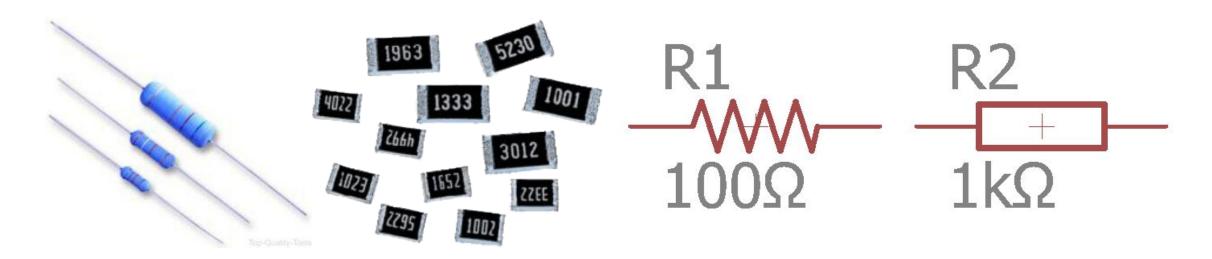


Resistors



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- A **resistor** is a passive two-terminal component that **has electrical resistance**.
- The resistance of a resistor is measured in **Ohms** (Ω).
- It is used to control current, adjust voltages, and so much more.
- It is the simplest part to use, as it linearly relates voltage and current.



Resistor Color Codes and SI Units



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Colour	Band 1 First digit	Band 2 Second digit	Band 3 Multiplier	Band 4 Tolerance	The Prefixes Used with SI Units			
Black	0	0	x 1 (x 1)	-	Prefix Symbol Meaning		ol Meaning	Scientific Notation
Brown Red	2	2	x 10 (x 10) x 100 (x 100)	1% 2%	exa- E 1,000,000,000,000,000,000 peta- P 1,000,000,000,000,000 tera- T 1,000,000,000,000		[1] INTERPORT TO SERVED AND SERVED AND SERVED STATE ST	10 ¹⁸ 10 ¹⁵
Orange	3	3	x 1 000 (x 1k)	not used	giga-	giga- G 1,000,000,000		10 ¹² 10 ⁹ 10 ⁶ 10 ³ 10 ² 10 ¹
Yellow	4	4	x 10 000 (x 10k)	not used	mega- kilo- hecto-	k k	1,000 1,000 100	10 ³
Green Blue	5 6	5 6	x 100 000 (x 100k) x 1 000 000 (x 1M)	not used not used	deka-	da	10	10 ¹
Violet	7	7		not used	deci- centi-	d	0.1 0.01	10 ⁻¹ 10 ⁻²
Grey	8	8	2	not used	milli-	m u	0.001 0.000 001	10 ⁻³ 10 ⁻⁶
White	9	9		not used	nano-	n	0.000 000 001	10 ⁻⁹ 10 ⁻¹²
Gold	1-	2	湿	5%	pico- femto-	1	0.000 000 000 001 0.000 000 000 000 001	10-15
Silver	-5			10%	atto-	a	0.000 000 000 000 000 0	01 10-18





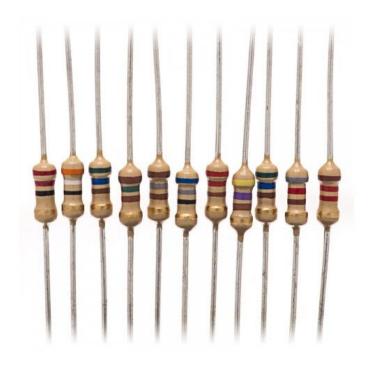
 $391 = 39 \times 10^{1} = 390 \Omega$ $270 = 27 \times 10^{0} = 27 \Omega$

Speccing Resistors



- Different resistors are made for different applications.
- When designing a circuit, it is important to choose correct components (speccing) to fit your application.
- For resistors, power rating is what matters:
 - This uses the formulas we discussed before.
 - Wattage rating cause resistors to be massively different in size (100W on the left and 0.25W on the right)

