Power factor in A.C :

In Steady current circuit ; the product of current and potential difference is known as power.

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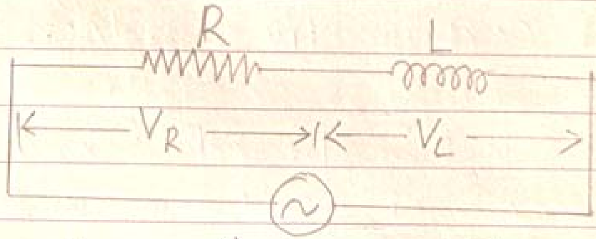
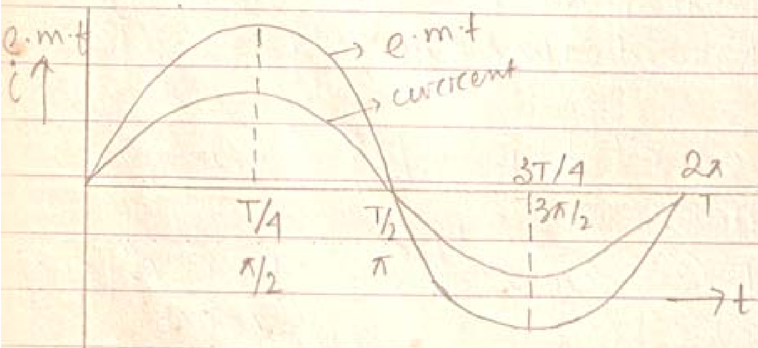
A . C

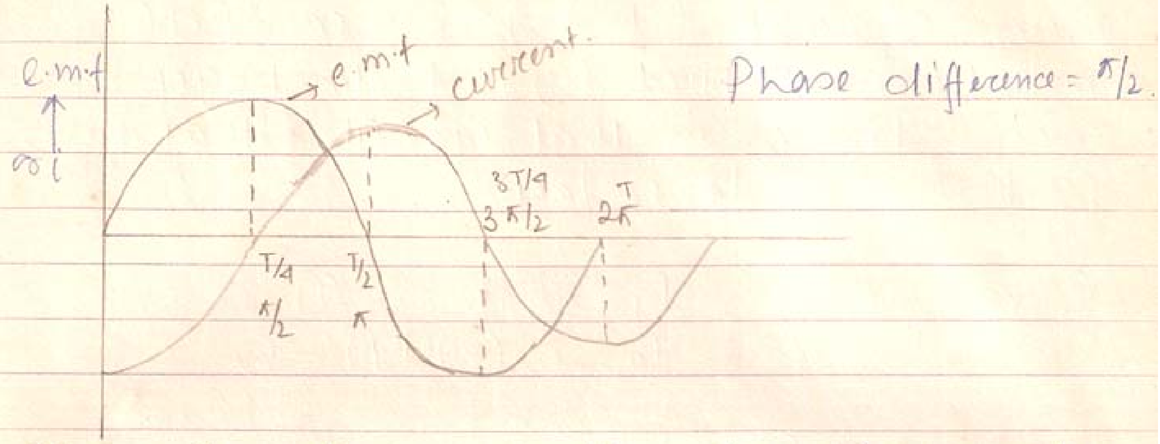
Phase in A.C :



In an A.C circuit we come across, two or more than two alternating quantities simultaneously. It may happen that the peak values of the alternating quantities may or may not occur simultaneously. The interval measured in terms of angle or time between the corresponding peak values of two alternating quantities is known as phase difference between them.



Phase difference is zero.



The alternating quantity, whose peak value occurs first is said to lead & which comes later is said to lag.

Imp. Power factor in A.C:

In steady current circuit; the product of current and potential difference is known as power. In A.C circuit since current and potential difference change continuously with time; the product of instantaneous current and instantaneous potential difference gives instantaneous power in the circuit. Hence we have to find a mean value of power in the circuit. We know that $I_{r.m.s}$ and $E_{r.m.s}$ represent the mean value of current and potential difference in an A.C circuit. Hence following the definition of power in D.C circuit if we define the mean power as the product of mean current ($I_{r.m.s}$) & mean P.d ($E_{r.m.s}$) we don't get the correct result. It is found that the product of mean current ($I_{r.m.s}$) & mean P.d ($E_{r.m.s}$) is to be multiplied by a factor to get real mean power in that circuit & that factor is known as power factor.

Given: $e = E_p \sin \omega t$ — ①
$i = I_p \sin(\omega t \pm \phi)$ — ②

{Eq^n ① and ② represent the instantaneous e.m.f & current respectively.
ϕ = Phase difference between the e.m.f and current.

Instantaneous current Power:

$$P_{ins} = e \cdot i$$

Hence the average power consumed over a complete cycle, can be obtained by taking the arithmatic mean of all the instantaneous powers over a complete cycle.

$$\therefore P_{ave} = \frac{1}{T}\int_0^T (P_{ins})\,dt = \frac{1}{T}\int_0^T e \cdot i\,dt$$

putting eq^n ① and ②:-

$$P_{ave} = \frac{1}{T}\int_0^T E_p \sin \omega t \cdot I_p \sin(\omega t \pm \phi)\,dt$$

$$\therefore P_{ave} = \frac{E_p I_p}{T\,2}\int_0^T 2\sin \omega t \cdot \sin(\omega t \pm \phi)\,dt$$

$$\text{or } P_{ave} = \frac{E_p I_p}{2T}\int_0^T \left[\cos\phi - \cos(2\omega t \pm \phi)\right]dt$$

$$P_{av} = \frac{E_P I_P}{2T}\left[\int_0^T \cos\phi \, dt - \int_0^T \cos(2\omega t \pm \phi)\, dt\right]$$

$$= \frac{E_P I_P}{2T}\left[\cos\phi . T - \frac{1}{2\omega}\left\{\sin(2\omega . T \pm \phi) - \sin(2\omega . 0 \pm \phi)\right\}\right]$$

$$= \frac{E_P I_P}{2T}\left[\cos\phi . T - \frac{1}{2\omega}\left\{\sin(4\pi \pm \phi) - \sin(\pm\phi)\right\}\right]$$

$$= \frac{E_P I_P}{2T}\left[\cos\phi . T - \frac{1}{2\omega}\underbrace{\left\{\pm \sin\phi \mp \sin\phi\right\}}_{=0}\right]$$

$$= \frac{E_P I_P}{2T} . T\cos\phi$$

$$P_{av} = \frac{E_P I_P}{2} . \cos\phi$$

$$\therefore P_{av} = \frac{E_P}{\sqrt{2}} . \frac{I_P}{\sqrt{2}} \cos\phi$$

$$P_{av} = E_{r.m.s} . I_{r.m.s.} \cos\phi \quad \text{--- (3)}$$

$E_{r.m.s}$ and $I_{r.m.s}$ are known as virtual volt & virtual current, hence their product is known as apparent power.

Apparent power = $E_{r.m.s} \times I_{r.m.s}$

True power = Apparent power × power factor

$\cos\phi$' in eqn (3) is known as power factor of the circuit and is defined as the factor by which the apparent power of the circuit is to be multiplied to get true power in the circuit.