Department of ECE, Bennett University

EECE105L: Fundamentals of Electrical and Electronics Engineering

Some components of ac wave

Definitions:

Waveform: The path traced by a quantity (for example: voltage, current) plotted as a function of some variable (for example time, position, degrees, radians).

Instantaneous value: The magnitude of a waveform at any instant of time; denoted by lowercase letters (v_1 in fig. 1).

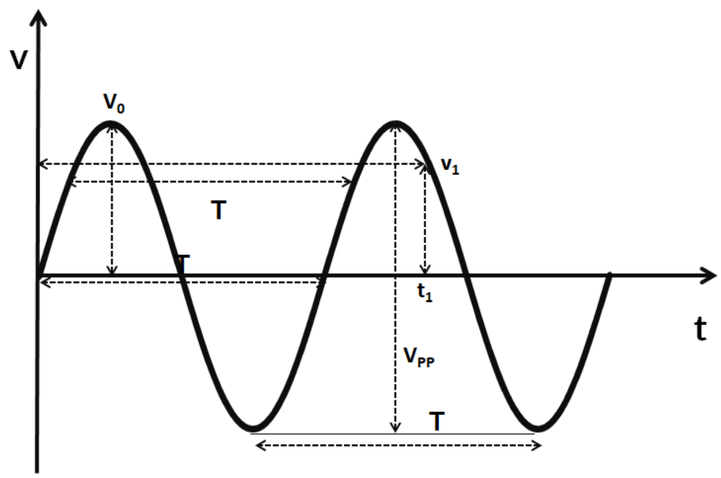

Fig. 1: A sinusoidal waveform

Peak amplitude: The maximum value of a waveform as measured from its average, or mean value, denoted by uppercase letters. In the waveform shown in Fig. 1, the average value is zero volts, and peak amplitude V_0 is as defined in fig. 1.

Peak value: The maximum instantaneous value of a function as measured from the zero-volt level. For the waveform in fig. 1, the peak amplitude and peak value are the same, since the average value of the function is zero volts.

Peak-to-peak value: Denoted by V_{PP} (as shown in fig. 1), peak to peak voltage is the full voltage between positive and negative peaks of the waveform, that is, the sum of the magnitude of the positive and negative peaks.

Periodic waveform: A waveform that continually repeats itself after the same time interval. The waveform in fig. 1 is a periodic waveform.

Period (T): The time of a periodic waveform.

Cycle: The portion of a waveform contained in one period.

Average Value: Average Value of an ac wave is defined as the average of all the instantaneous values of a wave over an interval. Generally average over one complete cycle is considered in electronics.

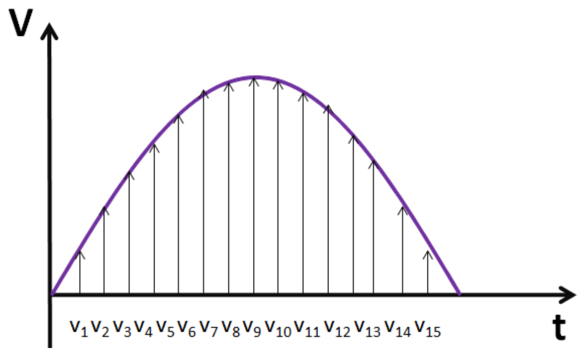

Fig. 2: Description of mid-ordinates to find average or RMS value of wave

Method 1:

In this method, the average value is found by knowing mid ordinates or instantaneous values. As shown in fig. 2, let us assume that v_1 through V_{15} are the instantaneous values (here represented as mid-ordinates) of the wave under consideration. Now, the average value of the wave is given by Eq. (1) .

$$V_{average} = \frac{V_1 + V_2 + V_3 + +V_4 + V_5 + V_6 + V_7 + V_8 + V_9 + V_{10} + V_{11} + V_{12} + V_{13} + V_{14} + V_{15}}{15} \quad \text{Eq. (1)}$$

In its most general form, re-writing Eq. (1) as in Eq. (2) results in,

$$V_{average} = \frac{\sum_{k=1}^{n} V_k}{n} \quad \text{Eq. (2)}$$

As observed from Eq. (2), the actual value of average value depends on the number of samples. As the number of samples increase, the average value approaches its actual value.

