LECTURE NOTES
ON

Basic Electrical & Electronics Engineering
(ESC-S101)

B. Tech. Ist Semester

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Unit-1
Sinusoidal Steady State Analysis

1.1 Characteristics of Sinusoidal

1.2 Phasors

1.3 Phasor Relationships for R, L and C

1.4 Impedance

1.5 Parallel and Series Resonance

1.6 Examples for Sinusoidal Circuits Analysis

Sinusoidal Steady State Analysis

- Any steady state voltage or current in a linear circuit with a sinusoidal source is a sinusoid
  - All steady state voltages and currents have the same frequency as the source
- In order to find a steady state voltage or current, all we need to know is its magnitude and its phase relative to the source (we already know its frequency)
- We do not have to find this differential equation from the circuit, nor do we have to solve it
- Instead, we use the concepts of phasors and complex impedances
- Phasors and complex impedances convert problems involving differential equations into circuit analysis problems

❖ Focus on steady state; Focus on sinusoids.

Sinusoidal Steady State Analysis

1.1 Characteristics of Sinusoidal

Key Words:

Period: T,

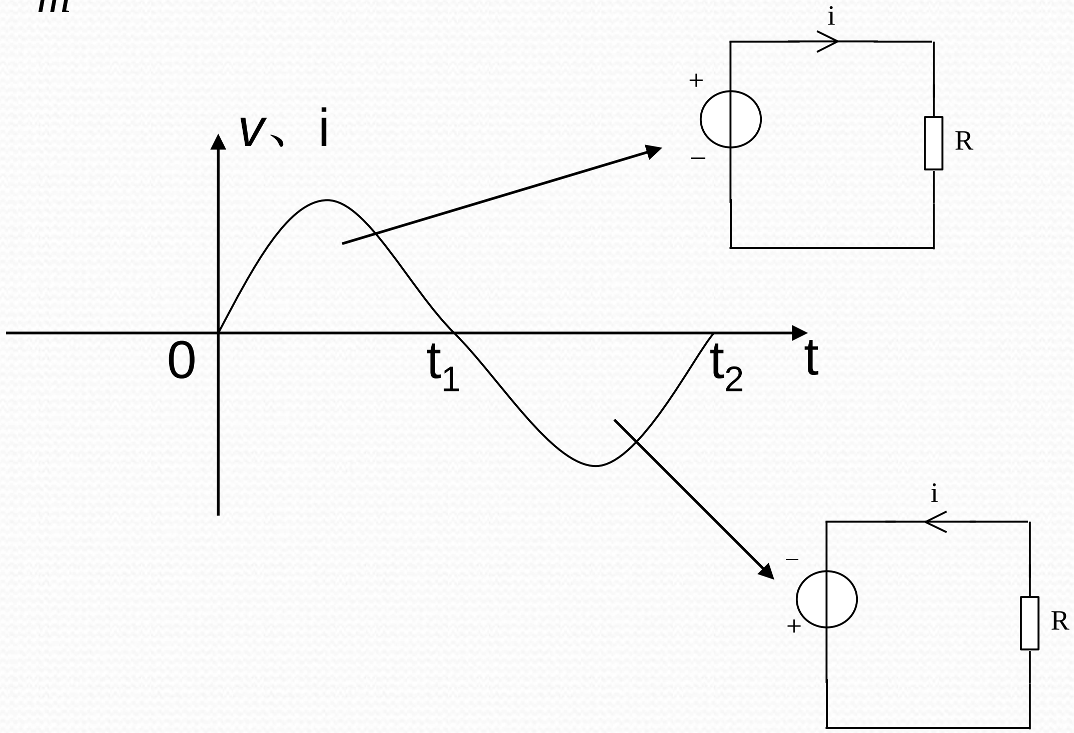
Frequency: f, Radian frequency ω

Phase angle

Amplitude: V_m I_m

1.1 Characteristics of Sinusoidal

$$v_{(t)} = V_m \sin \omega t$$



Both the polarity and magnitude of voltage are changing.

