

Basic Electronics Part 20
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We can define an ac voltage as one that continuously varies in magnitude and periodically reverses in polarity. An ac voltage is usually represented by a sine wave or a sinusoid because the amount of voltage is proportional to the sine of the angle of rotation in the circular motion producing the voltage from a generator. When a sine wave of alternating voltage is connected across a load resistance, the current that flows in the circuit is also a sine wave. Suppose we connect a 100 ohm resistor, R, to a sine wave voltage generator as in the circuit below.

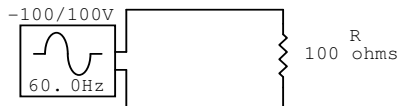


Fig. 1

The amount of current is given by Ohm's Law: $I = V/R$. If we make a small table of values of voltage, V, and current, I, using Ohm's Law we get the following:

V	I	V	I
0 volts	0 A	0 volts	0 A
+50 volts	0.5 A	-50 volts	0.5 A
+100 volts	1.0 A	-100 volts	1.0 A
+50 volts	0.5 A	-50 volts	0.5 A
0 volts	0 A	0 volts	0 A

As the voltage builds in the positive half-cycle from 0 volts to 100 volts, the current is flowing in one direction through R and building from 0 amp to 1 amp. The voltage then decreases from 100 volts back down to 0 volts so the current decrease from 1 amp back down to 0 amp, still flowing in the same direction. In the next half-cycle, the voltage builds in the negative direction and the current builds accordingly, but it is flowing in the opposite direction from the preceding half-cycle.

We see that the alternating current in the circuit has sine-wave variations corresponding exactly to the sine-wave alternating voltage. Only the waveforms of V and I can be compared. There is no comparison between relative values, because the current and voltage are different quantities. You should note that the two half cycles of voltage produce the same size current but the direction of current flow is reversed. The direction does not matter, since it is just the motion of electrons against resistance that produces power dissipation. In short, resistance R has the same effect in reducing I for either direct current or alternating current.

Since an alternating sine wave of voltage or current has many instantaneous values through the cycle, it is convenient to define specific magnitudes for comparing one wave with another. The peak, average, and root-mean-square (rms) values can be specified. These values can be used for either current or voltage.

Peak value is the maximum value of either the voltage, V_M , or of the current, I_M . In the example above, $V_M = 100$ volts, and $I_M = 1$ amp. This specifies the highest value that the sine wave reaches. Notice that peak voltage and peak current occur at the same time. The peak value applies to either the positive or the negative peak.

In order to include both peak amplitudes, the peak-to-peak (p-p) value may be specified. In the above example the peak-to-peak value of voltage is 200 volts and the peak-to-peak current is 2 amps.

The average value is the arithmetic average of all the values in the sine wave for one half-cycle. The half-cycle is used for the average because over a full cycle the average value is zero. The relationship between the peak value and the average value is as follows:

$$\text{Average value} = 0.637 (\text{ peak value}).$$

In the above example, the average value is $0.637 (100 \text{ volts}) = 63.7 \text{ volts}$.

The most common method of specifying the amount of a sine wave of voltage or current is by relating it to dc voltage and current that will produce the same heating effect. This is called the root-mean-square value (rms value). The relationship between the peak value and the rms value is as follows:

$$\text{rms value} = 0.707 (\text{ peak value }).$$

In the above example, the rms voltage is $0.707 (100 \text{ volts}) = 70.7 \text{ volts}$. The rms current is given by $0.707 (1 \text{ amp}) = 0.707 \text{ amp}$.

There are times when we need to convert from rms voltage to peak voltage (or current). We do this by inverting the above formula.

$$\begin{aligned} \text{Peak value} &= (1/ 0.707) (\text{ rms value }) \\ &= 1.414 (\text{ rms value }). \end{aligned}$$

The rms value of an alternating sine wave corresponds to the same amount of direct current or voltage in heating power. An alternating voltage with an rms value of 120 V is just as effective in heating the filament of a light bulb as 120 V from a steady dc voltage source. For this reason, the rms value is also called the effective value.