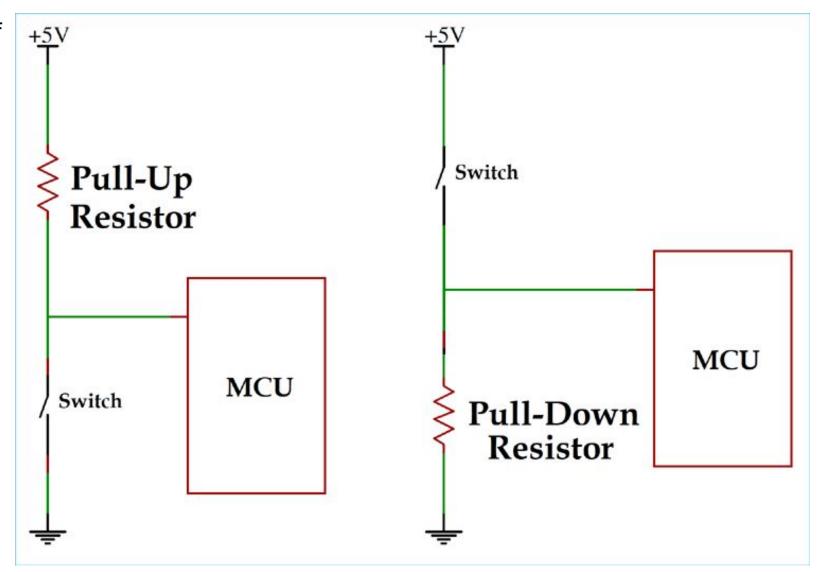




Pull-Up/Pull-Down Resistors



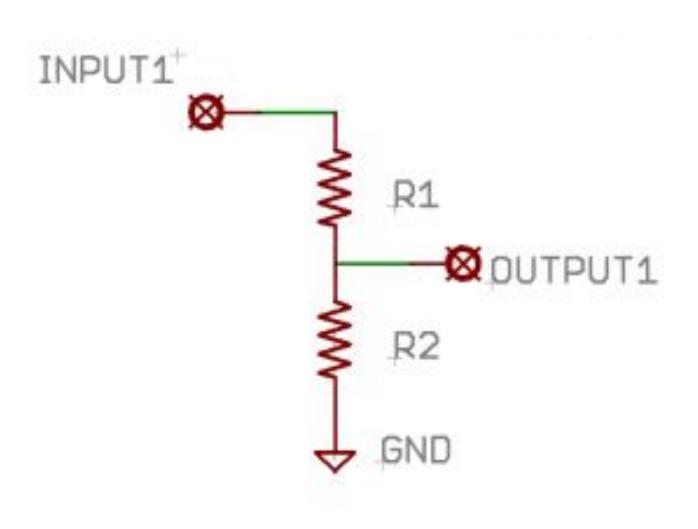
- There are two major applications of resistors.
 - Pull-up resistors are used to ensure that a signal line goes to Power if disconnected from the source of the signal. (e.g. buttons and switches)
 - Pull-down resistors are used to ensure that a signal line goes to Ground if disconnected from the source of the signal. (e.g. sensor signal)



Voltage Dividers



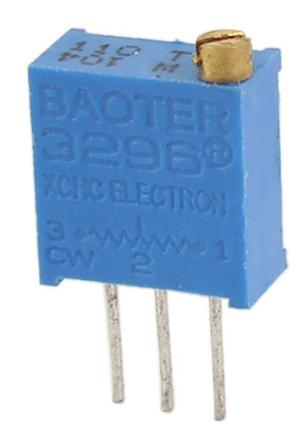
- Voltage dividers do exactly what they sound like, they divide the voltage of a input.
- HyTech often uses voltage dividers (e.g. to read an analog signal that has a range of 0-12V with a microcontroller that can only accept up to 5V).
- Their behavior can be calculated using Ohm's Law.
- It is defined as $OUTPUT1 = INPUT1 \cdot \frac{R2}{R1 + R2}$.
 - An example is converting a 12V signal from the charger into a 3V signal for the charger controller microcontroller.
 - R1 is 30kΩ and R2 is 10kΩ, which is ¼ ratio of output to input.

