EEE201
Circuit Analysis II

Ankara University

Faculty of Engineering

Electrical and Electronics Engineering Department

Sinusoidal Steady-State Power Calculations

EEE201 Circuit Analysis II

Lecture 5

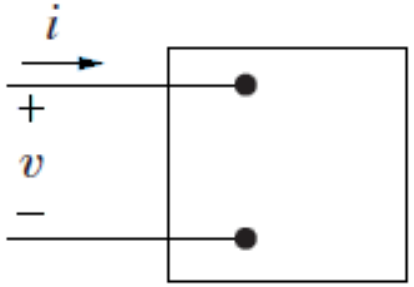
Agenda

- Instantaneous Power
- Average and Reactive Power
- The rms Value
- Complex Power

Instantaneous Power

$$v = V_m \cos(wt + \theta_v)$$

$$i = I_m \cos(wt + \theta_i)$$



$$v = V_m \cos(wt + \theta_v - \theta_i) \text{ and } i = I_m \cos(wt) \Rightarrow$$

$$p = v \cdot i$$

$$= \frac{V_m I_m}{2} \cos(\theta_v - \theta_i) + \frac{V_m I_m}{2} \cos(\theta_v - \theta_i) \cos(2wt) - \frac{V_m I_m}{2} \sin(\theta_v - \theta_i) \sin(2wt)$$

Average and Reactive Power

$$p = P + P\cos(2wt) - Q\sin(2wt)$$

Average power: $P = \frac{V_m I_m}{2}\cos(\theta_v - \theta_i)$ (watt, W)

Reactive power: $Q = \frac{V_m I_m}{2}\sin(\theta_v - \theta_i)$ (volt-amp reactive, VAR)

Average and Reactive Power

Power for **purely resistive** circuits ($\theta_v = \theta_i$)

$$p = P + P\cos(2wt)$$

Power for **purely inductive** circuits ($\theta_v - \theta_i = +90°$)

$$p = -Q\sin(2wt)$$

Power for **purely capacitive** circuits ($\theta_v - \theta_i = -90°$)

$$p = -Q\sin(2wt)$$

Average and Reactive Power

Power factor: $pf = \cos(\theta_v - \theta_i)$

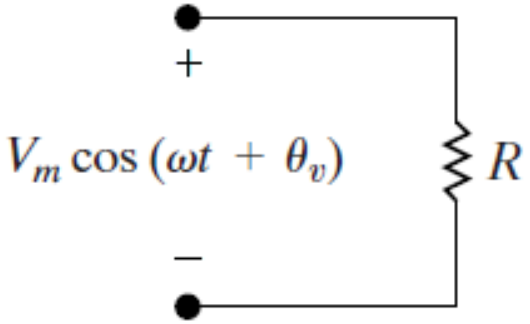
Reactive factor: $rf = \sin(\theta_v - \theta_i)$

$\theta_v > \theta_i \implies lagging\ power\ factor$

$\theta_v < \theta_i \implies leading\ power\ factor$

The rms Value (or Effective Value)

$$P = \frac{1}{T}\int_{t_0}^{t_0+T} p\,dt = \frac{1}{T}\int_{t_0}^{t_0+T} \frac{V_m^2 cos^2(wt+\emptyset_v)}{R}\,dt$$



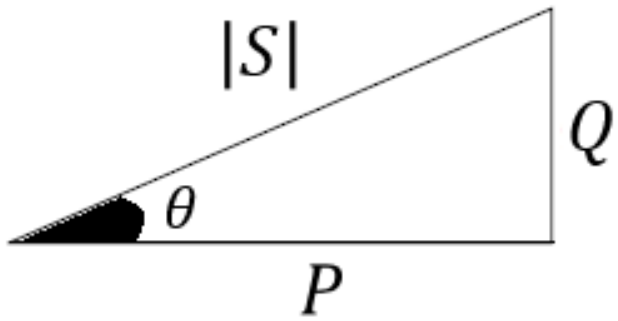
$$P = \frac{V_{rms}^2}{R}$$

$$P = I_{rms}^2 R$$

Complex Power

$S = P + jQ$ (volts-amps, VA)

$$\frac{Q}{P} = \tan\theta = \tan(\theta_v - \theta_i)$$



Apparent power:

$$|S| = \sqrt{P^2 + Q^2} \quad \text{(volts-amps, VA)}$$

Reference

- Electric Circuits, Tenth Edition, James W. Nilsson, Susan A. Riedel Pearson, 2015