Basic Electronics Overview

As it pertains to simple PCB design

Voltage/Current

Voltage - Electric potential difference between two points

- Units - volts
- Usually relative to ground (GND), defined as zero volts
  - However, just relative, no universal “zero” which is why it is important to connect grounds

Current - “Rate of flow of electric charge” - wikipedia

- Units - amps
- Convention: flows from positive to negative
  - In reality it is negative charges (electrons)

V=IR

What is ground?

Ground is a reference voltage

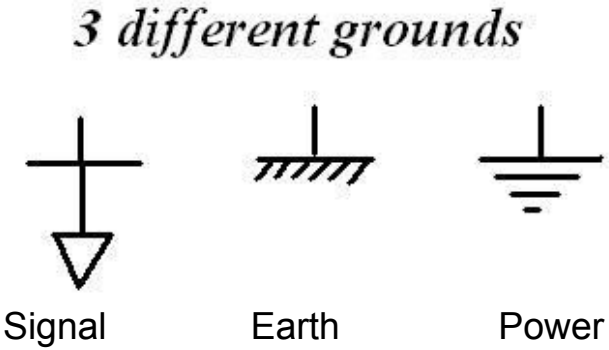
There are digital, analog, chassis, and earth ground

Earth ground is literally metal shoved into the earth

Chassis is the metal enclosure around something, ex) Ethernet jack

Digital/analog/signal grounds are local to a circuit and can be tied to chassis and/or earth

Tie all your signal grounds together or they can't communicate!!



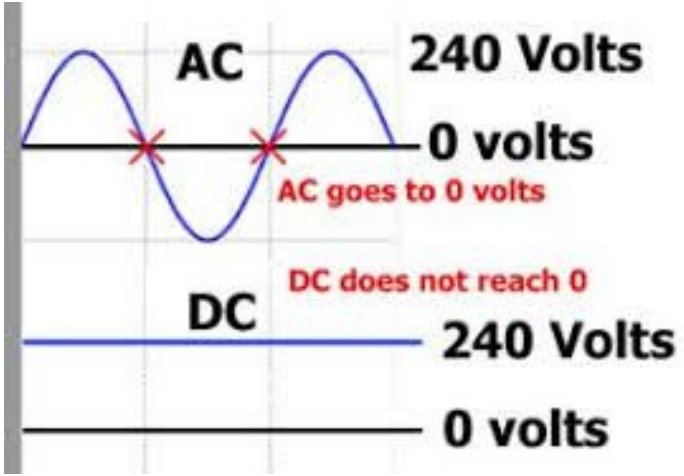
AC/DC

DC - direct current, charge flows from positive to negative and is at a constant voltage and current.

- Powers most electronics

AC - Alternating current, both current and voltage swing from positive to negative value

- Comes out of wall (120VAC in US, higher in Europe, etc)
- Often use converter to go from AC to DC



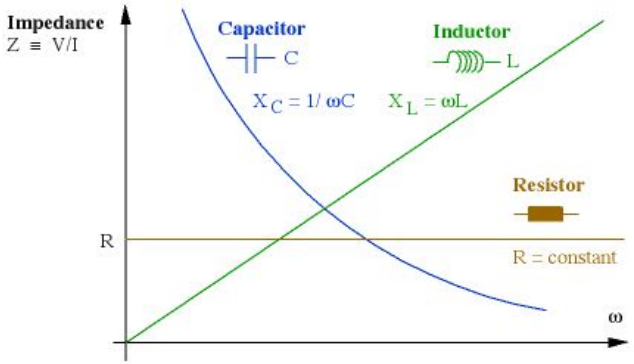
Passives - RLC

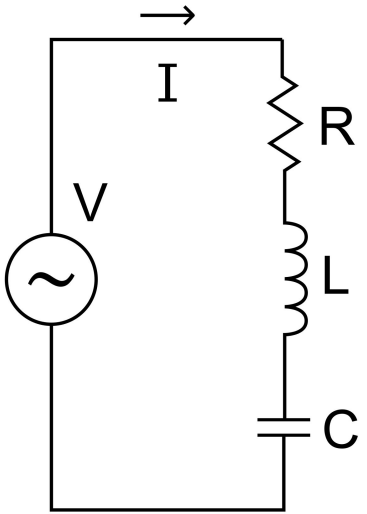
Impedance - Like resistance but in AC. Depends on frequency

Resistors - Z = R. Not frequency dependent. Useful for pullups/pulldowns, dissipating energy, setting voltage level

Capacitor - Z = 1/jwC, gets less “resistive” with higher frequency. Useful for filtering noise, AC coupling

Inductors - Z = jwL, gets more “resistive” with higher frequency. Useful for feedback, power regulation, etc (beyond scope of seminar)