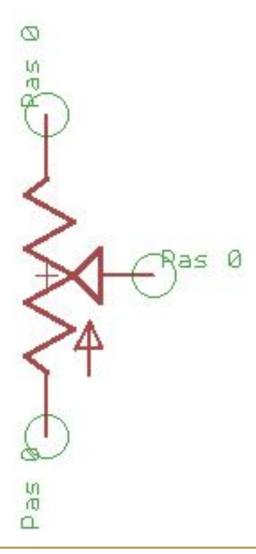


Potentiometers



- A potentiometer is a passive three-terminal component that has adjustable electrical resistance.
- It is also called a trimpot or pot.
- It is often part of a tunable voltage divider to allow for later circuit adjustment:
 - The middle lead to an outer lead has the adjustable resistance.
 - The outer leads combined have the maximum fixed resistance

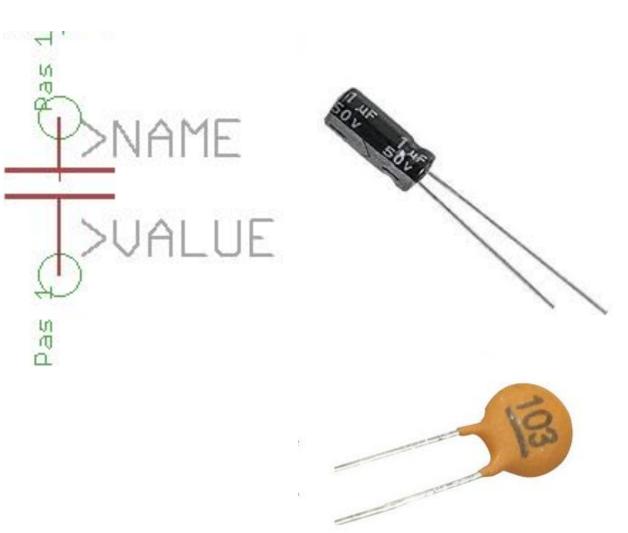




Capacitors



- A capacitor is a passive two-terminal device that stores electrical charge.
- The measure of the amount of stored charge is capacitance, which is measured in Farads (F).
- It is a more complex part to use, however, as it nonlinearly relates voltage and current.



Speccing Capacitor



- Different capacitors are made for different applications.
- For capacitors, voltage rating and capacitance is what matters:
 - Capacitance causes the capacitors to be massively different in size (1F on the left and 1µF on the right).
 - Voltage rating cause capacitors to be made of different materials.

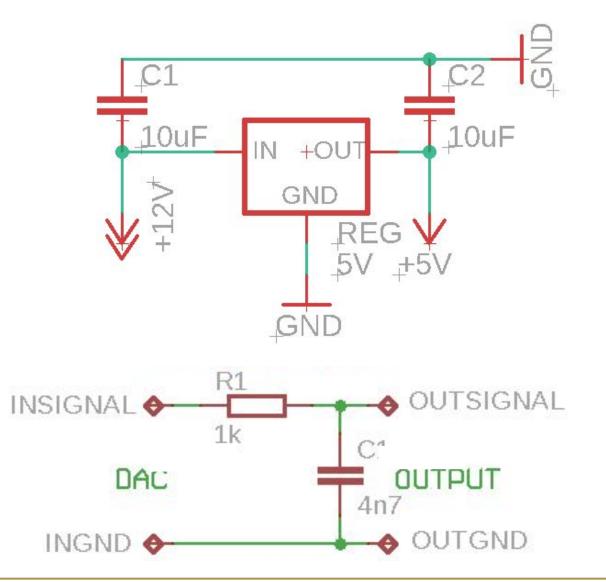




Capacitor Uses



- There are three major uses:
 - Decoupling capacitors (top) are capacitors
 between power and ground that ensure there is no
 noise on the power rails.
 - Delay timing uses the charging/discharging of a capacitor, which is nonlinear, to act as a delay to activate a signal.
 - Filtering (bottom) uses a resistor and capacitor to remove certain signals to have less "noise" in the signal.

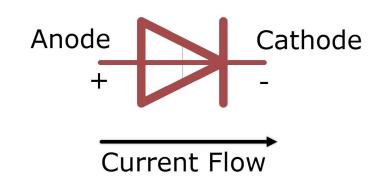


Diodes



- A diode is a two-terminal device that conducts current primarily in one direction:
 - It has a very low resistance in one direction after a certain voltage.
 - It has a very **high resistance** in another direction.
- There are several different kinds of diodes:
 - LEDs emit light.
 - PN Junction diodes are the main diodes HyTech uses.

