THE INSTALL DOCTOR™

Basic DC Electronics

(Voltage/Current/Resistance)

Document# 999001

What are: Voltage, Current, and Resistance?

Voltage (letter symbol: V; unit of measure: volts), **Current** (letter symbol: I; unit of measure: amps), and **Resistance** (letter symbol: R; unit of measure: ohms) are the 3 most fundamental principals in electronics. To understand how these 3 principals relate together, lets look at an everyday garden item, a water hose. Everything needed to understand these 3 basics of electronics can be seen in a simple garden hose. (This concept is so strong that medical researchers use voltage, current, and resistance to describe blood movement through blood vessels; very similar to the garden hose concept.

Voltage: The technical definition of voltage is the "electric" energy potential between 2 points. Potential means that the possibility exists between the 2 points. If the 2 points are never connected, the potential is zero. When the points are connected, then voltage in the circuit actually exists and there is no longer a potential. The garden hose definition of voltage would be the water pressure in a garden hose. You can control the amount of water flowing from the garden hose by turning a control valve to allow more or less water to flow from the hose. Voltage can be either "DC" or direct current, or "AC" or alternating current. Batteries, the primary power supply in you automobile, are "DC" or direct current. The voltage in your house is "AC" usually noted as 120V AC. "AC" voltage flips between (+) positive and (-) negative every other wave. "AC" current is more stable and can be transmitted very long distances over wires; you might recognize these as the power wires running on towers and power poles throughout the world. But, for automotive purposes, we will concentrate on "DC" voltage or battery voltages, usually noted as 12V DC. In automobiles, the battery in your vehicle contains acids which, through the miracles of chemistry and physics, eat away at metal plates inside the battery. This erosion of the plates creates free electrons, which when grouped inside the battery, create an electric "potential" between the (+) positive and (-) negative battery posts. A typical automotive battery will produce 10 to 16 Volts DC.

Resistance: To understand current, we must first look at resistance. The technical definition of resistance is simply the opposition to the flow of electrons in an electric circuit. The garden hose definition is two fold: the first resistance would be the diameter and length of the garden hose. A large diameter garden hose will offer low resistance and allow the water to flow easily. A second resistance of a garden hose would be a sprayer or sprinkler attached to the end of the water hose. The sprayer or sprinkler would restrict the flow of water out of the end of the garden hose. Remember, voltage is the potential difference between two points. Restricting the flow of water would restrict the flow of water between the two ends of a garden hose. Every item or component in an electric circuit will have resistance, even the wires that connect the components of the circuit has a small resistance. The great physicist Albert Einstein developed the Law of Conservation. What The Law of Conservation stated was that NO energy can ever be mysteriously lost. ALL energy MUST be accounted for.

When an electric circuit is connected and power is applied, the voltage through the circuit can be measured using a multimeter or other voltage measurement devices. Resistance plays a key role in how voltage is distributed throughout the circuit. To visualize this, we can set up a basic circuit where we can measure the voltage at different points in the circuit. When measurements are taken, the voltage at the end of the circuit is less than the voltage at the beginning of the circuit. So in an automotive application, when the 12V DC battery power is turned on, the circuit draws what power it needs to operate. Lets say all 12 Volts were needed by the circuit. It you were to apply the multimeter to measure the voltage at the very end of the circuit you would notice that the multimeter would NOT read 12 Volts. What happened to all the voltage? According to Einstein's Law of Conservation, the circuit MUST have absorbed the lost voltage. And, he is correct. The resistance of every item in the circuit actually absorbs or dissipates voltage in the circuit. In the world of electronics, resistance acts an a "voltage drop" in a circuit. A circuit cannot exist without a resistance "load" in the circuit. A load is the main object of the circuit. A light bulb would be the "load" of the lighting circuit. In a car stereo application, a speaker (speakers are usually 2, 4, or 8 ohms in resistance) is an example of a "load" when connected to an amplifier.