1.1 Characteristics of Sinusoidal

Period: T — Time necessary to go through one cycle. (s)

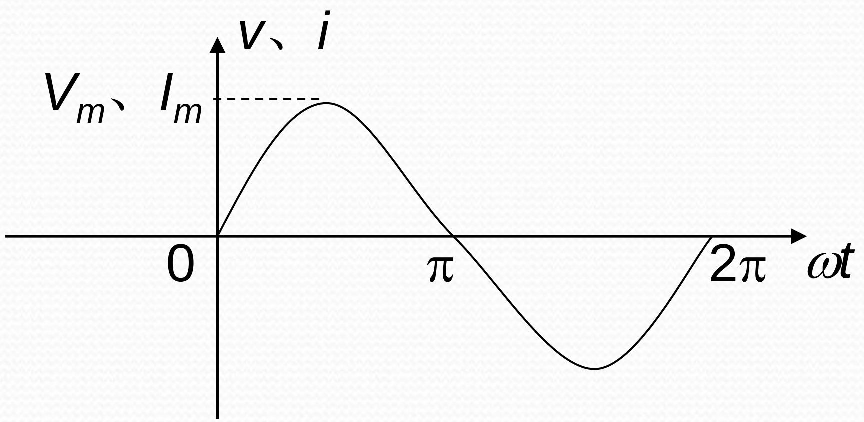
Frequency: f — Cycles per second. (Hz)

$$f = 1/T$$

Radian frequency(Angular frequency): $\omega = 2\pi f = 2\pi/T$ (rad/s)

Amplitude: V_m I_m

$$i = I_m \sin\omega t, \quad v = V_m \sin\omega t$$



1.1 Characteristics of Sinusoidal

Effective Roof Mean Square (RMS) Value of a Periodic Waveform — is equal to the value of the direct current which is flowing through an R-ohm resistor. It delivers the same average power to the resistor as the periodic current does.

$$\frac{1}{T}\int_0^T i^2 R dt = I^2 R$$

→ Effective Value of a Periodic Waveform $I_{eff} = \sqrt{\frac{1}{T}\int_0^T i^2 dt}$

$$I_{eff} = \sqrt{\frac{1}{T}\int_0^T I_m^2 \sin^2 \omega t dt} = \sqrt{\frac{I_m^2}{T}\int_0^T \frac{1-\cos 2\omega t}{2} dt} = \sqrt{\frac{1}{T} I_m^2 \cdot \frac{T}{2}} = \frac{I_m}{\sqrt{2}}$$