Method 2:

In this method, the average value is estimated by finding area under curve. Mathematically, if $f(t)$ generally describes the wave equation, then the area under the curve for a base between two instants t_1 and t_2 is given by Eq. (3).

$$Area = \int_{t_1}^{t_2} f(t)\,dt \quad \text{Eq. (3)}$$

The average value is given by Eq. (4).

$$V_{average} = \frac{\int_{t_1}^{t_2} f(t)\,dt}{t_2 - t_1} \qquad \text{Eq. (4)}$$

RMS Value: Root Mean Square or RMS value is defined as the square root of means of squares of instantaneous values.

Method 1:

In this method, the RMS value is found by knowing mid ordinates or instantaneous values. As shown in fig. 1, let us assume that v_1 through V_{15} are the instantaneous values (here represented as mid-ordinates) of the wave under consideration. Now, the RMS value of the wave is given by Eq. (5).

$$V_{RMS} = \sqrt{\frac{V_1^2 + V_2^2 + V_3^2 + V_4^2 + V_5^2 + V_6^2 + V_7^2 + V_8^2 + V_9^2 + V_{10}^2 + V_{11}^2 + V_{12}^2 + V_{13}^2 + V_{14}^2 + V_{15}^2}{n}} \qquad \text{Eq. (5)}$$

In its most general form, RMS value can be written as in Eq. (6).

$$V_{RMS} = \sqrt{\frac{\sum_{k=1}^{n}\left(V_k^2\right)}{n}} \qquad \text{Eq. (6)}$$

Method 2:

In this method, the RMS value is estimated by finding the area under the square of the curve. Mathematically, if $f(t)$ generally describes the wave equation, then the RMS of the wave for a base between two instants t_1 and t_2 is given by Eq. (7).

$$V_{RMS} = \sqrt{\frac{\int_{t_1}^{t_2}\left(f(t)\right)^2 dt}{t_2 - t_1}} \qquad \text{Eq. (7)}$$

Phase Difference:

Consider fig. 3. When compared to $f_r(t)$, the wave f(t) has a greater instantaneous value at position t=0. If $f_r(t)$ is given by Eq (8), then f(t) is given by Eq (9).

$$f_r(t) = A_m sin(\omega t) \qquad \text{Eq (8)}$$

$$f(t) = A_m sin(\omega t + \theta) \qquad \text{Eq (9)}$$

Thus f(t) leads $f_r(t)$ by an angle θ or in general, it is said that f(t) and $f_r(t)$ are out of phase by an angle θ.

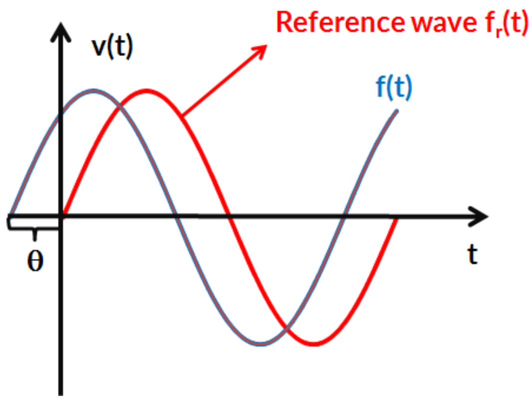

Fig. 3: f(t) leads $f_r(t)$ by an angle θ

Now consider fig. 4. When compared to f(t), the wave $f_r(t)$ has a greater instantaneous value at position t=0. If $f_r(t)$ is given by Eq (8), then f(t) is given by Eq (10).

$$f\left(t\right)=A_m sin\left(\omega t-\theta\right) \qquad \text{Eq (10)}$$

Thus in general, it is said that $f_r(t)$ and f(t) are out of phase by an angle θ, or more precisely f(t) lags $f_r(t)$ by an angle θ.

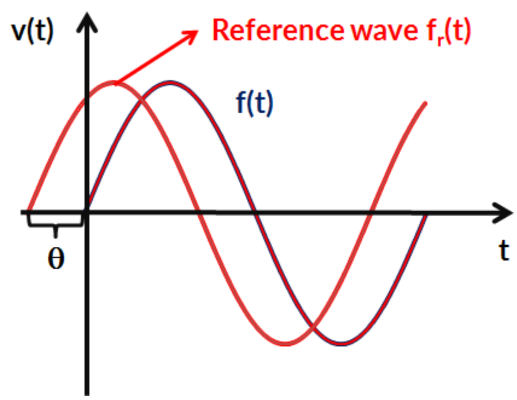

Fig. 4: $f_r(t)$ leads f(t) by an angle θ

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