Droid Wiring & Workshop

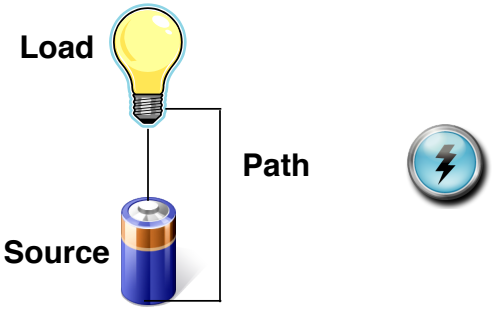
Overview

- Circuits
- Ohm's Law
- Voltage, Current & Resistance
- Safety
- Fuses & Breakers
- Wire Selection
- Connections & Power Distribution
- Installation & Protection
- Using a Digital Multi-Meter (DMM)
- Troubleshooting
- Q & A
- Workshop!

Circuit

- Electricity cannot flow without a complete circuit.
- A circuit consists of
  - Source = Energy Potential, Battery, Outlet, Fusion Reactor, Force
  - Load = Conversion from Energy to Work, resistor, motor, LEDs, HoloProjector
  - Path = allows an electrical flow from a Source to a Load back to Source, wiring, traces, power coupler

Circuit - cont.



The flow of electricity along the path is governed by a basic law… Ohm's Law.

Ohm's Law

- The basic law concerning the flow of electricity
- Ohm's law states: that when electrical potential (voltage) creates a flow of electricity (current), the current and the electrical resistance of the circuit are proportional to the voltage.
- In mathematical terms: V= I x R
  - V is voltage
  - I is current
  - R is resistance

Voltage, Current & Resistance

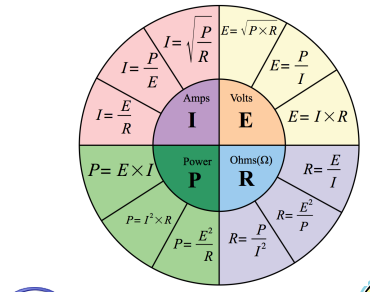
- **Electrical Potential** is the energy stored ready to do work. It is measured in volts V, but is represented 'E', and is determined by the source in a circuit.
- **Electrical Flow** is the flow of energy from a high potential point to a low potential point. This flow is called the current, is measured in amperes (amps), and is represented as "I."
- **Electrical Resistance** is the resistance to the flow. The resistance can be either a function of the circuit material, or it can be the load. Measured in ohms and represented as "R"
- The **load** is the part of the circuit that converts the electrical energy into another form. (light bulbs, motors, heaters, etc.)

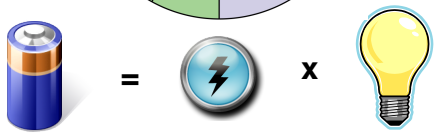
Ohm's Law - Certain Point of View

- Potential (volts) equals current (amps) times the load (ohms).
- In a basic circuit, one of the three values can be calculated from the other two.

E = I x R

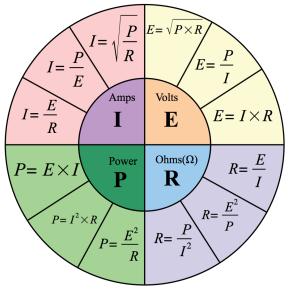
Ohm's Law Wheel





E = I x R

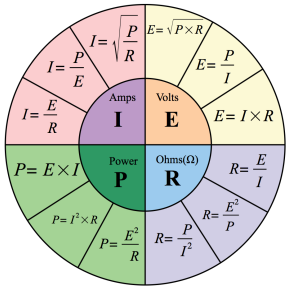
Voltage Example



What *E* lectromotive force is needed for a circuit with R of 1.2K ohms and a I of .03 amps?

E	=	I	x	R
??	=	.03	x	1200

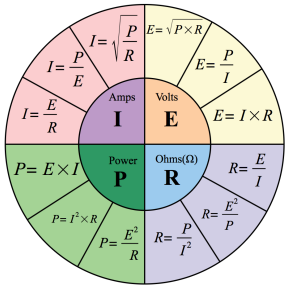
Current Example



How much *I* intensity of current flow could flow through a 36 ohm R in a motor powered by a 12V battery?