Switches/Buttons

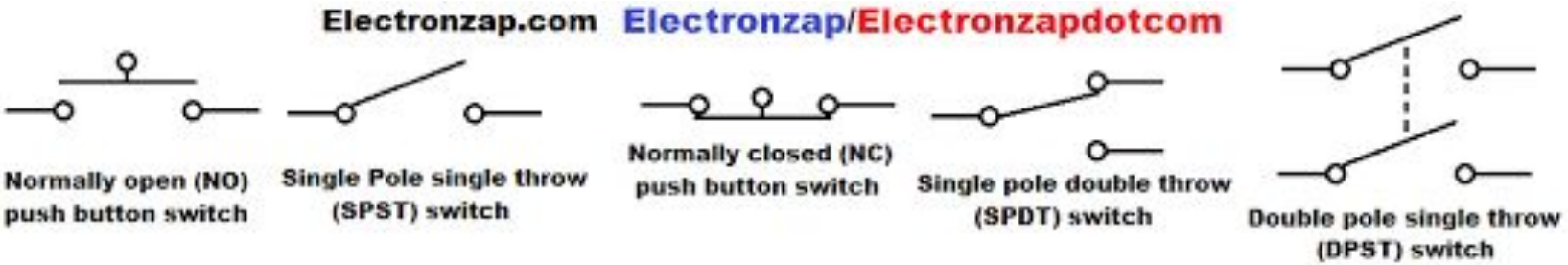
Connect or disconnect two or more components

Normally open (NO) - disconnected by default

Normally Closed (NC) - connected by default

Pole - Circuits that switch can control in one operation

Throw - Number of contact points per pole



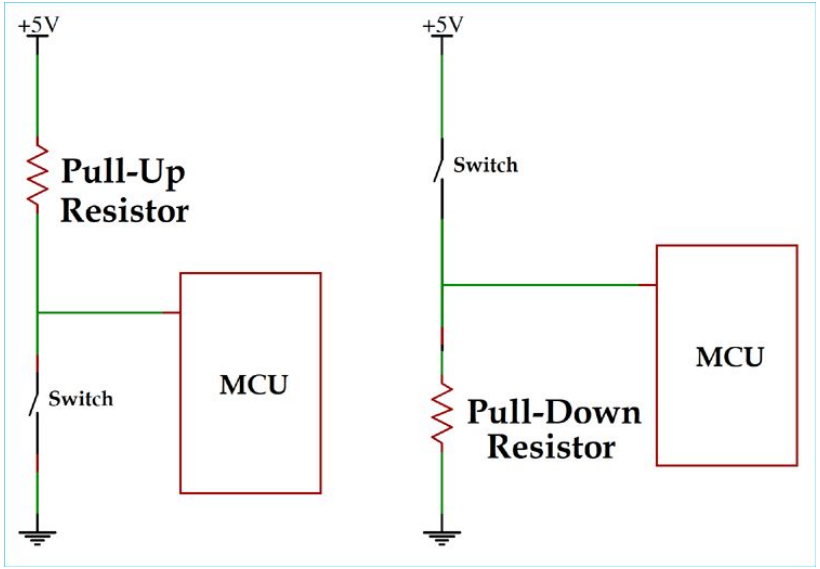
Pull-ups/Pull-downs

If nothing is connected to an input, it will be floating (undefined state)

Big resistors tied to known value set default state of input

Pull-up - default high, switch pulls low

Pull-down - default low, switch pulls high

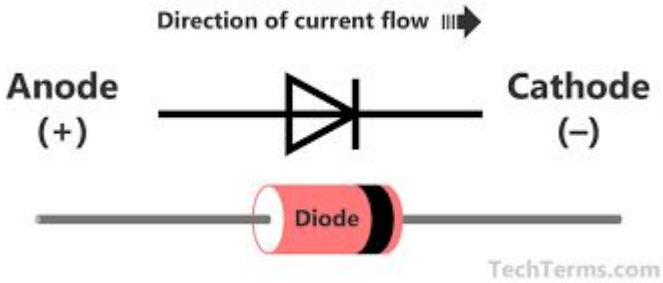


Diodes

(Ideally) only let current flow in one direction

Need high side and low side to let current flow

LEDs - Light emitting diodes; emit light when enough current flows



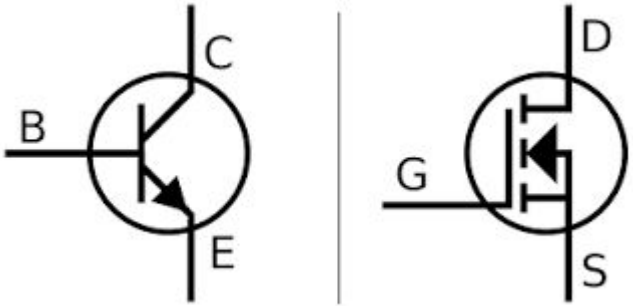
Transistors

“A semiconductor device used to amplify or switch electronic signals and electrical power” -wikipedia

Several courses taught on these bad boys to learn more

ICs are made of these, who am I to disagree?

