The Amateur in You, Part 1

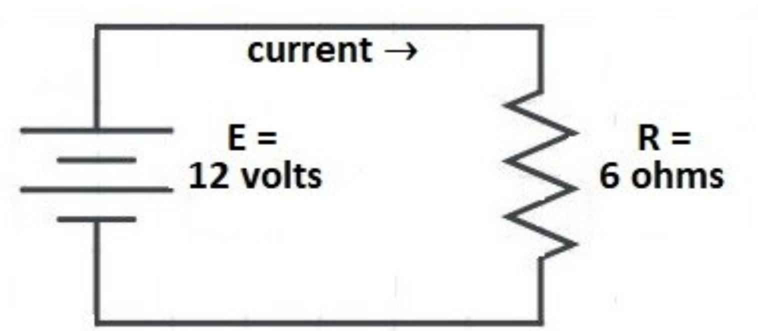
What have you been pondering?

Reviewing Ohm’s Law

Ohm's Law is nothing more than a simple mathematical relationship between four electrical quantities, *voltage*, *current*, *resistance*, and *power*. Even if circuits and electronics seem to have little relevance to anything you do in ham radio, you as a licensed operator will likely encounter at least one of these in your amateur radio career. And if you encounter one, you'll likely encounter another, because they're inter-related.

A power source, such as a *battery*, places ***electrical pressure*** on the electrons in a *conductor*, such as a wire. If the wire provides a *complete path* back to the other end of the power source, that electrical pressure causes electrons to flow in the path. We call the electrical pressure ***voltage***, the flow of electrons ***current***, and the path a ***circuit***. Typically, somewhere in that path is at least one component that reduces the flow of those electrons. We call that component a ***resistor***. The result is that, the greater the resistance value of the resistor, the lower the electron flow (the fewer electrons passing by, per second) for a given voltage pressure.

Let's start by examining this simple circuit, which contains a battery, a resistor, and two wires that connect the ends of the battery to the resistor:



In fact, there’s a mathematical relationship between them all. If we represent the voltage with ***E*** (for *electromotive force*, or electrical pressure), and the current with ***I*** (intensity), and the resistance with ***R***, we have

$$E = I \times R$$

In other words, the voltage pressure on the electrons is equal to the current times the resistance. This is known as ***Ohm's Law***. Another way to say it is that the electron flow can be found by dividing the voltage pressure by the component resistance value, or

$$I = E \div R$$

and by the same way, we can say that the resistance of the component can be determined by dividing the voltage pressure on it, by the electron current flow through it, or

$$R = E \div I$$

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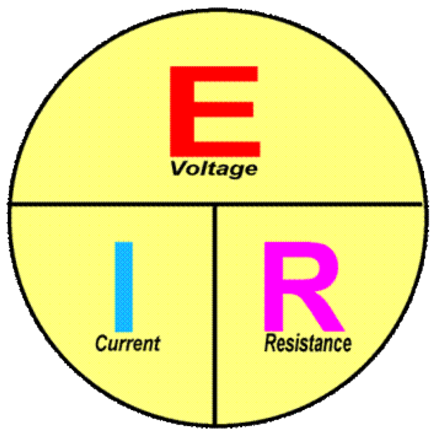
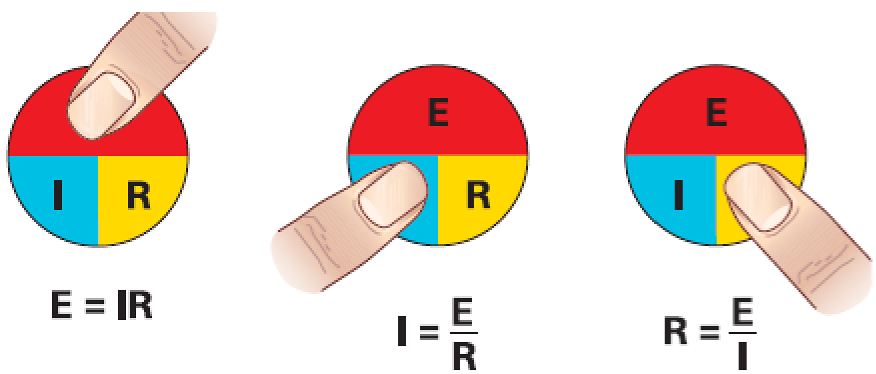
The voltage pressure is measured in ***volts***, the current flow is measured in ***amperes*** (or ***amps***, for short), and the resistance value is measured in ***ohms***. To make these easier to calculate, we can use this handy circle, which contains our three quantities, arranged to provide the answer we're looking for, if we know the other two:



So, to make use of it, simply cover the unknown quantity, to help calculate that value:



The circuit on the previous page depicts a 12-volt battery connected across a 6-ohm resistor. The unknown quantity is the current, so cover the ***I*** in the above circle, as is shown in the middle diagram. It reveals that the current ***I*** can be calculated by E / R, which is the same as E ÷ R, or 12 volts ÷ 6 ohms = 2 amperes (amps):

$$I = E \div R$$

$$I = (12 \text{ volts}) \div (6 \text{ ohms}) = 2 \text{ amps}$$

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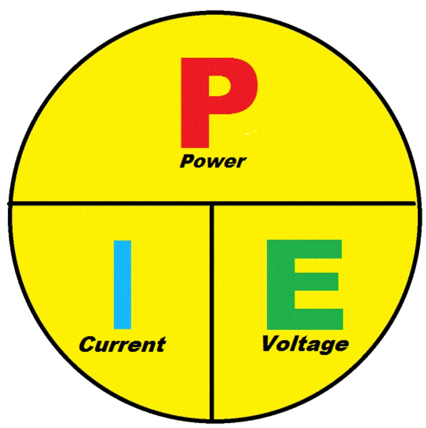
Power Rule

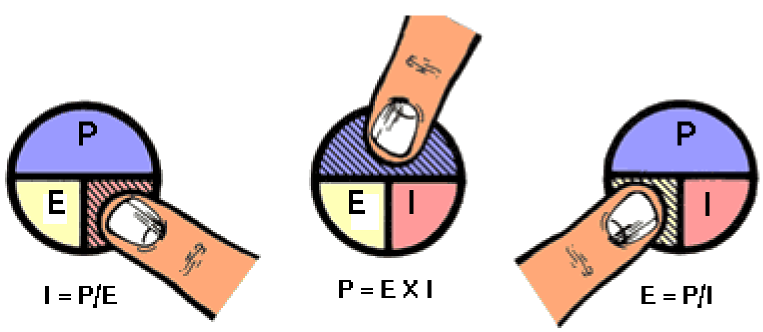
What we sometimes refer to as the *Power Rule* is only an extension of Ohm's Law, so there is no "Power Rule" in electronics, except as we use it for convenience in discussion. The Power Rule is another mathematical relationship, for which the amount of heat is called ***power***. Voltage you know, and current you know. Power is the ***amount of heat given off by a component*** if you apply a certain amount of voltage pressure on the component. The power given off can be determined by the current and the voltage, as in

$$P = I \times E$$

Using the same letter representations for the values in Ohm's Law, we can use ***E*** to represent voltage, ***I*** for current, and now ***P*** for power, which is measured in ***watts***. And just like with Ohm's Law, we can use a Power Rule circle to provide the answer we're looking for, if we know the other two:



To make use of it, again cover the unknown quantity, to calculate that value:



Returning to our original circuit with the 12-volt battery and 6-ohm resistor, we calculated the current as 2 amps. Now, let's calculate the power given off by the resistor. The unknown quantity is the power. Using the Power Rule, cover the P in the above circle, as shown in the middle

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diagram. It reveals that the power P can be calculated by E x I, or 12 volts x 2 amps = 24 watts:

$$P = E \times I = (12 \text{ volts}) \times (2 \text{ amps}) = 24 \text{ watts}$$

That's a pretty hefty amount of heat that the resistor will give off, and if it's not rated for 24 or more watts, then it'll likely burn up. Here's a summary chart of our four electrical quantities:

Letter	Quantity	Unit	Symbol
E	voltage	volt	V
I	current	amp	A
R	resistance	ohm	Ω
P	power	watt	W

$$E = I \times R \qquad P = E \times I$$

Examples

Instead of a 6-ohm resistor, say we have a 60-watt light bulb, and instead of a 12-volt battery, we use voltage supplied by the house wall socket, which is 120 volts. How much current is being drawn by the light bulb?

$$I = P \div E = (60 \text{ watts}) \div (120 \text{ volts}) = 0.5 \text{ amps}$$

So, how many 60-watt light bulbs can your 10-amp circuit breaker handle (not actually part of Ohm's Law)? (10 amps) ÷ (0.5 amps per bulb) = 20 light bulbs!

Going back to the 12-volt battery, let's say now that the resistor (which we often call the ***load***) value is unknown, but that you discover the load is drawing 4 amps from the battery. What's the value of the load resistance?

$$R = E \div I = (12 \text{ volts}) \div (4 \text{ amps}) = 3 \text{ ohms}$$

What is the voltage if you measure 2 amps of current going through a 10-ohm resistor?

$$E = I \times R = (2 \text{ amps}) \times (10 \text{ ohms}) = 20 \text{ volts}$$

How much power is being used in a circuit when the applied voltage is 13.8 volts and the current is 10 amperes?

$$P = E \times I = (13.8 \text{ volts}) \times (10 \text{ amps}) = 138 \text{ watts}$$

And so forth.