I	=	E	/	R
??	=	12	/	36

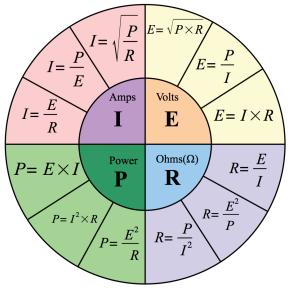
Resistance Example



The *I* intensity of current flow of a R is 0.3A
The measured E drop across R is 6V
What is the Ohm value of R?

R	=	E	/	I
??	=	6V	/	0.3A

Power Example



The *I* intensity of current flow is 12.5A
The measured E drop across R is 12V
What is the Watts value of P?

P	=	E	x	I
??	=	120V	x	12.5A

LED Example

Blue LED 20mA
It's a Diode, it has a Voltage forward drop of 3.2V (Vf)

I run a 12V battery in my droid to power the LEDs
I want to light 1 Blue LED
What value of R should I use to use the Blue LED?

R	=	E	/	I
??	=	(12V-3.2V) /		0.02A

Safety

- Voltage
  - it gives you a shock
  - 120 volts vs. 10,000 volts
  - 12 volts vs. 120 volts
  - Voltage doesn't kill you - Ever lick a 9v? You feel static shock at 20,000vDC
- Current (I = E/R)
  - 10 milliamps (0.01 amp) produces a painful shock
  - 100 mA causes ventricular fibrillation
  - >200 mA causes severe burns & breathing stop
  - Current Kills … notice your DMM are rated for 10 amps
  - Travels ~300,000 km per second
- Resistance
  - Wet vs. Dry skin
  - Hand to Foot = 500ohms
  - Between the ears = 100 ohms
  - Wedding ring = 0 ohms - remove metal

Fuses & Breakers

- Major Safety Feature
- Fuses melt once the current goes above their rating
- Breakers trip due to heat, above their rating
- Slow vs. Fast Trip
  - Quick Spiking Loads
  - Fast is safer IMHO
- Fuses on the battery lead for power distribution
- RigRunner or Fuse/Breaker Block
- Max Rating for the wire used
- Safer: Use the smallest fuse you can reliably use
- Examples
  - 2 AMP on DOME Power
  - 2 AMP on SERVO Load
  - 1 AMP on USB
  - 5 AMP on Audio Amplifiers
  - 5 AMP on Linear Actuators
  - 30 AMP on Dome Drive Controller (AWG 12)
  - 80 AMP on RigRunner (AWG 10 or 8)

Wire Selection

- AWG = American Wire Gauge
- Use a color scheme & document inside your droid
- Solid Conductor (aka Solid Core or Single Core)
  - Not flexible, must bend
  - Easy to break conductor in insulation
- Stranded Conductor (Multi Core, Wire Rope)
  - Flexible
  - Tends to be a better conductor, due to greater surface ar
  - Harder to kink
  - 100+ strands or better for repeated flexing
  - Ultra Wire (660) & Wet Noodle (1660) GREAT STUFF
- Insulation Covering
  - Rated for abrasion, oils, acid, voltage
  - Plastic
  - Vinyl - 2nd Choice
  - Silicon - 1st Choice
- Avoid the cheap stuff

AWG gauge	Diameter Inches	Diameter mm	Ohms per 1000 ft	Maximum amps for chassis wiring	Maximum amps for power transmission
8	0.1285	3.2639	0.6282	73	24
9	0.1144	2.90576	0.7921	64	19
10	0.1019	2.58826	0.9989	55	15
11	0.0907	2.30378	1.26	47	12
12	0.0808	2.05232	1.588	41	9.3
13	0.072	1.8288	2.003	35	7.4
14	0.0641	1.62814	2.525	32	5.9
15	0.0571	1.45034	3.184	28	4.7
16	0.0508	1.29032	4.016	22	3.7
17	0.0453	1.15062	5.064	19	2.9
18	0.0403	1.02362	6.385	16	2.3
19	0.0359	0.91186	8.051	14	1.8
20	0.032	0.8128	10.15	11	1.5
21	0.0285	0.7239	12.8	9	1.2
22	0.0254	0.64516	16.14	7	0.92
23	0.0226	0.57404	20.36	4.7	0.73
24	0.0201	0.51054	25.67	3.5	0.58
25	0.0179	0.45466	32.37	2.7	0.46
26	0.0159	0.40386	40.81	2.2	0.36
27	0.0142	0.36068	51.47	1.7	0.29
28	0.0126	0.32004	64.9	1.4	0.23
29	0.0113	0.28702	81.83	1.2	0.18
30	0.01	0.254	103.2	0.86	0.14