Discrete transistors used on boards for high power, reverse polarity protection, switches, etc.



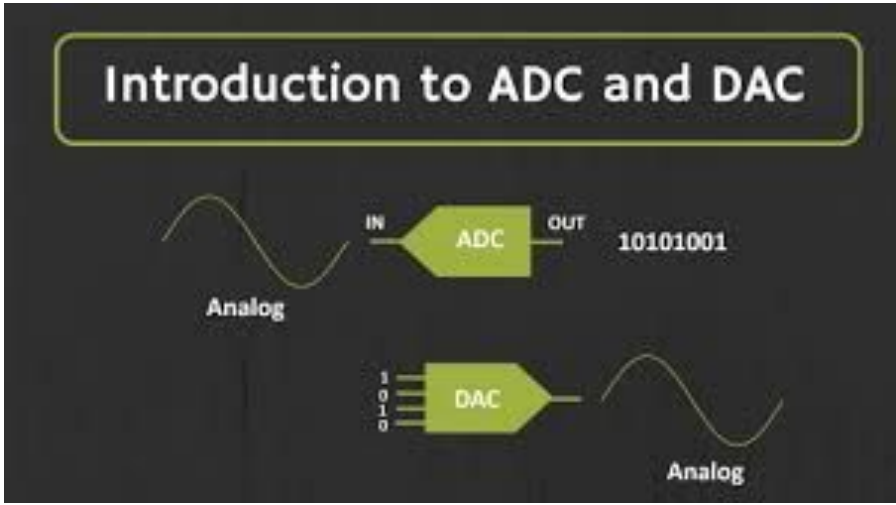
ADC/DAC

ADC - Analog to digital converter

- Some signals fall on a spectrum rather than binary value, need to translate to something a computer can understand

DAC - Digital to analog converter

- Computer can only generate binary values, but, for example, audio sounds like garbage if it is not continuous



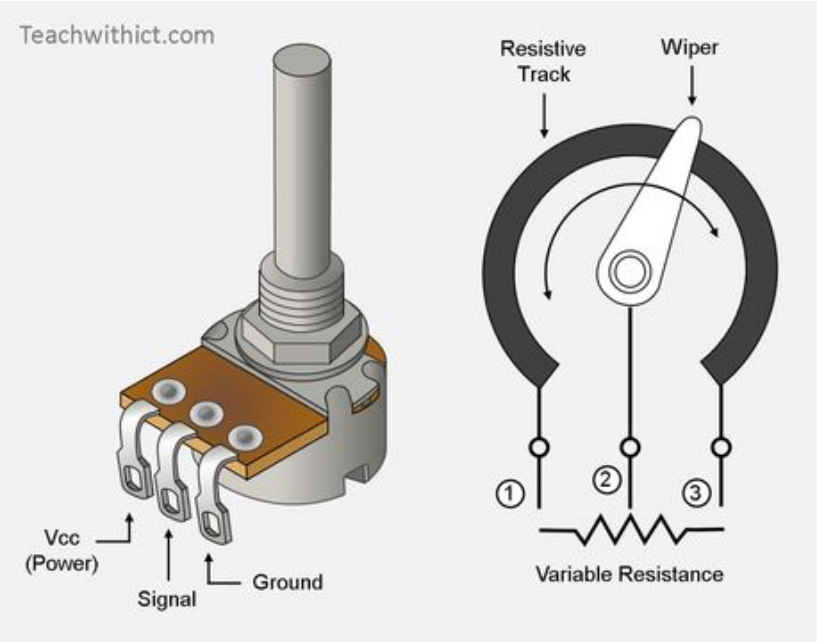
Potentiometers

Used for input or setting values

Vary from low to high resistance based on angular location of knob

Because the value is not binary, an ADC is used to translate value

Useful for calibration, user input, monitoring location of spinning parts, etc



ICs

Integrated circuit - many components on a single chip

Examples: microcontroller, power regulation, current monitoring, etc

Come in many different shapes and sizes

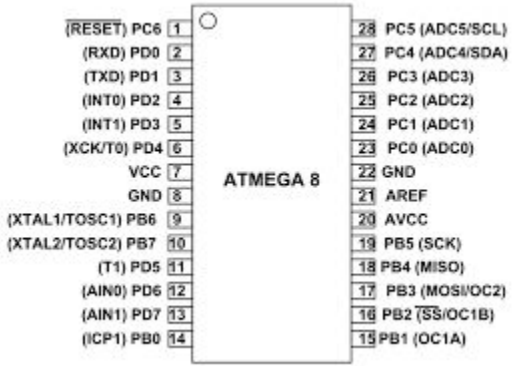
MCU - Microcontroller

Small computer on IC

Has CPU, memory, input/output

Can be very simple or very complex

Used for embedded applications, must be real-time (makes them fast but simple)