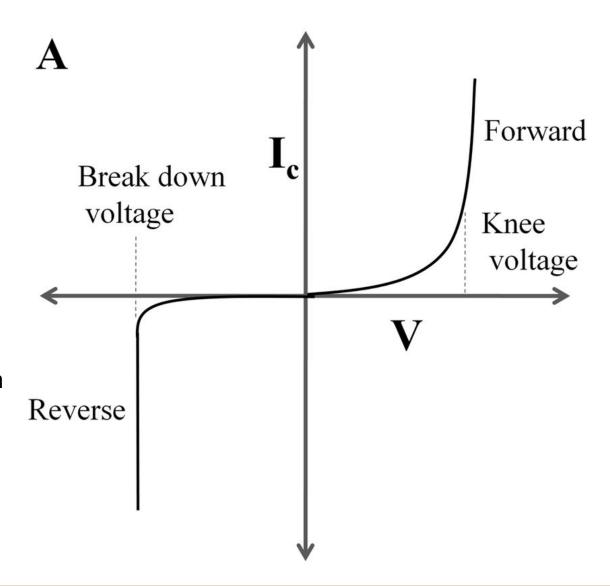




Diode Characteristics



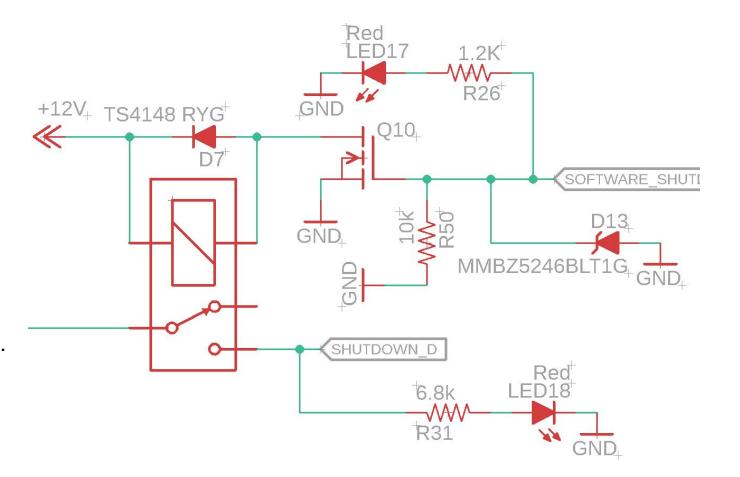
- Diodes have a bias or direction.
- Diodes have a knee voltage.
 - Before its knee voltage, the diode has a very high resistance.
 - After the knee voltage, the diode has a very low resistance.
- Diodes have a breakdown voltage or reverse bias voltage.
 - This is the maximum voltage that can be applied in reverse.
 - Beyond this point usually causes damage to the diode.



Diode Applications



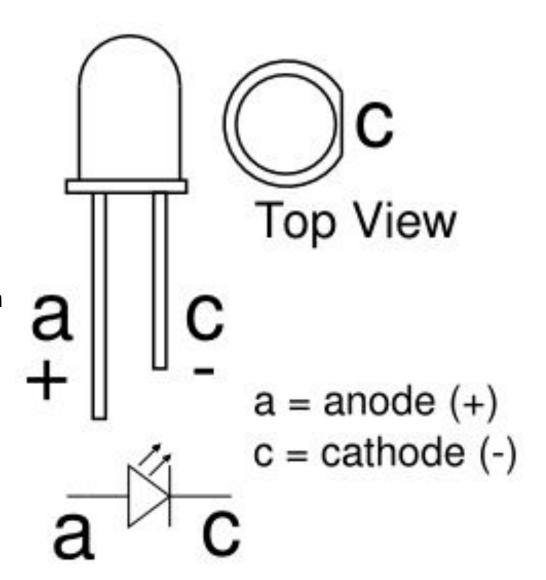
- A flyback diode (D7 in the schematic) is a diode used to eliminate voltage spikes.
 - The reason for those spikes is complicated, but is due to the change in state of the big square relay.
- LEDs (LED17 and LED18 in the schematic)
 are used as status indications.
 - These are especially useful in debugging.



Light Emitting Diodes (LEDs)



- A LED is a two-terminal diode that emits light when current passes through it.
- It acts like a normal diode otherwise.
- It is important, however, to maintain a constant current for a steady brightness.
 - That value is usually listed in a datasheet.
 - Every color of LEDs have a different relationship between voltage and resistor.