$$V_{eff} = \sqrt{\frac{1}{T}\int_0^T v^2 dt} = \frac{V_m}{\sqrt{2}}$$

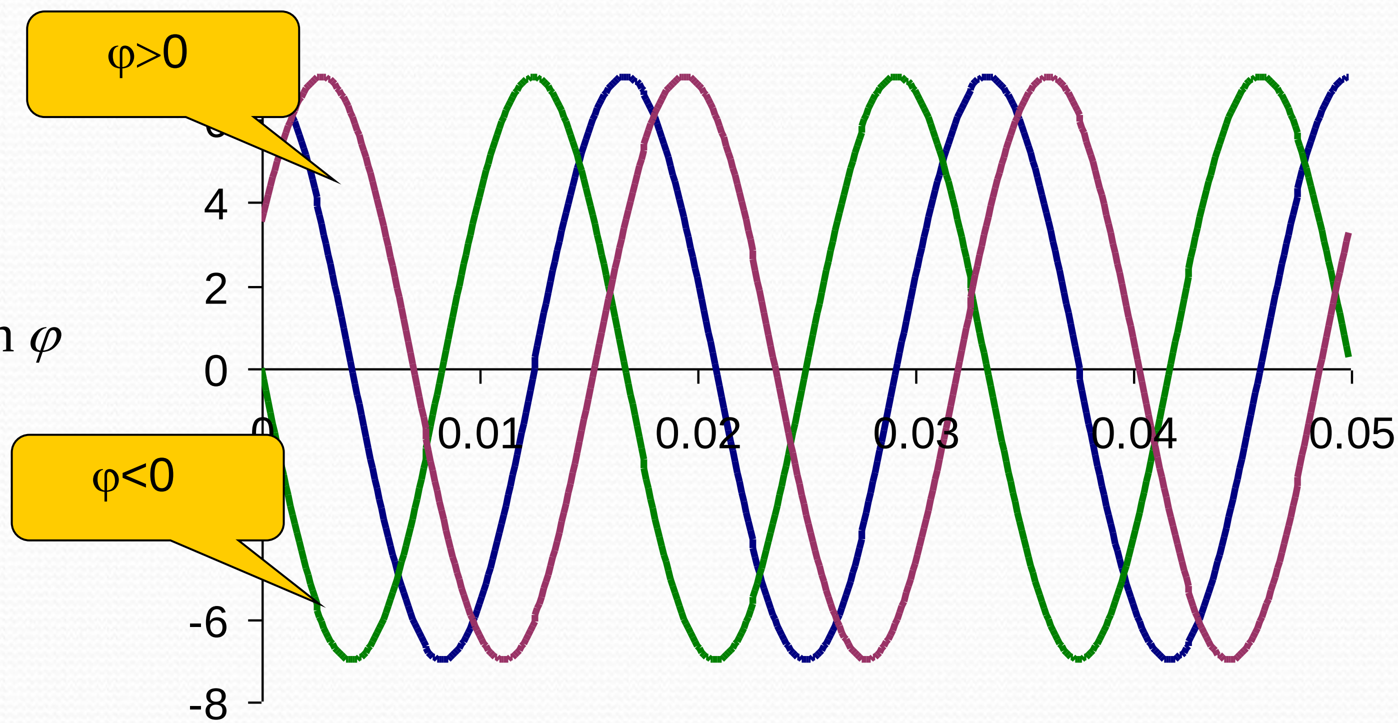
1.1 Characteristics of Sinusoidal

Phase (angle)

$$i = I_m \sin(\omega t + \varphi)$$

Phase angle

$$i_{(0)} = I_m \sin \varphi$$



1.1 Characteristics of Sinusoidal

Phase difference

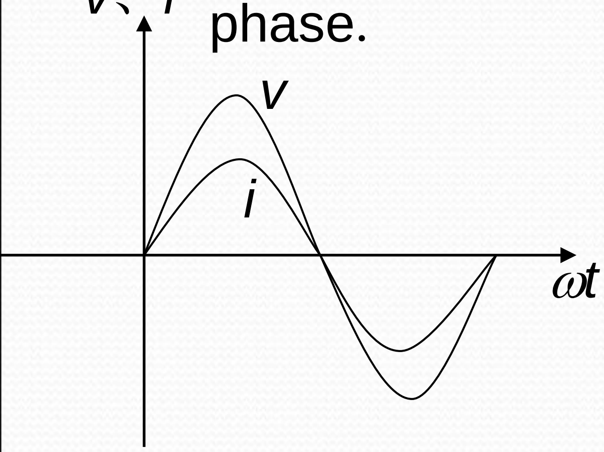
$$v = V_m \sin(\omega t + \varphi_1) \qquad i = I_m \sin(\omega t + \varphi_2)$$

$$\Delta\varphi = \varphi_v - \varphi_i = \omega t + \varphi_1 - (\omega t + \varphi_2) = \varphi_1 - \varphi_2$$

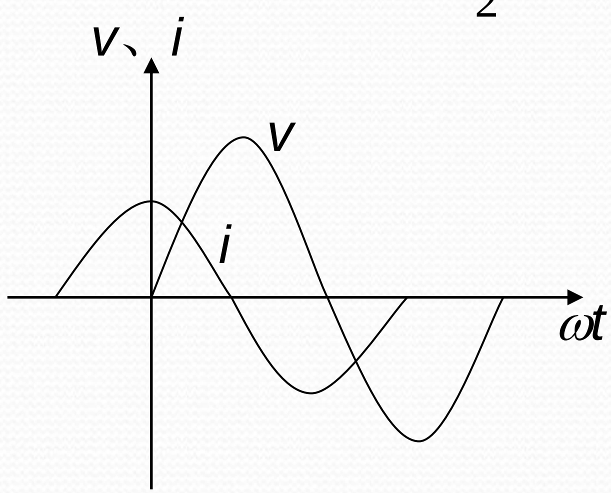
$\Delta\varphi = \varphi_1 - \varphi_2 > 0$ — *v*(*t*) leads *i*(*t*) by (φ_1 - φ_2), or *i*(*t*) lags *v*(*t*) by (φ_1 - φ_2)

$\Delta\varphi = \varphi_1 - \varphi_2 < 0$ — *v*(*t*) lags *i*(*t*) by (φ_2 - φ_1), or *i*(*t*) leads *v*(*t*) by (φ_2 - φ_1)

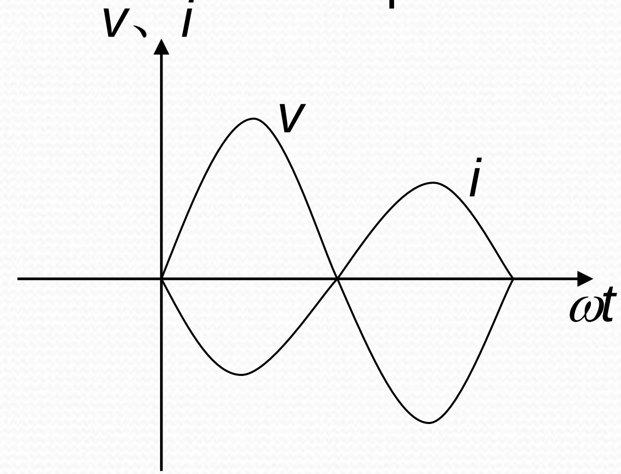
$\Delta\varphi = \varphi_1 - \varphi_2 = 0$ In phase.



