Chapter 10 : Power

- Instantaneous Power $P(t)$:

$$P(t) = \frac{V_m I_m}{2}\left[\cos(\theta_v - \phi_i) + \cos(2\omega t + \theta_v + \phi_i)\right] \text{ watt}$$

- Average Power :- (Real Power)

$$P_{av} = \frac{1}{2} V_m I_m \cos(\theta_v - \phi_i)$$

Resistor

- $\frac{I_m^2 R}{2}$

$\theta_v - \phi_i = 0$

Inductor

$P_{av} = 0$

$\theta_v - \phi_i = 90$

Capacitor

$P_{av} = 0$

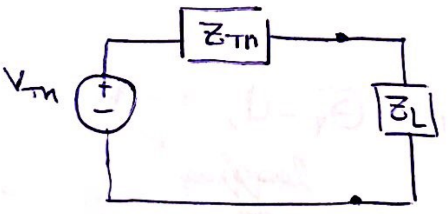
$\theta_v - \phi_i = -90$

* Reactive impedances absorb No average Power

- Maximum average Power Transfer

$Z_{Th} = R_{Th} + j X_{Th}$

$Z_L = R_L + j X_L$



$\longrightarrow Z_L = Z_{Th}^*$

$P_{L,max} = \frac{1}{8}\frac{V_{Th}^2}{R_L}$ or R_{Th} (Real part Only)

* Effective or RMS Value:

$$V_{rms} = V_{eff} = \frac{V_m}{\sqrt{2}}$$ ← Max amplitude

$P_{av} = V_{rms} I_{rms} \cos(\Phi_v - \Phi_i)$

$V_{rms} = R I_{rms}$ $\qquad \Theta_v - \Phi_i = 0$

$P_{av} = I_{rms}^2 R \leftarrow$ real part

$P_{apparent} = V_{rms} I_{rms}$ measured in VA

$PF = $ Power factor

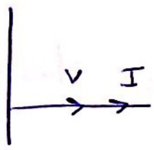
$PF = \cos(\Theta_v - \Phi_i) \leftarrow$ Phase shift

So $\boxed{P_{av} = P_a \cdot P_F}$

* P_F of Types of loads:-

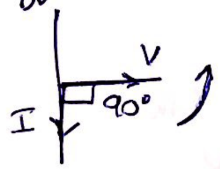
1) Resistor: $\Theta_v - \Phi_i = 0$

$P_F = 1$



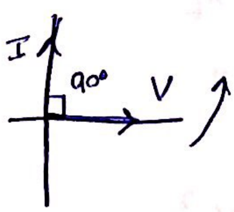
2) Inductor: $\Theta_v - \Phi_i = 90$ lagging

$P_F = 0$



3) Capacitor: $\Theta_v - \Phi_i = -90$ leading

$P_F = 0$



4) Inductive load

$90° > \Theta_v - \Phi_i > 0$

$1 > P_F > 0$ $\qquad$ lagging Power factor

(5) Capacitive load

$-90 < \theta_v - \theta_i < 0$

$1 > PF > 0$ leading Power factor

* عشان تعرف اذا ال P_F leading or lagging بنغي

اذا كان فرق الزوايا موجب ← lagging

اذا كان فرق الزوايا سالب ← leading

Note: $P_{supplied} = P_{av_L} + P_{av_{Load}}$ ← احنا بنحسبها

علامة معكوسة

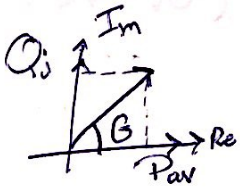
* ملاحظة :- اذا كان ال P_F lagging اضرب ال cos بسالب

Complex Power

$$\vec{S} = V_{rms} I_{rms} \angle \theta_v - \theta_i = V_{rms} \cdot \vec{I}_{rms}^{\,*}$$

$$= \underbrace{V_{rms} I_{rms} \cos(\theta_v - \theta_i)}_{P_{av}\text{: average Power in Watt}} + \underbrace{V_{rms} I_{rms} \sin(\theta_v - \theta_i)}_{Q\text{: Reactive Power in VAR}} j$$

VAR: Volt Ampere reactive



* Q for Types of load:-

Note:

$\vec{S}_T = \vec{V}_{rms} \vec{I}_s^{\,*}$

$P_a = |S_{L^T}|$

$P_{av\,loss} = |I_s|^2 \cdot (0.05)$

1) Resistance $\quad \theta_v - \theta_i = 0$

$Q_R = 0$

2) Inductance $\quad \theta_v - \theta_i = 90$

$$Q_L = \omega L\, I_{rms}^2 = \frac{V_{rms}^2}{\omega L}$$

3) Capacitance $\quad \theta_v - \theta_i = -90$

$$Q_c = \frac{-I_{rms}^2}{\omega c} = -\omega c (V_{rms})^2$$

Remember $\quad \theta = \theta_v - \theta_i = \tan^{-1}\left(\frac{Q}{P_{av}}\right)$

$Q = P_{av} \tan[\cos^{-1}(PF)]$ lagging

$Q = -P_{av} \tan[\cos^{-1}(PF)]$ leading

• لإيجاد Q نجب V_{rms}, I_{rms} كلي ونجد Q كلية

أو نجب I , V لكل ملوسن ونجمع جمع جبري

تذكر لك Q جمع جبري في جميع الحالات توازي أو توالي

* Conservation of AC Power

$$P_F = \cos(\theta_v - \theta_i)$$

Power factor Correction

→ Increasing PF without alternating voltage or current

To improve the power factor we decrease Q

In an inductive circuit we add a capacitor parallel to the load

$$Q_c = Q_{final} - Q_{initial}$$

$$C = -\frac{Q_c}{\omega V_{rms}^2}$$

Measuring Power : Wattmeter

- Two Coils used
- high impedance voltage coil
- low " current "

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ملاحظات عند حل الأسئلة :-

اذا طلب ال Powerfactor

اوجد S لكل عنصر load ثم اوجد ΣS

ثم حوله إلى ال Pol.form وخذ الزاوية

Cos(الزاوية) = PF