Automotive Electrical Basics by John D

(After reading many of the excellent “Basic of Basics” topics authored and posted by “MartinSR” on TC, and reading and replying to numerous posts in the electrical forum, I thought it was about time to write a “Basics” of my own.)

(I make no claims to being an “expert”, nor am I a professional automotive electrical specialist, but I feel I have a good knowledge of DC circuitry and troubleshooting skills.)

A lot of us without hesitation will completely disassemble an engine, transmission, or other intricate and precise mechanical device, repair it, and put it back together. But when it comes to why a lamp won’t light, or “weird turn-signal, horn, name something” problems occur, a lot of us throw up hands in frustration. I hope this will help you to get an understanding of the elusive “Eddie Electron”. My descriptions will deal with DC circuitry, in negative ground situations.

Circuit 101:
In easy terms the positive/full “boxes of juice” leave the battery (source), travels down the wire (“To” path), into the light bulb (load). The lamp uses the “juice” (load) and the negative/empty “juice boxes” travel back (“From” path) to the battery (source) to be replenished. This makes a complete circle or circuit.
Any break or marginal connection/conductor in this circuit will result in something wrong or not working properly.

A basic thing to remember is that BOTH paths must be of EQUAL capacity for the circuit to work properly! Example: The load asks for 150 boxes of “juice” to do its work, but has only 75 boxes worth of road (path) to send it back – the light won’t light – or it will find another road to send the boxes back (screwing up other things along the way). This brings us to the next topic, Grounding.

Ground, Grounds, or Grounding.
The cars we love/hate use a negative grounded system. The negative side of the battery is attached by a cable to the body/frame of the car, and uses the frame, or steel/metal components of the car as a path back to the battery (source). The entire car becomes our “From” path back to the battery. This is why our wiring harnesses typically contain 1 wire for a given circuit.

Example: Positive juice leaves the battery or fuse block via a wire, it might go through a switch, or relay down another wire to a bulb, then….??? The base/case of the bulb is screwed into a socket, which is attached via metal contact, by bolts or friction to the metal of the car, which is attached to the negative side of the battery. A complete circuit! (An exception might be a lamp socket attached to plastic or other poor conductor – then a negative or “from” wire will be run to the nearest convenient metal object to complete the circuit.)

The problematic part of automotive electrics (except for an obviously failed component) is usually the negative or Ground side of the circuit. It relies upon the mechanical contact between electrically conductive parts to do its job. Remember the “equal” example? *If you don’t have good connections on the “from” side, the “to” side won’t work.*

A good ground consists of clean metal to metal contact from the load all the way back to the negative post of the battery! This would include scraping off all paint or corrosion, putting a “star” washer (it bites into the metal) under the connection, and tightening.

Paint does not conduct electricity! Powder Coat does not conduct! Grease or Oil does not conduct! Rust/Corrosion does not conduct electricity! *Twisting a bare wire around the nearest convenient screw and tightening it down does not make a good ground!*

(You may have spend hundreds of dollars and hours restoring your engine bay, *but if the ground wire/star washer from the headlight harness doesn’t bite hard into bare steel, expect problems!)*
The guys who built our cars didn’t expect them to last 30+ years. They designed and built the circuits for

(guessing) a 10 year service life. “Joe 6-Pack” rams his 20,437th self-tapping screw of the day into the radiator support of #489,783 Chevelle that week. Back then the star washer did its job, bit into the steel and provided the conductivity needed for the circuit to work. After 30 years, billions of vibrations and years of corrosion, the connection may need attention. Remember – tight metal to metal contact!

On the “Positive” side:
With a negative ground system, we rely upon wires to carry the positive ½ of a circuit to the “load”. The same connection practices apply here as well, but with a few precautions.

All of the “metal to metal” contact rules still apply! You must have good clean connections! The caveat is that the connection must be protected from accidental “grounding” or contact to the negative side by insulation – plastic, tape, etc. This is why the wiring or connectors are encased in rubber, plastic, or similarly protected from the ground or negative side (entire car) of the circuit.

Glossary:
Circuit:
A complete DC electrical circuit MUST have the following components at a minimum to operate:
1) Source of Power (Battery)
2) A “To” Path (a way to get the electricity from the Source to the Load - usually wires.)
3) Load (a device that uses/consumes electricity – bulb, motor)
4) A “From” Path (a way to get spent electricity from the Load, back to the Source – Ground).
In dealing with automotive electricals, the thing to remember is the word “circuit”. Note it’s similarity to the word “circle”!

Conductors:
A conductor is something that does not resist the flow of electricity. Silver, Gold, Copper, Brass, Aluminum and Steel are all common materials used in our cars for electrical conductors.

Fuses – Fusible links:
A fuse is a nothing more than a sacrificial element in an electrical circuit. It is a device that lives in line (like a switch, but without a choice) within a circuit, and when something goes wrong will self-destruct and save the other components. It is sized/rated for the maximum current a circuit is designed to handle (plus a bit of a cushion). If a fuse repeatedly blows, something is WRONG.

Insulators:
A insulator is something that resists/prevents the flow of electricity.
Plastic, Rubber, Paint, and Oxidation are all common materials in our cars used for (and create) electrical insulators.

Schematic/Diagram:
A "connect the dots" map explaining in a one-line form the electrical path for a given circuit. Absolutely invaluable in troubleshooting!

Switch
A switch is used to make or break a circuit. A switch (in general terms) has two states – open or closed. A switch can be used to either enable *or* prevent a “load” from working. Switches can be inserted in either the positive or negative “path” of a circuit – it doesn’t matter – it still breaks the circuit! When a switch is closed current flows, when opened the circuit is broken. **Important** The mechanical contacts of a switch must able to equal or exceed the load of the circuit/conductors that it is inserted into!

Relays:
A relay is nothing more than a heavy duty remote control toggle switch. By activating a relay, you energize an electromagnetic coil that either engages or releases a set of heavy-duty contacts. You're using a small load device to turn a large load device on or off.
(Example: The starting circuit. A starter solenoid is just a relay on steroids. The key switch in the dashboard or column couldn’t possibly handle the current needed to crank over your engine! The switch in the column merely makes/breaks the circuit to a BIGGER heavy-duty switch that energizes the starter motor.)

Take a few bits of advise from one of those wierd guys who actually *likes* working on & troubleshooting electrical problems:

Do:

- Spend the $19.99 on eBay and get a wiring diagram for your car! (Knowing the wiring colors, where taps & splices are, and seeing the circuit spread out in map form *will save you hours & $$$!)*
- Spend another $25 on a decent (but still inexpensive) digital volt/ohm meter (VOM) and learn how to use it.
- Spend some time doing preventative maintenance on the electrical system! Anywhere you'd be putzing around on the car, you can find a electrical connection. Just unplug/replug it a few times, or take that grounding screw out and scrape/wire brush the terminal and the attachment point. Either will improve and clean the connection.

Don't:

- "Throw Parts at It". Most electrical problems are usually pretty simple. By using the above knowledge and a few tools you can find out what component is giving you fits. (By just throwing parts at something you never really find out what was wrong.)
- Expect that a brand new wiring harness will magically solve all your electrical problems.... It may be new, but it still connects into your "old" car. (re-read the above descriptions of good connections).
- (Don't) think you can't learn about the electrical system! Our cars are in the stone age as far as electrics go. It's very linear and straightforward if you spend the time to figure it out.
- *** Please don't take this post as an insult to your intelligence!*** I posted this to try and share & educate others in the black art/voodoo of electricity