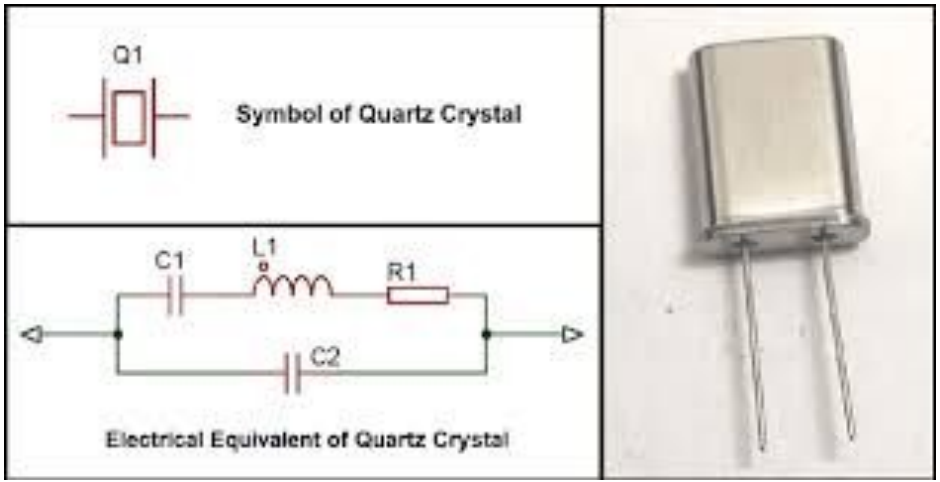


Crystals/Clocks/Oscillators

Used to keep time - precise cycles per second

Accuracy is important for real time computations

Some MCUs/ICs have built in oscillators, others need external on PCB



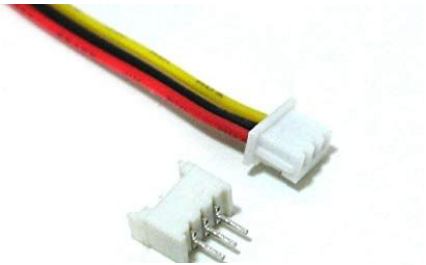
Connectors/Headers

Headers denote on-board connection points

Selection criteria include:

- Number of pins
- Current capacity of pins
- Lifecycle (how many times can you plug and unplug)
- Lock in
  - Can’t naturally come undone, require tab
- Directionality
  - So you can’t plug it in backwards and fry your board

Matters so much in aerospace, automotive, etc



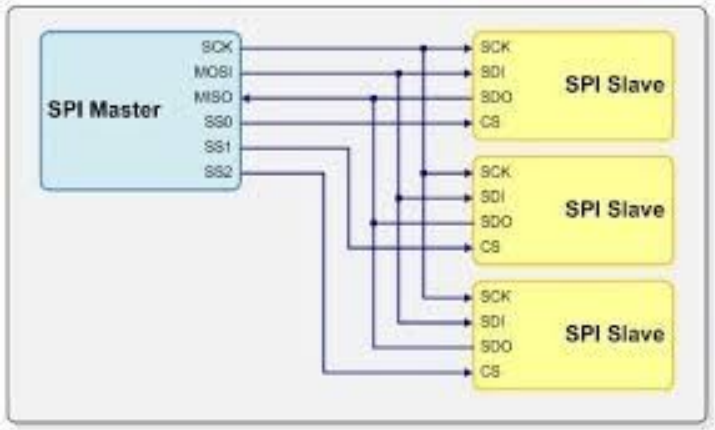
Common Communication Protocols

Ways that two devices can transmit/receive information (TX/RX)

Board level examples: Serial, I2C, SPI

What defines protocol?

- Synchronous/asynchronous (clocked)
- Impedance control: better for long distances
- Bus or direct
- Wired or wireless (WiFi, Bluetooth)



Serial Communication Protocols: Comparison

	UART	SPI	I2C
Maximum Speed	115200b/s	10 Mbps	5 Mbps
Synchronous/ Asynchronous	Asynchronous	Synchronous	Synchronous
# Of Wires	2	4	2
Max # of Masters	1	1	Unlimited
Max # of Slaves	1	Unlimited*	1008

Borrowed from Prof. Petersen's ECE 3400 Class

Low/hi pass filters

Low pass allows low frequency (including DC) signals through

High pass is the opposite (filters out DC and low frequency signals)

Cut-off frequency determined by value of passive components in RLC filters