Power Distribution

- Higher Current Needs
- High current = heat in thin wiring
- Droid Wiring = Chassis Wiring
- AWG 12 or AWG 10
- No kinks or tight coils
- Stranded Conductor
  - 100+ strands
  - Ultra Wire (660)
  - Wet Noodle (1660)
- Insulation Covering
  - Vinyl
  - Silicon - Best Choice
- NO BARE WIRES

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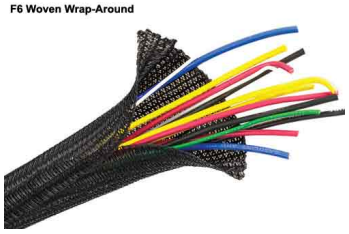
Connections

- Avoid nicking wire when stripping insulation
- No bare wire connections
- Solder Joints
  - Inline, neat & out of bends
  - Protect with Heat Shrink Tubing*
  - Do not move till normal temp to avoid cold joints
- Rated Connectors
  - Current ratings vary greatly
  - EC3/EC5, PowerPoles, XT60, Deans Ultra 45 to 60amps
  - Tamiya 20 amps
  - Heat shrink each wire
  - Avoid “wire nuts” & “twist & tape”
- Protect terminal strips & connectors
- No bare wire or J hook “electrical” connections
- Look for crimp & kink points

Installation & Protection

- Abrasion or Rubbing
  - Use wire braiding to protect
  - Use Tie Wraps & Mounts
  - Electrical tape will unwrap
- Shorts
  - Shrink wrap* all exposed joints
  - Connection points to connectors
  - Know the safety ratings
- Terminal Strips
  - Mount vertically if you must use them
  - Secure wiring via cable ties
  - Use terminal strip cover
  - No J hooks, use automotive wire connectors at least
- Shrink Wrap
  - Use it!
  - Match wiring color scheme
  - Use heat gun only!



Digital Multi Meter

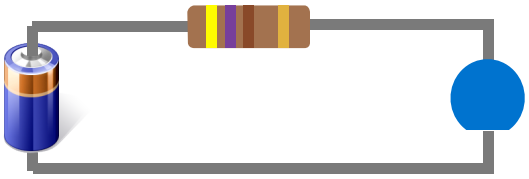
- When using a DMM
  - No Horse Play!
  - Know the safety ratings
  - Check probe wiring before using
  - COM = BLACK
  - mAVO= RED
  - 10A = RED
- Voltage DC & AC
  - Notice 2 knob selection range areas
  - Max 600V DC (5 ranges)
  - Max 600V AC (2 ranges)

Digital Multi Meter - cont.

- Current
  - Power off
  - Put DMM in line with load
  - Select Range, 20uA to 200mA (5 ranges)
  - 200mA to 10A (Move Red lead)
  - If more than DMM rating consider using AMP CLAMP
  - Power on the circuit to measure current
- Diode/Continuity
  - Power off circuit
  - Diodes only allow electric to flow one direction
    - Folks from UK call them “valves”
  - Point A to Point B continuity (Breaks & Shorts)
  - Useful for check Diode, assuming 9V is strong enough
  - Light up most LEDs safely

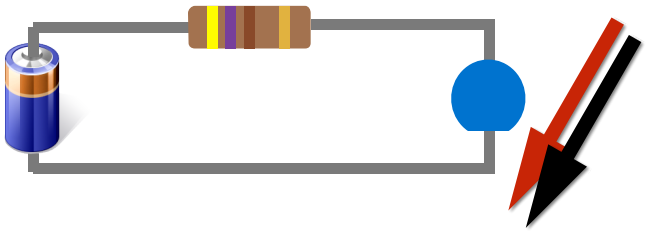
Using a “Meter”

