Chapter 9

Sinusoids and Phasors

By Eng. Emad Mahdy

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Chapter Contents

9.1 Introduction محتوي الشابتر

A sinusoid is a signal that has the form of the sine or cosine function.

9.2 Sinusoids

$$v(t) = V_m \cos(\omega t + \emptyset)$$

- $V_m \longrightarrow$ *Amplitude*
- $\omega \longrightarrow$ *radian frequency*
- $\emptyset \longrightarrow$ *phase*
- $T \longrightarrow$ *period*
- $f \longrightarrow$ *frequency*

$$T = \frac{2\pi}{\omega}$$
$$f = \frac{1}{T}$$

A periodic function

- أي periodic function لازم تحقق العلاقة دي

$$f(t) = f(t + nT)$$

ملاحظات:

- في كل المسائل بنشتغل فقط على cos ولو اعطاني المسالة على شكل sin لازم احول المسالة ل cos
- للتحويل من sin الي cos نطرح 90
- للتحويل من $-cos$ الي cos اجمع ± 180

Ex:

$$v(t) = 10\sin(5t + 70) = 10\cos(5t + 70 - 90) = 10\cos(5t - 20)$$

Ex:

$$v(t) = -10\cos(5t + 20) = 10\cos(5t + 20 + 180) = 10\cos(5t + 200)$$

Ex:

$$v(t) = -20\sin(5t + 40)$$

$$v(t) = -20\sin(5t + 40) = 20\sin(5t + 40 + 180) = 10\sin(5t + 220)$$

$$v(t) = 10\,sin(5t + 220) = 10\,cos(5t + 220 - 90) = 10cos\,(5t + 130)$$

- للتحويل من $-cos$ الي cos اجمع ± 180
- اطرح 90 عشان احول من sin الي cos

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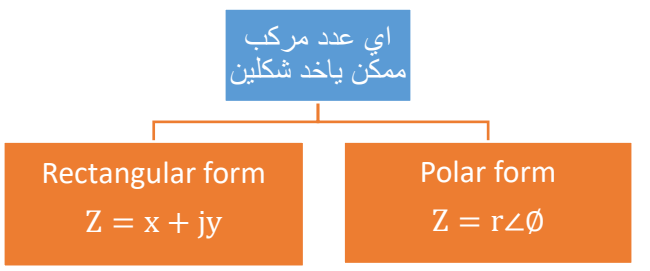
9.3 Phasors

A phasor is a complex number that represents the amplitude and phase of a sinusoid.

- للتحويل من phasor الي sinusoids

sinusiod	phasor
$v(t) = V_m \cos(\omega t + \emptyset)$	$V = V_m \angle \emptyset$
Time domain	Frequency domain
$v(t)$ *is time dependant*	V *is time independant*
All symbols are small.	All symbols are capital.

Note: Phasor analysis applies only when frequency is constant



Time domain representation	Phasor domain representation
$V_m \cos(\omega t + \phi)$	$V_m \angle \phi$
$V_m \sin(\omega t + \phi)$	$V_m \angle \phi - 90°$
$I_m \cos(\omega t + \theta)$	$I_m \angle \theta$
$I_m \sin(\omega t + \theta)$	$I_m \angle \theta - 90°$

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9.4 Circuit Elements

	Time domain	Frequency domain
Resistor R	$v = Ri$	$V = RI$
Inductor L	$v = L\frac{di}{dt}$	$V = j\omega LI$
Capacitor C	$i = C\frac{dv}{dt}$	$V = \frac{I}{j\omega C}$

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9.5 Impedance and Admittance

$$Z = \frac{V}{I} = R + jX$$

$$Y = \frac{I}{V} = \frac{1}{Z}$$

	Impedance	Admittance
R	$\mathrm{Z} = \mathrm{R}$	$\mathrm{Y} = \frac{1}{\mathrm{R}}$
L	$\mathrm{Z} = \mathrm{j}\omega\mathrm{L}$	$\mathrm{Y} = \frac{1}{\mathrm{j}\omega\mathrm{L}}$
C	$\mathrm{Z} = \frac{1}{\mathrm{j}\omega\mathrm{C}}$	$\mathrm{Y} = \mathrm{j}\omega\mathrm{C}$

9.6 †Kirchhoff’s Laws in the Frequency Domain

- نفس القوانين اللي كنا بنطبقها في ال time domain قبل كدا هي نفسها أقدر اطبقها في ال phasor domain

