When the magnitude of the voltage waveform is specified in Volts RMS (root mean square), the average power dissipated in a resistor, R, is given by:–

$$\text{Power} \quad = P = \frac{V_{RMS}^2}{R} = I_{RMS}^2 \times R \quad \text{Watts}$$

where:-

$$\begin{aligned} V_{Amplitude} &= 1.4 \times V_{RMS} \\ V_{Peak-to-Peak} &= 2 \times V_{Amplitude} \end{aligned}$$

Instantaneous power dissipation is $P = V \times I$.

For the special case of a resistor we have Ohm's law $V = I \times R$

When we substitute for I we get $P = \frac{V^2}{R}$.

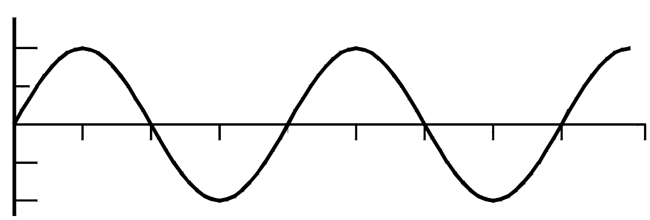
When sinusoidal voltage waveforms are applied across the resistor we are interested in the average power dissipation rather than the instantaneous dissipation which changes during the cycle.

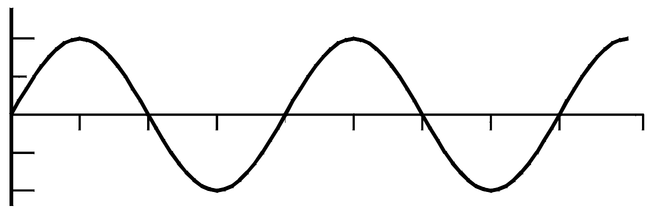
So it is necessary to integrate the power dissipation over a cycle and then average over the period, T.

$$
\begin{aligned}
P_{Average} &= \frac{1}{T}\int_0^T \frac{V^2}{R}dt \\
&= \frac{1}{T}\int_0^T \frac{V_0^2 \sin^2(\frac{2\pi t}{T})}{R}dt \\
&= \frac{1}{T}\int_0^T V_0^2 \frac{1-\cos\frac{4\pi t}{T}}{2R}dt \\
&= \frac{1}{T}\left[\frac{V_0^2 t}{2R} + \frac{V_0^2 T \sin\frac{4\pi t}{T}}{8\pi R}\right]_0^T \\
&= \frac{V_0^2}{2R} \\
\text{Let} \quad 1.414 \times V_{RMS} &= V_0 \\
\text{which gives} \quad P &= \frac{V_{RMS}^2}{R} \\
\text{Form Factor} &= 1.414 = \sqrt{2}
\end{aligned}
$$

Example 1

Calculate the RMS voltage for the oscilloscope tracing of the voltage waveform shown in Figure 9.1. Calculate the frequency. The oscilloscope settings are 2 msec per division for the time base and 5 Volts per division for the Y amplifier.





From the figure the amplitude is $2 \times 5V$ and the period is $4 \times 2 \times 10^{-3} s$.

$$
\begin{aligned}
V_{RMS} &= \frac{2 \times 5}{1.41} \\
&= 7.07V \\
\text{and} \quad \text{Frequency} &= \frac{1}{\text{Period}} \\
&= \frac{1}{4 \times 2 \times 10^{-3}} \\
&= 125 Hz
\end{aligned}
$$