

Energy and Power

We define **energy** as the ability to do work. An object can have energy because of its position (like a rock ready to fall off the edge of a cliff). An object in motion also has energy (like the same rock as it falls to the bottom of the cliff). In electronics, a power supply or battery is the source of electrical energy. We can make use of that energy by connecting the supply to a light bulb, a radio or other circuit.

A voltage source pushes electrons through the resistance in an electric circuit. Suppose we have a circuit with two resistors connected so the current goes from the battery, through one resistor, then through the other and finally back to the battery. If we know how much current flows through the circuit, we can use Ohm's Law to calculate the voltage across each resistor. The example shown in **Figure 7.13** has two equal-value resistors, and each resistor has half the battery voltage because the total battery voltage is applied across both resistors. The voltage that appears across each individual resistor is called a *voltage drop*. In our example, after the current has gone through the first resistor, the voltage has dropped from 10 V to 5 V, and after the second resistor it has dropped to 0 V because it is back to the battery terminal at that time.

These voltage drops occur because electrical energy is “used up” or “consumed.” Actually, we can't lose the electrical energy; it is just changed to some other form. The resistor heats up because of the current through it; the resistance converts electrical energy to heat energy. More current produces still more heat, and the resistor becomes warmer. If the current is too large the resistor might even catch fire!

As electrons flow through a light bulb, the resistance of the bulb converts some electrical energy to heat. The filament in the bulb gets so hot that it converts some of the electrical energy to light energy. Again, more current produces more light and heat.

You should get the idea that we can “use up” a certain amount of energy by having a small current go through a resistor for a long time or by having a larger current go through it for a shorter time. When you buy electricity from a power company, you pay for the electrical energy that you use each month. You might use all of the energy in one day, but you probably use a small amount every day. Your bill would be the same in either case, because the electric meter on your house just measures how much energy you use. The power company sends someone around to read the meter each month to determine how much electrical energy you used.

Sometimes it is important to know how fast a circuit can use energy. You might want to compare how bright two different light bulbs will be. If you're buying a new freezer, you might want to know how much electricity it will use in a month. You will have to know how fast the freezer or the light bulbs use electrical

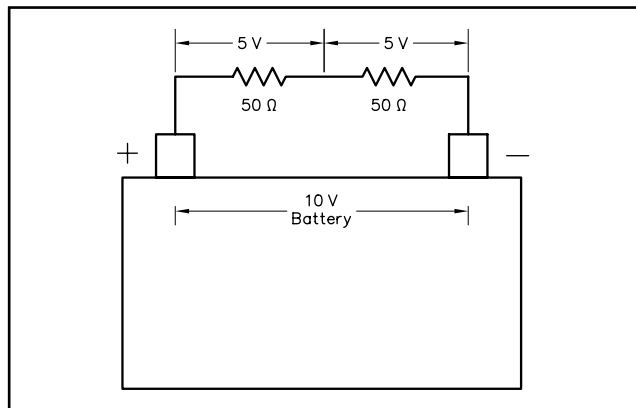


Figure 7.13 — When two resistors are connected in series with a battery, part of the battery voltage appears across each of the resistors. Here, each resistor has half the voltage because the two resistors have equal values.

energy. We use the term **power** to define the rate of energy consumption. The basic unit for measuring power in the metric system is the **watt**. You have probably seen this term used to rate electrical appliances. You know that a light bulb rated at 75 watts will be brighter than one rated at 40 watts. (Sometimes we abbreviate watts with a capital W.) These same numbers tell us which light bulb uses more electrical energy each minute (or hour) that they are turned on. For example, if you turn on light bulbs of 60 watts, 75 watts and 100 watts, the 100-watt light bulb will use the most electrical energy in an hour.

Power and Decibels

The **decibel** is one unit that you will hear used (and misused) quite often in electronics. Just what does this term mean? First we'll define the term, and then we'll take a look at some of the ways we use decibels in electronics.

You have probably recognized *deci* as the metric prefix that means one tenth. So the unit we are really talking about here is the *bel*, and a decibel is just 1/10 of a bel. We often use a capital B to abbreviate bel. Since the lower case d is the abbreviation for deci, the proper abbreviation for a decibel is dB. The bel is named for Alexander Graham Bell. Most people remember Bell for his invention of the telephone. Bell was also very interested in working with deaf people and studying the way we hear sounds.

In electronics, we use the decibel as a comparison of power levels. A decibel is ten times the logarithm of a ratio of two power levels. We aren't going to get too technical or go into a lot of math here, so don't panic.

A couple of examples will make this easier to understand. Suppose you are operating a transmitter with a power output of 5 watts. Now increase that output power to 10 watts. Find the ratio of these power levels by dividing the new (higher) power by the original value:

$$\text{Power Ratio} = \frac{10 \text{ W}}{5 \text{ W}} = 2$$

If you have a scientific calculator, you can find the logarithm (log) of 2, and the answer is 0.3. Now if we multiply that result by ten, we have our answer of 3 dB. So by going from 5 W to 10 W, we have increased our transmitter power by 3 dB.

Suppose you increased the power from 10 W to 20 W. Well, the ratio of those power levels is 2, so that is another 3 dB-increase in power.

Now you may be wondering how we would describe the change from 5 W to 20 W. Well in that case the ratio of output powers is:

$$\text{Power Ratio} = \frac{20 \text{ W}}{5 \text{ W}} = 4$$

The basic unit of power is the watt. This unit is named after James Watt (1736-1819). Watt made engineering design changes to earlier steam engines, and developed a practical steam engine that helped create the industrial revolution.

Table 7.2
Some Common Decibel Values and Power Level Ratios

P_2/P_1	dB
0.1	-10
0.25	-6
0.5	-3
1	0
2	3
4	6
10	10

Using your scientific calculator again, you can find that the log of 4 is 0.6. Multiply that answer by ten to find that this represents a 6-dB increase in power.

There is one more example that will give an answer worth remembering. Suppose we increase that transmitter power from 5 W to 50 W. That new power is 10 times larger than the first power. The log of 10 is 1. So we have a 10-dB increase in power for this last example.

Every time you increase the power by a factor of 2 times, you have a 3-dB increase of power. Every 4 times increase of power is a 6-dB increase of power. When you increase the power by 10 times, you have a power increase of 10 dB. You can also use these same values for a decrease in power. Cut the power in half for a 3-dB loss of power. Reduce the power to ¼ the original value for a 6-dB loss in power. If you reduce the power to 1/10 of the original value you will have a 10-dB loss. The power-loss values are often written as negative values: -3, -6 or -10 dB. **Table 7.2** shows these common decibel values and power ratios.