

Power Relations in AC Circuits - GATE Study Material in PDF

In the previous articles we discussed the sinusoidal responses of series and parallel circuits. In these free GATE 2018 Notes, we will see all about Power Relations in AC Circuits. We will learn all about Instantaneous Power in an AC Circuit. We will also learn the meanings of the terms Power Factor, Apparent Power, Reactive Power, Power Triangle, and Complex Power.

This free GATE material can be used for GATE EC, GATE EE, IES, BARC, BSNL, DRDO and other exams. You can have these GATE notes downloaded as PDF to have your preparation made easy, and so you ace your exam.

Don't forget to read up on the important concepts you will need to build the basics of this topic.

Recommended Reading –

Basic Network Theory Concepts <u>Kirchhoff's Laws, Node and Mesh Analysis</u> <u>Voltage and Current Division, Star to Delta Conversion</u> <u>Parameters of Periodic Wave Forms</u> <u>Sinusoidal Response of Series Circuits</u> <u>Sinusoidal Response of Parallel Circuits</u>

Instantaneous Power in AC Circuits







In a passive a.c. circuit, let the instantaneous voltage be $V = V_m \sin \omega t$ while the current is given by $i = I_m \sin(\omega t \cdot \phi)$,

 ϕ being the phase difference between the voltage and current at any instant.

The instantaneous power P is thus given by

 $P = V_i = V_m I_m \sin\omega t \sin(\omega t - \phi)$

 $= \mathcal{K} \quad m \operatorname{Im} \cos \phi - \mathcal{K} \quad m \operatorname{Im} \cos(2\omega t - \phi)$

The second term in the right hand side of above equation contains a double frequency term and it is evident that the magnitude of the average value of this term is zero. Thus the instantaneous power consists only the term ($\mathcal{M}_m I_m \cos \phi$) which is the average power in the passive.

Thus the average power in the passive circuit is given by

 $P_{av} = \frac{1}{2} V_m I_m \cos \phi$

$$=\frac{V_{m}}{\sqrt{2}}\frac{I_{m}}{\sqrt{2}}\cos\varphi$$

= VI cos ϕ

In a purely resistance circuit $\phi = o$

 \Rightarrow P_R = VI cos o = VI watts

In a pure Inductive circuit $\phi = -90^{\circ}$

 $\Rightarrow P_L = VI \cos (-90) = 0$

In a pure capacitive circuit, $\phi = 90^{\circ}$

 $\Rightarrow P_{C} = VI \cos (90) = 0$

Thus the average power consumed by the pure inductance or capacitance is zero.

The average power in a.c. circuits is also termed as a true power, real power, active power.





Power Factor: It is the cosine of the angle between the voltage and current in any a.c. circuit. Power factor is unity in resistive circuit, leading in capacitive, lagging in inductive circuit.

Power factor = $\cos \phi$

Apparent Power: The product VI is called the apparent power and is usually indicated by the symbol 'S'. It is expressed in (VA).

Reactive power: The product of r.m.s. values of voltage and current with the sine of the angle between them is called the reactive power in a.c. circuit and is denoted by Q, the unit being VAR (Volt-ampere reactive)

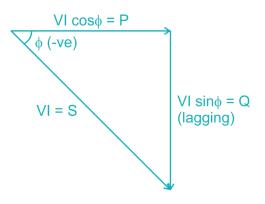
 $Q = VI \sin \phi$

The other names of reactive power are wattles power and quadrature power.

Power Triangle: It is the geometrical representation of the apparent power,

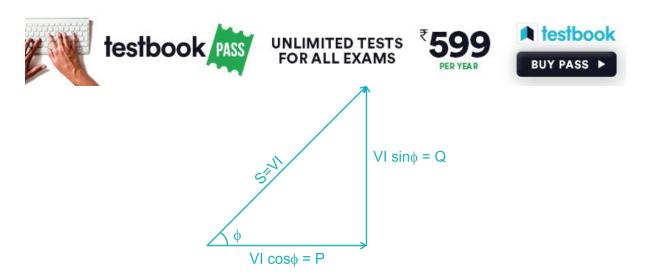
average power and reactive power.

For the inductive circuits, the power triangle is as shown below.



For the capacitive circuits, the power triangle is as shown below





Complex Power: Complex power can be obtained from the product VI*.

Complex power is frequently denoted by S and is given by

For the capacitive circuit,

 $VI^* = Ve^{j\theta}$. Ie^{-j(\theta + \phi)} = VIe^{-j\varphi}

 $VI^* = VIcos\phi - jVIsin\phi$

S = P - jQ

For the inductive circuit,

 $VI^* = Ve^{j\theta}$. $Ie^{-j(\theta-\phi)} = VIe^{j\phi}$

=VI $\cos\phi + jVI \sin\phi = P + jQ$

 \Rightarrow S = P + jQ

(+ Q) indicates lagging reactive power while (– Q) indicates leading reactive power.

Example 1:

A 0.2 HP induction motor runs at an efficiency of 85 %. If the operating power factor is 0.8 lag, find the reactive power taken by the motor.

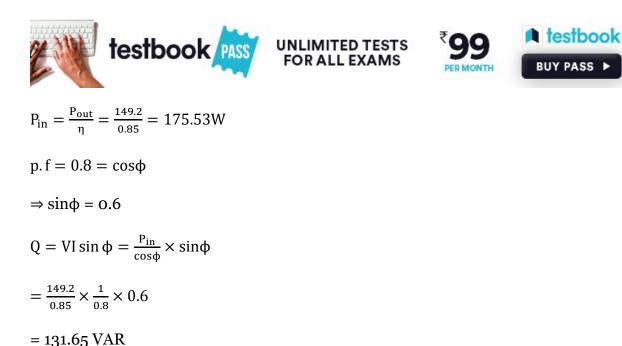
Solution:

 $P_{out} = 0.2 \text{ HP} = \frac{746}{5} = 149.2 \text{W}$

CURREN







Example 2:

The current in a circuit lag the voltage by 30°. If the input power be 400 W and the supply voltage be V=100 sin (377+10), find the complex power is

Sol

Φ=

$$30^{\circ} \log, \cos \phi = 0.866 \log$$

$$I = \frac{P}{V\cos\phi} = \frac{400}{\frac{100}{\sqrt{2}} \times 0.866}$$

 $I = 6.53 \angle - 30^{\circ}$

$$S = VI^* = \frac{100}{\sqrt{2}} \times 6.53 \angle 30^\circ$$

 $= 461.74 (\cos 30^\circ + j \sin 30^\circ)$

Did you like this article on Power Relations in AC Circuits? Let us know in the comments. You should also read some articles like -





Network Theory Revision Test 1

Series Resonance

Parallel Resonance

Mock Tests on GATE 2018

List of 40+ PSUs Recruitment through GATE 2018

testbook.com





6 | Page