EEE201
Circuit Analysis II

Ankara University

Faculty of Engineering

Electrical and Electronics Engineering Department

Sinusoidal Steady-State Analysis

EEE201 Circuit Analysis II

Lecture 2

Agenda

- Phasor
- Passive Circuit Elements in the Frequency Domain
- Kirchhoff’s Laws in the Frequency Domain

Phasor

The phasor is a complex number that carries the amplitude and phase angle information of a sinusoidal function:

$$v = V_m \cos(wt + \emptyset) = V_m \Re\{e^{j(wt+\emptyset)}\} = V_m \Re\{e^{jwt} e^{j\emptyset}\} = \Re\{V_m e^{j\emptyset} e^{jwt}\}$$

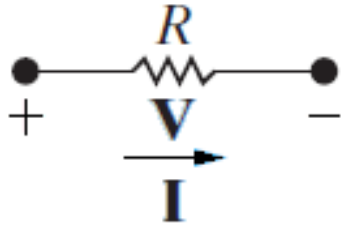
$$\boldsymbol{V} = V_m e^{j\emptyset} = \mathcal{P}\{V_m \cos(wt + \emptyset)\} \quad \textbf{(Phasor Transform)}$$

$$\mathcal{P}^{-1}\{V_m e^{j\emptyset}\} = \Re\{V_m e^{j\emptyset} e^{jwt}\} \quad \textbf{(Inverse Phasor Transform)}$$

Passive Circuit Elements in the Frequency Domain

V-I relationship for a resistor:

$$i = I_m \cos(wt + \theta_i) \Longrightarrow v = RI_m \cos(wt + \theta_i)$$



$$\boldsymbol{V} = RI_m e^{j\theta_i} = RI_m \angle\theta_i$$

$$\boldsymbol{V} = R\boldsymbol{I}$$

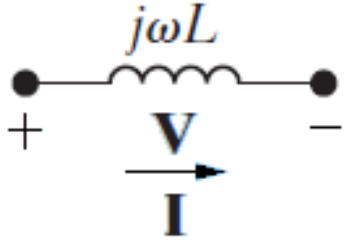
Passive Circuit Elements in the Frequency Domain

V-I relationship for an inductor:

$$i = I_m \cos(wt + \theta_i) \Longrightarrow v = L\frac{di}{dt} = -wLI_m \sin(wt + \theta_i)$$

$$\boldsymbol{V} = jwLI_m e^{j\theta_i} = wLI_m \angle(\theta_i + 90°)$$

$$\boldsymbol{V} = jwL\boldsymbol{I}$$

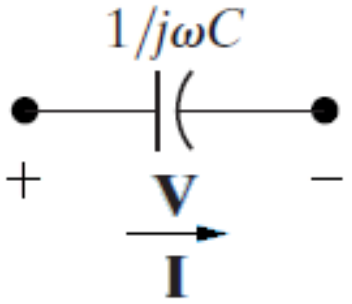


Passive Circuit Elements in the Frequency Domain

V-I relationship for a capacitor:

$$\boldsymbol{V} = \frac{I_m}{wC}\angle(\theta_i - 90°)$$

$$\boldsymbol{V} = \frac{1}{jwC}\boldsymbol{I}$$



Passive Circuit Elements in the Frequency Domain

Z represents the impedance of the circuit element:

$$\boldsymbol{V} = Z\boldsymbol{I}$$

The imaginary part of the impedance is called **reactance**.

Kirchhoff's Laws in the Frequency Domain

Kirchhoff's Voltage Law:

$$\boldsymbol{V}_1 + \boldsymbol{V}_2 + \ \ldots + \boldsymbol{V}_n = 0$$

Kirchhoff's Current Law:

$$\boldsymbol{I}_1 + \boldsymbol{I}_2 + \ \ldots + \boldsymbol{I}_n = 0$$

Reference

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