Introduction to Electronics for Rapid Prototyping

or notes on how not to make things smoke and burn

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Power Concepts

- Alternating and Direct Current
  - DC has polarity (+ VCC, - GND), AC has cycles
  - DC is usually lower voltage and is less dangerous to the human body but it can still hurt you real bad (lightning is DC).
- Measuring power (hydrology analogy)
  - Volts [V] (water pressure)
  - Amps [A, I, ma] (size of the pipe) (milla means thousandths not millionths)
  - Watts [W] (total water delivered at a given point in time)
  - A = W / V or my Aunt is from West Virginia
    - Or W=V*A, e.g. a hair dyer at 1500W is drawing 13.6A at 110V AC
    - A 2000W motor plugged into 15 amp 110V house current is why we have circuit breakers.
  - Volts is how much your power source supplies *regardless* of the circuit demand, Amps is how much your circuit demands from that source. A 15A power supply will only provide 1A to a circuit that draws 1A and will be fine. A 12V power supply **will** supply 12V to a 5V part, almost certainly burning it out.

Power Sources

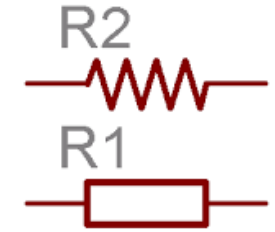
- Wall power
  - 110v AC at 60hz at up to 15amps in the US.
  - Usually use a DC adapter to bring that down to 3-12v at up to a couple amps. USB is 5v DC at least 500ma.
- Battery power
  - Alkaline, typical sizes: AAA-D, 1.5v nominal
  - NiMh rechargable: 1.25v nominal
  - Lithium Ion (fire hazard), 3.7v nominal, 1C is 1A discharge for 1hr.
  - Series vs. parallel
- Remember that most common electronic components (aside from motors) run at 5v or 3.3v DC. 5v battery?

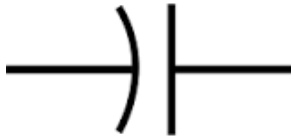
Wiring

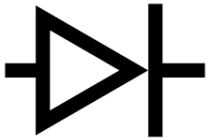
- Circuit board traces
- Wire types and capacities
  - Solid core vs. stranded
  - Gauge system, higher gauge is smaller wire
    - 12ga can carry 9 amps on a long run with little loss.
    - 20ga can carry 1.5 amps
    - 28ga can carry 226 ma (.226A)
    - Gauge matters with high current applications (e.g. stalled DC motor). Too much resistance because the gauge is too small can result in melted wires, shorts, and fire. Take care with extension cords.

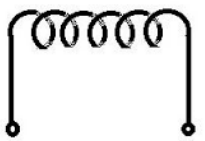
Passive electronics

- **Resistors** resist current, turning voltage into heat to maintain amps. Measured in Ohms Ω and Watts plus precision in %. Not polarized.
- **Capacitors** deliver power intermittently, smoothing out spikes and dips. Farads, µF, nF, or pF. Usually polarized.
- **Diodes** act as one way valve, and sometimes they turn power into light (LEDs). Vf, Vr, If. Always polarized.
- **Inductors** regulate the flow of electricity using magnetism. Henrys anyone?



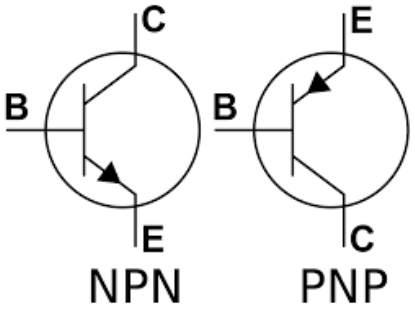


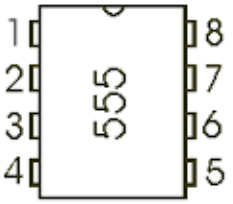




Active electronics

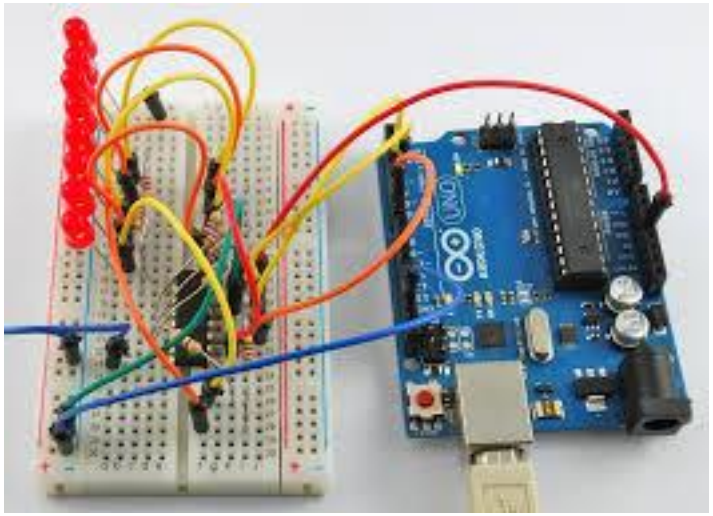
- **Transistors** allow a low current to change the conductive state of a circuit path.
  - They can be used for a low power circuit to control a higher one (e.g. a 5V 20ma Arduino output pin controlling a 7V 200ma DC motor).
  - They can be used as temporary memory devices or logic gates (e.g. computers)
- **Integrated Circuits** built from many different components that have a single set of IO pins (e.g. computer chips).