Current: Now that you have a basic understanding of both voltage and resistance, current will become a little clearer to understand. The technical definition of current is the flow of electrons when an electric circuit is activated. The garden hose definition is that the volume flow of water itself is the current. When the water is turned off, water still resides in the garden hose, but there is no movement. Nothing is forcing it to move. When the water is turned on, new water is forced into the hose. When the sprinkler or sprayer is turned on at the other end, the water begins to flow. As the sprayer is adjusted (a change in resistance), current changes, or the volume flow of water through the garden hose changes. This is current. And current changes as resistance and voltage change. As stated earlier, the diameter and length of the garden hose are some of the factors that determine the resistance to the flow of water through the hose. Current is directly proportional to BOTH voltage and resistance. If resistance is high (the garden hose is small and thin or the sprayer is set to only let a small amount of water to leave the hose) then volume flow of water through the hose would be low - or low current. If the garden hose has a large diameter, the water will have less resistance. Since the water will move through the hose with less resistance, the volume flow of water through and out of the hose will be high - or high current. The same applies to voltage. If less water pressure is allowed to flow into the hose, then the volume flow of water through the hose would also be low - or low current. If the water is turned up all the way, the garden hose would be full of water and the water pressure would be higher allowing a high volume of water to flow though the hose - or high current. Again, the circuit must be active for there to be current. In the garden hose definition, the sprayer or sprinkler must be turned on to allow water to flow.

Voltage, Current, and Resistance Applied To Mobile Electronics

Car Stereos and Speakers: The electronics inside your stereo are designed to operate on 12 Volts DC. Strangely, your speakers only operate when AC voltage is applied to them. How does this work? The amplifier inside your stereo is powered by the same 12 Volts DC that the radio is powered by, but an amplifier takes an audio signal and converts it to alternating AC voltages. Speakers move in and out when alternating voltage is supplied to a speaker through speaker wires. A speaker, on the outside looks relatively simple, but on the inside a speaker is a complex electromechanical machine. A speaker makes sound by moving in and out, moving and vibrating air which is the sound we hear. The funnel shaped part of the speaker we see is called the cone. Attached to the rear of the cone is a tube of cardboard which extends to the rear of the speaker. Surrounding the tube of cardboard is a magnet. Wrapped around the tube of cardboard is a very thin wire. Each end of this wire is connected to the (+) positive and (-) negative terminal of a speaker. When AC voltage from your radios amplifier is supplied to the speaker via speaker wires connected to these terminals, the speaker begins to move. As the AC voltage increases and decreases due to the music, the wire wrapped around cardboard tube induces an electromagnetic field which alternates between (+) positive and (-) as the music changes. The magnet will either attract or repel the electromagnetic field, repelling or pulling the cardboard tube and wire wrapped around it in and out, moving the speaker in and out, creating sound.

Types Of Circuits Common In Mobile Electronics

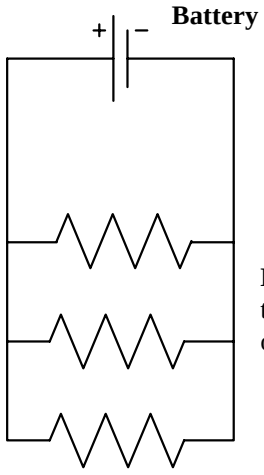
<u>Parallel Circuits</u>: Parallel circuits are very common in mobile electronic applications. Circuits are hard to explain and the best way to understand a circuit is to see a picture of a circuit: (the most common form of this type of circuit are speakers wired in parallel)

Voltage: is the same through each branch of the circuit.

Resistance: Adding resistance or loads will DECREASE the overall resistance of the circuit. To the battery, all the branches look like one single resistor or load. (called an "equivalent" resistance)

$$\text{Total Resistance} = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \frac{1}{R4} \cdots\cdots}$$

Current: Since there are multiple branches, each branch will have its own current flow through that branch. If all the resistors or loads are the same, the currents will be the same. If any of the resistors or loads are different, the currents through each branch will be different.



