Basics of Electricity, Part 2

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In the previous article I discussed the basics of electricity and the related terminology and abbreviations for using Ohm's Law. This law is essential for working with electricity. The best way to become fluent with Ohm's Law is to solve some electrical problems using it.

Review -- Basic Ohm's Law describes the relationship between the rate of current flow [I or i] in amperes , the electrical pressure [E or e] in volts and power [P or p] in watts: P=IE for direct current and p=ie for alternating current. This means that power or work is equal to amperes multiplied by volts. By playing algebraic musical-chairs with this formula we can also say that I=P/E and E=P/I. So if any 2 of the 3 quantities are known, the unknown, 3rd quantity can be found.

Here are some sample problems:

1. An aircraft landing light is rated at 13.8Vdc and 100W. How many amperes are needed to operate this light ? Solution: Using I=P/E, I=100W/13.8V, I=7.246A. If the ampere and voltage ratings were given and we wanted to know what the wattage or power rating is, we would use P=IE; P=7.246A x 13.8V = 100W. If only the ampere and wattage requirements were given, we could find the voltage rating by using E=P/I; E=100W/7.246A = 13.8V.

2. An alternating current electric heater is rated at 120v, 1500w. How much current will the heater require ? Using i=p/e, i=1500w/120v; i=12.5a.

3. A flashlight lamp is rated at 2.4V at .83A. How much power in watts does this lamp consume ? Using P=IE, P=.83A x 2.4V =1.992W

The unit of resistance to the flow of electrical current is the ohm [Ω]. One ohm is defined as one volt/ampere or volt per ampere. For example, if a circuit requires one volt of electrical pressure to cause one ampere of current to flow, the resistance of the circuit is one ohm, which would be written as 1Ω. If 3 volts of electrical pressure is required to cause one ampere of current to flow, the resistance is 3 volts per ampere or 3V/A and the resistance is 3Ωs. Ohms and volts per ampere [V/A] mean the same thing. If 100 volts were required to cause 1 ampere of current to flow, the resistance would be: R=E/I =100V/1A= 100Ω.

The resistance can also be calculated by using other than one ampere of current since the ratio of volts to amperes is constant even if the voltage is varied. If 10 volts causes a current of .1 ampere to flow in a circuit, the resistance, R, is equal to 10V/.1A = 100Ωs. The power dissipated by the resistor is P=IE; P=.1A x 10V=1 Watt. If 1200 volts were applied to this circuit, a current of 12 amperes would flow because the ratio of volts/amperes with a 100Ω resistor is always 100/1. The power dissipated by the resistor is P=IE; P= 12A x 1200V=14400 Watts.

The three basic formulas that involve resistance are R=E/I, I=E/R and E=IR. These formulas are also referred to as "Ohm's Law" although they are really spinoffs of basic Ohm's Law.

Here are some typical Ohm's Law problems:

1. A length of wire is known to have a resistance of .2Ω. If the wire is carrying 11A of current, ¨ how much Electro-Motive-Force or voltage [E] will be lost in the wire ? and ¡ how much power is lost as heat in the wire ? Solution: E=IR; E=11A x .2Ω=2.2V. . The power that is lost in the wire can be found using P=IE; P= 11A x 2.2V= 24.2 Watts [W]. This would be about half of the available power from a typical solar-panel.

2. A starter-motor for a tractor's engine is rated at 10V at 230A. How much resistance does this motor have ? Using R=E/I: R=10V/230A=.04348Ω. Another way to say that the resistance is .04348Ω is to express it in thousandths of an ohm, or milli-ohms. This is done by multiplying the number by 1000 and, so that we don't change the value, dividing the units by 1000. The abbreviation for milli is m, so the abbreviation for milli-ohms is mΩ. So we could also say that the resistance is 43.48 milli- ohms, which would be written as 43.48mΩ.

Note: it is a common practice to express electrical quantaties as a number between 1 and 1000 along with the appropriate suffix that makes this possible. The units for thousands is Kilo, which is abbreviated as K. Example: a DC current of 130,000 amperes would be 130 Kilo-amperes or 130KA.

3. How much current [I] in amperes will flow through a resistance of 17Ω when 4V is applied ? Solution: using I=E/R; I=4V/17Ω=.2353A. This could also be expressed in milli units. So we could also say that the current was 235.3mA.

4. A water pump is rated at 12V, 9A. The water pump is to be operated 164 meters away from the storage battery that will be used to operate the pump. The 2-conductor #10 gauge copper wire that connects the pump to the battery is 164 meters long. This wire has 1Ω of resistance to the flow of current. How much voltage must the storage battery provide if 12V at 9A are to delivered to the pump ? Solution: The voltage that is lost or dropped in the wire can be found by using E=IR; E=9A x 1Ω = 9V. So 9V more than the delivered 12V =21V must be provided by the battery. If only 12V were provided by the battery, there would not be enough voltage remaining after

making the trip through the resistance of the wire to operate the pump according to the manufacturers ratings. The performance of the pump will suffer. In some cases, this can result in motor stalling, overheating and premature motor failure.

Ohm's Law and its related formulas are a useful tool to anyone who is not connected to a public electric utility system. The "other side of the coin" is that electric utility companies seem to prefer that their customers understand as little about volts and amps as possible.