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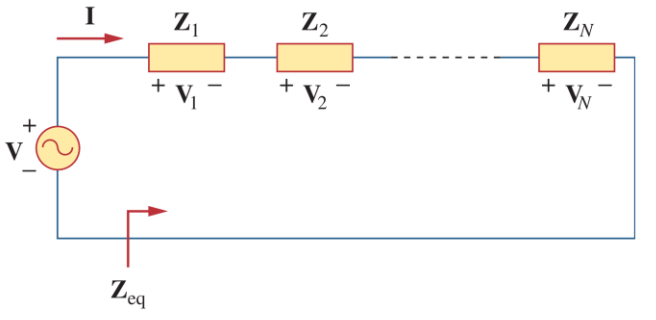
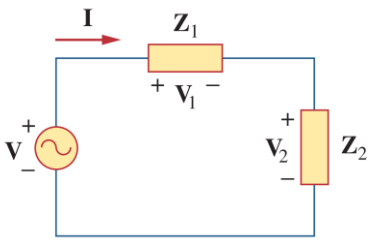
9.7 Impedance Combinations

Series Impedances



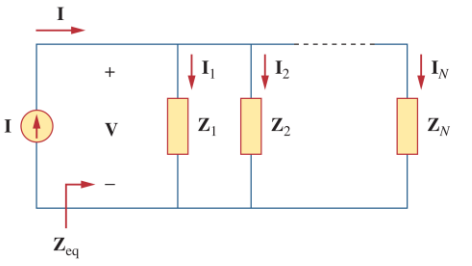
$$Z_{eq} = Z_1 + Z_2 + \cdots + Z_N$$

Voltage Division



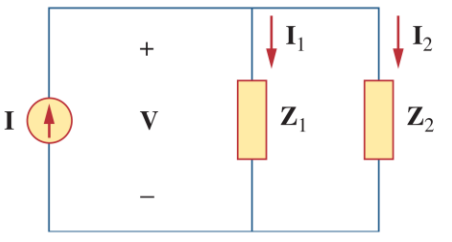
$$V_1 = \frac{Z_1}{Z_1 + Z_2} V, \qquad V_2 = \frac{Z_2}{Z_1 + Z_2} V$$

Parallel Impedances



$$Y_{eq} = Y_1 + Y_2 + \cdots + Y_N$$

Current Divider



$$I_1 = \frac{Z_2}{Z_1 + Z_2} I, \qquad I_2 = \frac{Z_1}{Z_1 + Z_2} I$$

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Chapter Laws Summery

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Sinusoids

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- $V_m \longrightarrow Amplitude$
- $\omega \longrightarrow radian\ frequency$
- $\emptyset \longrightarrow phase$
- $T \longrightarrow period$
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$$T = \frac{2\pi}{\omega}$$

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Circuit Elements

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Inductor L	$v = L\frac{di}{dt}$	$V = j\omega LI$
Capacitor C	$i = C\frac{dv}{dt}$	$V = \frac{I}{j\omega C}$

Impedance and Admittance

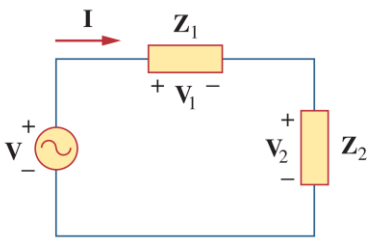
	Impedance	Admittance
R	$Z = R$	$Y = \frac{1}{R}$
L	$Z = j\omega L$	$Y = \frac{1}{j\omega L}$
C	$Z = \frac{1}{j\omega C}$	$Y = j\omega C$

Kirchhoff's Laws in the Frequency Domain

- نفس القوانين اللي كنا بنطبقها في ال time domain قبل كدا هي نفسها أقدر اطبقها في ال phasor domain

Impedance Combinations

Voltage Division



$$V_1 = \frac{Z_1}{Z_1 + Z_2} V, \qquad V_2 = \frac{Z_2}{Z_1 + Z_2} V$$

Current Divider

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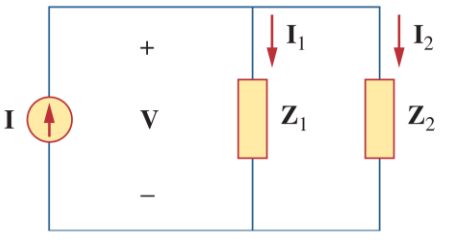

$$I_1 = \frac{Z_2}{Z_1 + Z_2} I, \qquad I_2 = \frac{Z_1}{Z_1 + Z_2} I$$