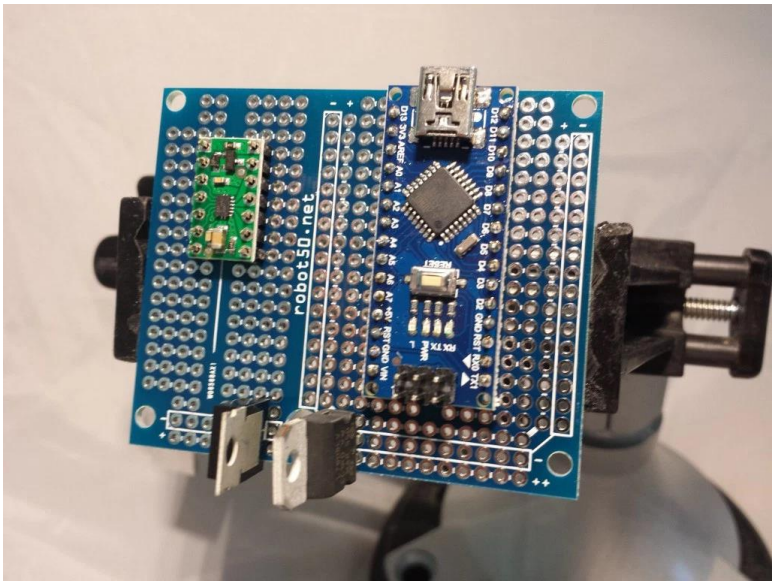




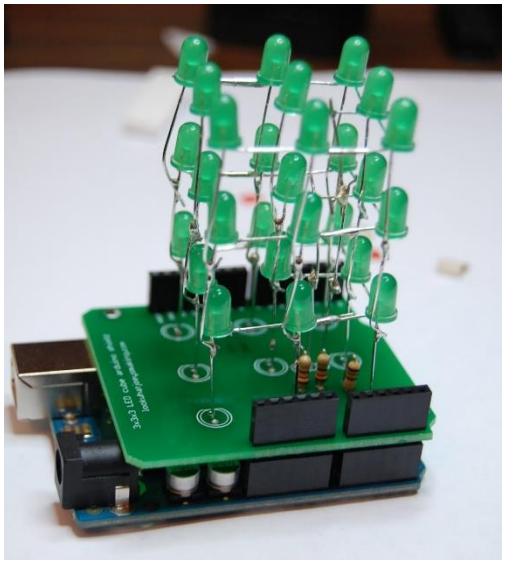
Circuits

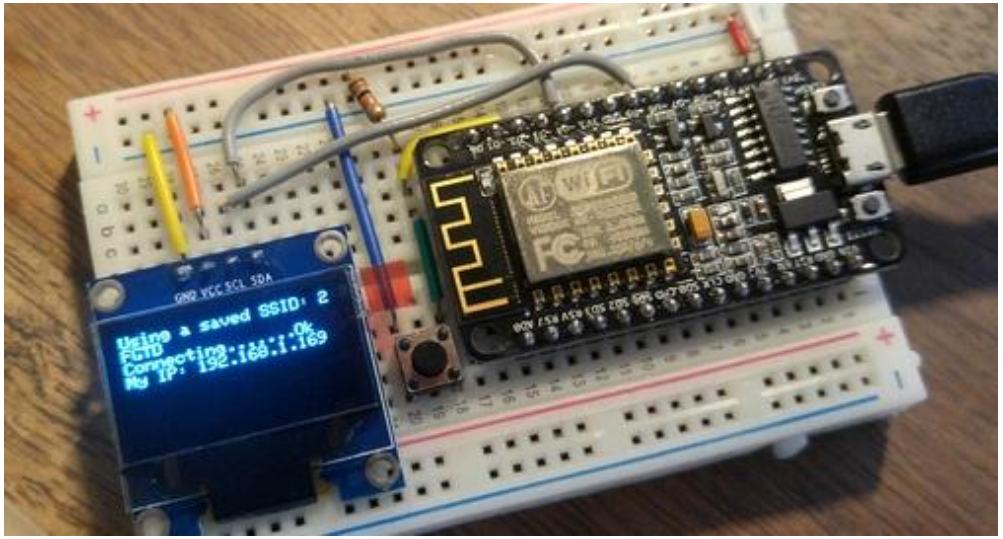
- Breadboard with jumper wires, vs prototyping board with soldering.
- All grounds must be tied together but don't mix DC and AC.
- **Before** your turn it on, use a multimeter to check continuity and polarity.
- Power, safety, and environmental concerns.
  - How much total power will your circuit draw and for how long?
  - What will happen when something shorts?
  - How does it need to be housed?





Microprocessors in Projects





Common Sensors/Actuators for Micros

- 5V, 3.3V, something else? It matters.
- Current flow based
  - On/off switch (momentary, latching), power transistor, switches require a pull-up/down resistor as well. Use digital pins.
  - Resistance sensors: potentiometers, most temp sensors, many touch sensors, light sensors, rain sensors, many infrared sensors. Needs analog pins (ADC 0-5V read as 0-255).
- Digital communication. Servos need PWM pins. ICs, displays, LED strips, keyboard readers. Generally use a control interface such as serial (UART), I2C, SPI.
- Variable current output. Non digital LEDs. Need PWM pins, high power LEDs require a controller.
- Motors. Low power motors at single speed and direction can use a transistor, high power should use a motor controller circuit.

More Information

- http://tinkerfarm.net/curated-tutorials/
- Use instruction that has been reviewed by an electrical engineer (i.e. sparkfun.com or adafruit.com), not something some dude learned yesterday (i.e. Instructables).

And don’t do it like this!