$\Delta\varphi = \varphi_1 - \varphi_2 = \pm\frac{\pi}{2}$



$\Delta\varphi = \varphi_1 - \varphi_2 = \pi$ Out of phase。



1.1 Characteristics of Sinusoidal

Review

The sinusoidal waves whose phases are compared must:
① Be written as sine waves or cosine waves.
② With positive amplitudes.
③ Have the same frequency.

360° —— does not change anything.
90° —— change between sin & cos.
180° —— change between + & -

$$*\sin\theta = \cos\left(\theta + \frac{2}{3}\pi\right) = \cos\left(\theta - \frac{\pi}{2}\right)$$

$$*\cos\theta = \sin\left(\theta + \frac{\pi}{2}\right)$$

1.1 Characteristics of Sinusoidal

Phase difference

P1.1, $v_1 = 220\sqrt{2}\sin\left(314t - 30^\circ\right)$ $\quad v_2 = 220\sqrt{2}\cos\left(314t + 30^\circ\right)$

Find $\Delta\varphi = ?$

$$v_2 = 220\sqrt{2}\cos\left(314t + 30^\circ\right) = 220\sqrt{2}\sin\left(314t + 30^\circ + 90^\circ\right)$$
$$= 220\sqrt{2}\sin\left(314t + 120^\circ\right)$$

$$\Delta\varphi = \varphi_1 - \varphi_2 = -30^\circ - 120^\circ = -150^\circ$$

If $v_2 = -220\sqrt{2}\cos\left(314t + 30^\circ\right)$

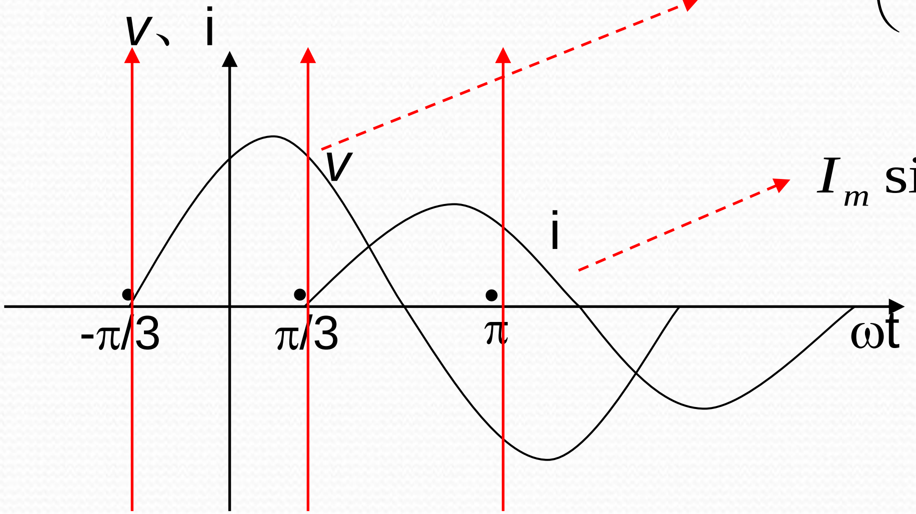
$$v_2 = -220\sqrt{2}\cos\left(314t + 30^\circ\right) = 220\sqrt{2}\cos\left(314t + 30^\circ + 180^\circ\right)$$
$$= 220\sqrt{2}\cos\left[360^\circ - \left(314t + 210^\circ\right)\right]$$
$$= 220\sqrt{2}\sin\left(314t - 150^\circ + 90^\circ\right)$$
$$= 220\sqrt{2}\sin\left(314t - 60^\circ\right)$$

$$\Delta\varphi = \varphi_1 - \varphi_2 = -30^\circ + 60^\circ = 30^\circ$$

1.1 Characteristics of Sinusoidal

Phase difference

P1.2,



$$V_m \sin\left(\omega t + \frac{\pi}{3}\right)$$

$$I_m \sin\left(\omega t - \frac{\pi}{3}\right)$$