Tech Basics: Ohm's Law

By Gerald Cooper & Femi G. Ibitayo

"The amount of current flowing in a circuit made up of pure resistances is directly proportional to the electromotive forces impressed on the circuit and inversely proportional to the total resistance of the circuit." WOW, what a mouth full!

Don't worry. Although Ohm's Law is one of the most important concepts in electricity or electronics, it is only a very simple mathematical relationship between Current, Voltage, and Resistance. Stated a little differently, Ohm's Law is a set of formulas used in electronics to calculate an unknown amount of Current, Voltage or Resistance. The following are algebraic expressions of the relationships between Current, Voltage or Resistance.

V=I*R OR **I=V/R** OR **R=V/I**

In these formulas: **V** is the voltage measured in Volts, **I** is the current measured in Amperes (Amps), and **R** is the resistance measured in Ohms. The symbols for Volts is V, for Current is A, for Resistance is Ω. So you may hear that a 12 Volts (V) alternator which puts out 70 Amps (A) has a field Resistance of 4 Ohms (Ω).

Voltage

Definition (technical): Voltage is the electrical pressure needed to move electrons through a circuit.

Definition (analogy): Voltage is like the water pressure needed to move water through a pipe.

Formula: Voltage (V) = Current, I, multiplied by Resistance, R. Amps times Ohms. I times R: I*R.

Current

Definition (technical): Current is the flow of electrons in a circuit

Definition (Analogies): Current is like the flow of water though a pipe

Current (I) = Voltage (V)/Resistance (R). Current is Voltage divided by Resistance. I = V/R

Resistance

Definition (technical): Resistance is the opposition to the flow of electrons in a circuit.

Definition (Analogies): Resistance is like the resistance that a valve can offer to the flow of water in a pipe

Resistance (R) = Voltage (V)/Current (R). Resistance is Voltage divided by Current. R = V/I

Okay, what does Ohm's law have to do with solving Aircraft Electrical Charging Systems (AECS) problems? The examples below show why understanding Ohm's Law is necessary to the understanding the troubleshooting of Aircraft Electrical Charging Systems (AECS). It is about three light bulbs: One dead, one bright, and one brighter.

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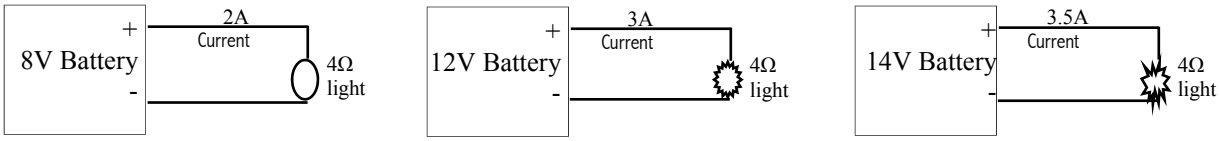
Example (application): How much electrical pressure (force, voltage) would it take to move 3 Amps flow of electrons (Current) through a light bulb that has 4 Ohms of opposition (resistance) in it before the light comes on?
In other words, how many Volts would a 3 Amps flow of Current cause across a 4 Ohms Resistor?

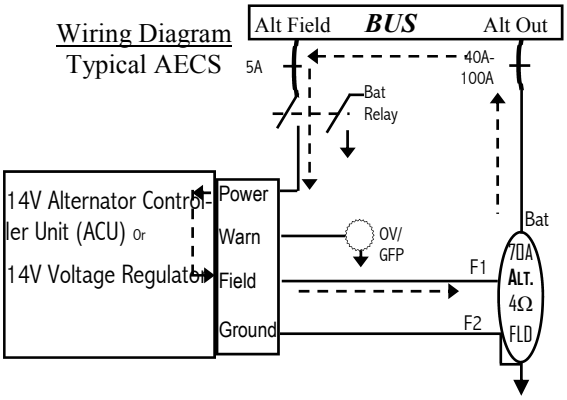
Example (formula): V = I*R. Volts = Amps times Ohms.
Volts = 3 x 4 = 12 Volts

For the light bulb to come on or illuminate, we must put 12V or more across it. With 8V across it, the light stays off. With 12V across it, the light comes on. With 14V across it, the light comes on brighter.



The light got brighter, so what? That is the point! Ohm's explains that you must have enough electrical force, voltage, to cause a given amount of current to flow through the resistance of a given device or material. Your cell phone will not work when its battery voltage is too low. The aircraft engine will not turn when the battery is drained. Ohm's law, get it and trouble shooting gets easier!

Ohm's law and Aircraft Electrical Charging Systems (AECS)



This is a typical 12V battery equipped AECS that has a 12V, 70A alternator with 4Ω field resistance.

Turning on the master switch applies battery voltage to the input of the ACU through the input devices and wires from the bus. The ACU passes current to the field of the alternator. Without the engine running, the field voltage is typically 0.5-2V less than the battery voltage. With the engine is running, the ACU passed (controlled) current to the alternator's field current, causes the alternator output voltage to increases to and stay at about 14V. At 14V, the alternator is able to charge a 12V battery and apply voltage to other aircraft equipment to cause them to operate as current flows through them.

If there is voltage drop in the input devices preceding ACU, due to high resistance, the system will not work correctly. For example, this alternator with 4Ω field resistance draws 3A at 12V and 3.5A at 14V. *Ohm's law again.*
If the 5A circuit breaker and Alt Sw have internal resistance of 2Ω, they will cause a 6V drop across them. That 6V loss in a 12V system, coupled with a 1-2V drop in the ACU and pre-alternator field wires, means that the 4Ω field will only see 4-5V. With I = V/R, 5/4, the maximum field current of 1.25A will not allow the system to operate the way it should. The same will be true if the 4Ω field resistance becomes 12Ω.

The primary key to solving most AECS problems is understanding, using, and adapting Ohm's law. *Ohm's law, get it, use it, and your AECS life becomes easier.* Ohm's law: the foundation of Electrical Charging Systems Solutions.

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