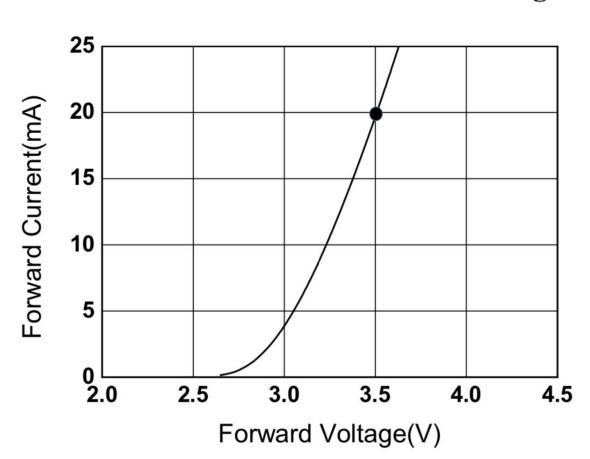


LED Applications



- The goal is to send a constant current to the LED.
- That means, if we have a known input voltage into the circuit, we need to figure out what resistor we need in series with the LED.
- It requires use of a **Current vs. Voltage Curves** like the one the right.
- If there is a 5V input, and 20mA needs to go through the LED:
 - We need to have 3.5V through the LED and 1.5V through the resistor (5V - 3.5V = 1.5V) and now apply Ohm's Law.
 - It should be a 75 Ω resistor from 1.5V / 20mA = 75 Ω .

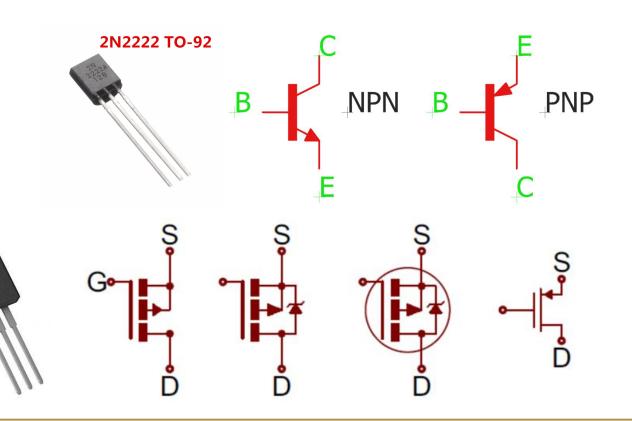
Forward Current vs. Forward Voltage



Transistors



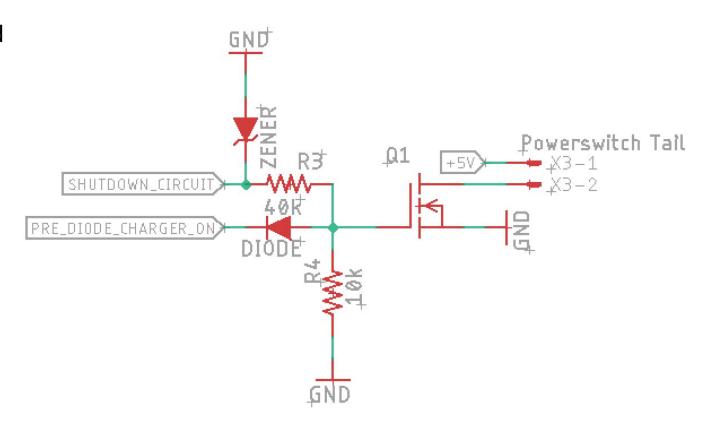
- A transistor is a semiconductor device used to amplify or switch electronic signals, usually with three terminals.
- Similar to diodes, there are several types:
 - BJTs (top on the right) are one major type.
 - MOSFETs (bottom on the right) are the other major type that HyTech prefers to use.
- For each type, there are two versions:
 - Normally open
 - Normally closed



Transistor Applications



- A MOSFET (Q1 in the schematic) here is used for switching on and off the charger.
 - The charger connection (X3 in the schematic) is considered the load, which is what the transistor is controlling.
 - This transistor is low side switching, meaning that the transistor is after the load and between it and ground.
 - This is opposed to high side switching, which has the transistor between power and the load.





Training Schedule

Date	Time	Location	Theme
Sunday 9/8	4:00pm - 6:00pm	SCC (Shop) AP Classroom	Arduino & EAGLE
Tuesday 9/10	6:30pm-8:15pm	SCC (Shop) AP Classroom	Car-related circuitry & EAGLE
Thursday 9/12	6:30pm-8:15pm	Invention Studio	Soldering