Basic Electronics Part 19
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As we saw in Basic Electronics, Part 18, you can change from just about any ac voltage to any other ac voltage using a transformer. The relationship between the input voltage and the output voltage depends on the number of turns in the primary winding and the number of turns in the secondary winding. It is important to realize that the amount of energy in a system must remain constant. We can neither create nor destroy energy, however, we can change energy from one form to another. In the case of transformers, we can't get more energy out of the transformer secondary than we put into the primary. Unfortunately, a real transformer will change some of the input energy into heat in the wires and the core material. It also takes some energy to overcome the resistance in the wire and that will show up as heat energy in the wire. All of this electrical energy converted to heat represents a loss of electrical energy, not a loss of energy.

The input power of a transformer can be calculated by measuring the primary voltage and the primary current. For example, if E_p represents the primary voltage and I_p represents the primary current, then the input power, P_{in}, is given by

$$P_{in} = I_p \times E_p .$$

If we also measure the secondary voltage, E_s, and the secondary current, I_s, then the output power, P_{out}, is given by

$$P_{out} = I_s \times E_s .$$

If no electrical energy is lost in the transformer, then we must have

$$P_{in} = P_{out} .$$

You realize that a real transformer will always have some electrical energy converted to heat and lost. This means that the output power is slightly less than the input power.

Now if we return to our current and voltage relationships we get

$$I_p \times E_p = I_s \times E_s .$$

This can be expressed in the form

$$\frac{E_p}{E_s} = \frac{I_s}{I_p} .$$

Referring back to Part 18 we realize that if N_p represents the number of turns in the primary winding and N_s represents the number of turns in the secondary winding, then

$$\frac{N_p}{N_s} = \frac{E_p}{E_s} .$$

This leads to a relationship concerning current

$$\frac{N_p}{N_s} = \frac{I_s}{I_p} .$$

Notice that the primary and secondary currents have the opposite order from the number of turns in the windings. This means the winding with more turns must carry a smaller current. Therefore, your should use a larger diameter wire for the winding with fewer turns and you can use smaller diameter wire in the windings with more turns.

The wire size determines how much current the transformer can safely handle. Remember that smaller diameter wire has more resistance; therefore, you have a trade-off based on the amount of current the secondary will require. A transformer made with smaller wire will be smaller in size. If you must have a higher secondary current, then you will need to select a transformer that will handle this higher current, therefore, it will need to be constructed of larger diameter wire.

Suppose you have a transformer that has a turns ratio of 5 to 1 (primary to secondary). That means that there are 5 times more turns in the primary winding than in the secondary winding. If the primary winding can handle 3 amperes, how much current can you draw from the secondary?

To solve this problem we use the relationship

$$\frac{N_p}{N_s} = \frac{I_s}{I_p}.$$

This results in the equation

$$5 = \frac{I_s}{3}.$$

Solving for I_s we get

$$I_s = 15 \text{ amperes.}$$

We usually think of a transformer in terms of it's ability to change voltage, however, the current available from a transformer must also be considered.