- Disconnect the power when every you can
- Check the Probed for zero ohms before each operating session
- DMM
  - No Horse Play!
  - Know the safety ratings
  - Check probe wiring before using



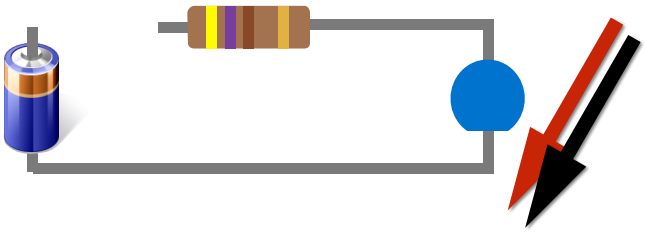
DMM Voltage

- Set the correct range VDC (in this example 2V DC)
- Voltage is measured across a component
- Don’t break the circuit



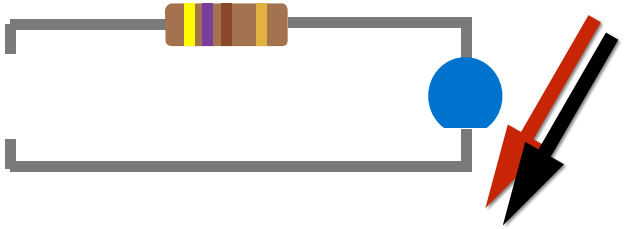
DMM Current

- Set the correct range 2mA
- Current is measured through a component
- You break the circuit
- DMM goes into the circuit



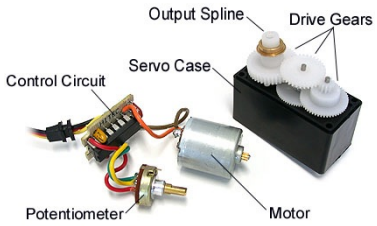
DMM Resistance/Continuity

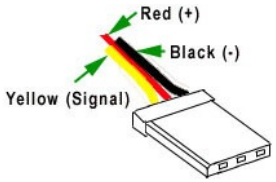
- Remove power
- Set the correct range Continuity 0))
- Voltage is measured across a component
- Don't break the circuit



Servos

- Voltage
  - VDC Ranges
  - 4.8VDC
  - 6.0VDC
  - 7.4VDC
  - VDC=Rotation Speed (Lower time=Faster)
  - VDC=Torque
- Current
  - Rest: ~8.8mA (no load)
  - Moving: ~340mA (no load)
  - Stall: ~980mA
  - Increase with Rotational Speed
  - Size of Servo vs Torque, easily 1 Amp!
  - Brown Outs
- Wiring
  - AWG 24 Micro & Standard
  - AWG 22 Standard & Heavy Duty





Troubleshooting

- Understand the Circuit
- Powered?
- Voltage going to the right places?
- Low Voltage?
- Power Off & Test Continuity : Short or Breaks?
- Power Off
- Select Amp measurement & approximate range
- Under Current?
- Over Current?
- Did you release the Magic Blue Smoke?

Safety - cont.

- Disconnect the power
- Use appropriately rated Fuse or Breaker on every feed
- Wiring
  - Use AWG for current load
  - Multi Stranded
  - Vinyl or Silicon insulation
  - Heat Shrink connections
- Shorts
  - No Bare Wires or Connections
  - Remove Jewelry, especially watches & rings
  - Braid Covering & Secured Cable Ties
  - Insulate connections with Heat Shrink & use a heat gun
  - Don't solder above other connections

Safety - cont.

- Breaks
  - Protect the Wiring
  - Braid Covering & Secured Cable Ties
  - Look for crimp points & kinks
- If some is getting shocked
  - Don't reach for them!
  - Disconnect power
  - Call 911, then start resuscitation
- DMM
  - No Horse Play!
  - Know the safety ratings
  - Check probe wiring before using

Workshop

- Teaming Workshop
- Each team will rotate through the "droid work station"
- Team will be asked several questions at each workstation
- Team will be required to diagnose & identify a problem(s)
- Ask questions
- We'll attempt to tell you when circuit is using >10mA
- Safety is EVERYONEs responsibility
- If you have the DMM leads, no one else should be messing with circuit.
- Be safe