Basic Electronics Part 2

by

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In the first article we treated series circuits and parallel circuits containing only resistance. One of the things we observed in the series circuit was that the sum of the voltage drops across the resistors was equal to the voltage applied to the circuit. In our simple circuit we had one voltage source applied to the circuit (See Fig. 1).

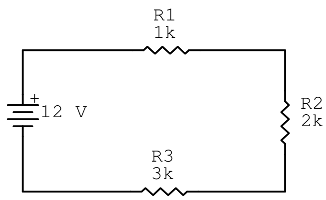

Fig. 1

Recall that we assumed the current through the circuit was 2 milliamps or 0.002 A. We then used Ohm's Law in the form E = I R to calculate the voltage drop across each resistor. Thus, E1 = I R1 = (0.002)(1000) = 2 volts. Similarly, E2 = 4 volts and E3 = 6 volts. There could have been multiple voltage sources interspersed among multiple resistors.

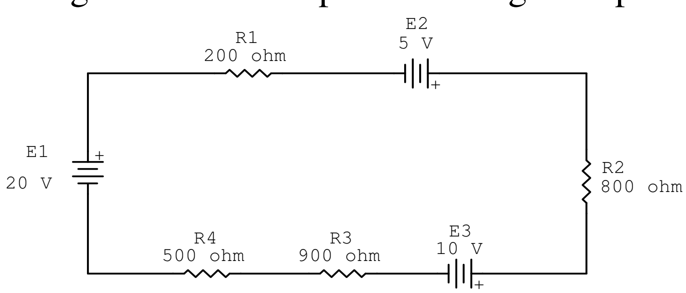

Fig 2

Note that we can go around this loop in two possible directions, clockwise or counterclockwise. Normally, go in a direction that takes you through the voltage sources from the negative to the positive terminal. If we start with voltage source E1 and go from negative to positive, we consider this a voltage increase of +20 volts. As we proceed across E2 we go from negative to positive so we have a voltage increase of +5 volts. When we cross E3, we go from positive to negative, therefore, we have a voltage drop and we indicate that by – 10 volts. Therefore, the total voltage sources result in a voltage of

$$E = E1 + E2 + E3 = +20\ v + 5\ v - 10\ v = 15\ v.$$

Each of the resistors has a voltage drop that is calculated by Ohm's law, E = I R. This means that the voltage drops across the resistors in this series circuit will add to be

$$\begin{aligned} &I (R1) + I (R2) + I (R3) + I (R4) \\ &= I (R1 + R2 + R3 + R4) \\ &= I (200 + 800 + 900 + 500) \\ &= I (2400). \end{aligned}$$

One of the properties that a series circuit has is that the total of the voltage sources has to be the same as the total of the voltage drops. This means that

$$E = 15 \text{ v} = I (2400).$$

Solving for the current, I, we get

$$\begin{aligned} I &= 15 / 2400 \\ &= 0.00625 \text{ A} \\ &= 6.25 \text{ mA}. \end{aligned}$$

The current flowing in the series circuit of Fig. 2 is therefore 6.25 mA. The process we followed suggests that we might want to construct an equivalent circuit. An equivalent circuit has the same voltage and current as the original. Such an equivalent circuit uses one voltage source and one resistor. According to what we calculated above, the equivalent circuit would be as follows:

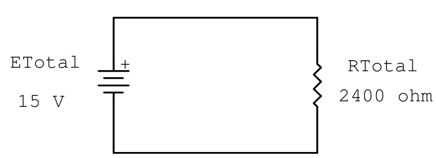

Fig. 3

Notice that the same current, I, must be flowing in both Fig. 2 and Fig. 3. This means that the one equivalent resistor must produce the same voltage drop as all the others combined. Therefore,

$$I (RTotal) = I (R1+R2+R3+R4).$$

Since the current, I, is the same on both sides of this equation, we can divide it out to give a simple equation to calculate the total resistance of a string of resistor connected in series.

$$R\ Total = R1 + R2 + R3 + R4.$$

This formula will work for any number of resistors connected in series. By the way, the statement that **ALL VOLTAGE DROPS MUST EQUAL ALL VOLTAGE RISES AROUND A CLOSED LOOP IS CALLED** ***Kirchhoff's Voltage Law***.