Resistors or Loads

Multiple Branches. Each connects to the (+) positive as well as (-) negative of the power source

---

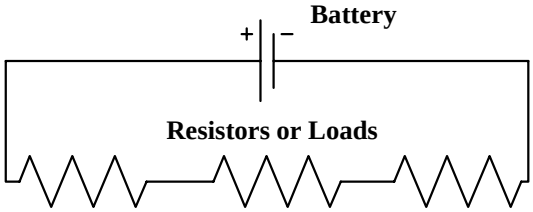
<u>Series Circuits</u>: Series circuits are also called voltage divider network circuits. Since none of the resistors or loads connect directly to the battery, there exists only one branch. Series circuits have a single current but each resistor or load has its own voltage across it which is determined by its resistance.

Voltage: Each resistor or load has a voltage drop across it. Einstein's Law of Conservation states that all the combined voltage drops across each resistor or load will equal the batteries total voltage.

Resistance: Resistance is added in a series circuit.

Total Resistance = Resistor 1 + Resistor 2 + Resistor 3 . . .

Current: there is one branch which means there is one current for the circuit.



One Branch. Each resistor or load connects into a chain

A Visual Of Voltage, Current, and Resistance

Ohms Law lets us calculate Voltage, Resistance, and Current in simple circuits.

Ohms Law

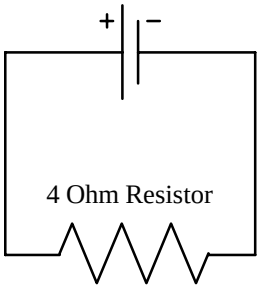
V = voltage
I = current
R = resistance

To determine V, or I, or R: cover the letter of the one you want to calculate.

V= I multiplied by R
I= V divided by R
R= V divided by I

Basic Circuit

+12 Volt DC Battery



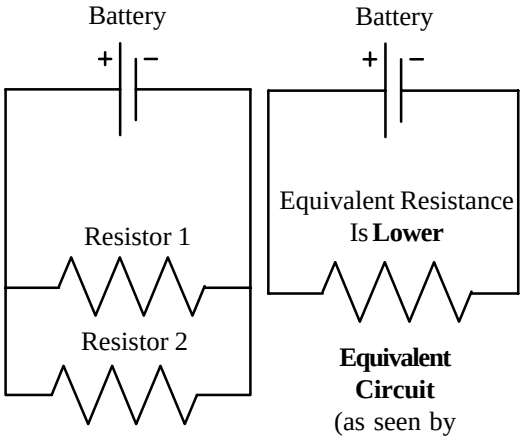
Find the current of the circuit above:

V= 12
I= unknown
R= 4

I=V divided by R
I= (12 Volts) / (4 ohms)

Answer: 3 Amps of current through the circuit

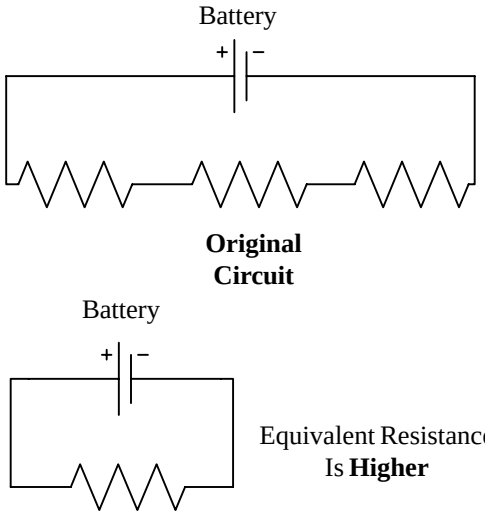
Parallel Circuit



Original Circuit

Equivalent Circuit (as seen by the battery)

Series Circuit



Original Circuit

Equivalent Circuit (as seen by the battery)