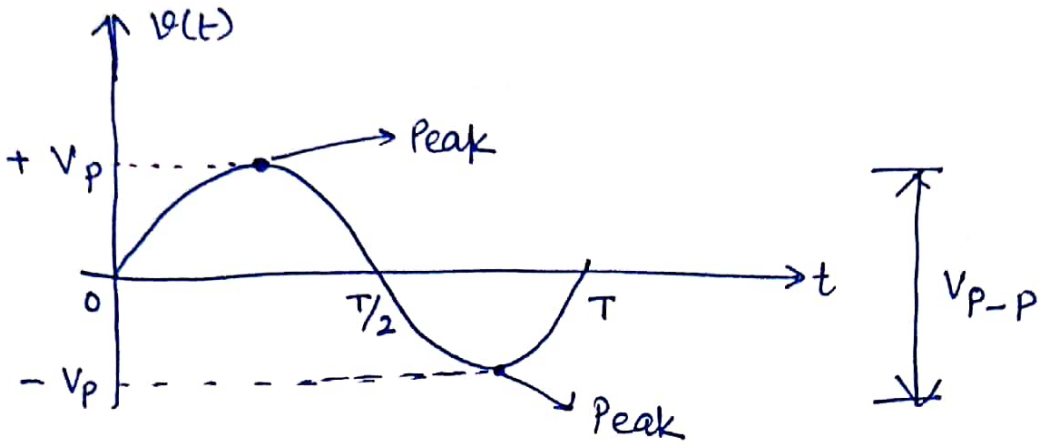
Experiment No. 9 (Theory / Formula)

To study the Root-Mean-square (RMS), Peak, and Peak-to-Peak values, Measurements with Oscilloscope.



V_p = Peak Voltage

V_{p-p} = Peak-to-Peak Voltage = $V_p - (-V_p) = 2V_p$

V_{rms} = Root-Mean-square Voltage

The root mean square value of a quantity is the square root of the mean value of the squared value of the quantity taken over an interval.

Here, quantity = sine wave (voltage)

Time Period = $T = \frac{2\pi}{\omega}$; ω - angular freq. (rad/sec)

$v(t) = V_p \sin \omega t$ → Expression of above sine wave

Mean Value of voltage, $v(t)$ = $\langle v(t) \rangle = \frac{1}{T} \int_0^T v(t)\,dt$

$$V_{rms} = \sqrt{\left[\frac{1}{T} \int_0^T \{v(t)\}^2 dt\right]}$$

Mean square

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T V_p^2 \sin^2 \omega t \, dt}$$

$$= \sqrt{\frac{V_p^2}{T}\int_0^T \left[\frac{1-\cos 2\omega t}{2}\right] dt}$$

$$= \sqrt{\frac{V_p^2}{2T}\int_0^T [1-\cos 2\omega t] \, dt}$$

$$= \sqrt{\frac{V_p^2}{2T}\left[\{t\}_0^T - \left\{\frac{\sin 2\omega t}{2\omega}\right\}_0^T\right]}$$

$$= \sqrt{\frac{V_p^2}{2T}\left[(T-0) - \frac{\sin 2 \times \frac{2\pi}{T} \times T}{2 \times \frac{2\pi}{T}}\right]}$$

$\omega = \frac{2\pi}{T}$

$\sin 4\pi = 0$

$$= \sqrt{\frac{V_p^2}{2T}[T-0]}$$

$$= \sqrt{\frac{V_p^2}{2T} \times T} = \frac{V_p}{\sqrt{2}}$$

$$\boxed{V_{rms} = \frac{V_p}{\sqrt{2}}} = 0.707\, V_p$$

Similarly,

Average / Mean voltage, $\langle v(t) \rangle = \frac{1}{T} \int_0^T v(t)\,dt$

$$= \frac{1}{T} \int_0^T V_p \sin \omega t \, dt$$

$$= \frac{V_p}{T} \left[-\frac{\cos \omega t}{\omega} \right]_0^T$$

$$= \frac{V_p}{T} \left[-\frac{\cos \omega T}{\omega} + \frac{\cos \omega \times 0}{\omega} \right]$$

$$= \frac{V_p}{T} \left[-\frac{\cos \frac{2\pi}{T} \times T}{\frac{2\pi}{T}} + \frac{1}{\frac{2\pi}{T}} \right]$$

$$= \frac{V_p}{T} \left[\frac{-1}{2\pi/T} + \frac{1}{2\pi/T} \right] = 0$$