Lab Session No. 12

STUDY THE PHASE DISPLACEMENT USING OSCILLOSCOPE

OBJECTIVE

- To study about Phase shift
- A phase-shifting circuit is often employed to correct an undesirable phase

EQUIPMENT REQUIRED

- Function Generator
- Cathode Ray Oscilloscope
- Bread board
- Resistors: 20 Ω, 1 kΩ, 4.2 kΩ, 1.5 MΩ, 6.3 MΩ
- Capacitors: 0.47 uF, 12 pF, 1uF
- Connecting wires

Theory :

A *sinusoid* is a signal that has the form of the sine or cosine function. A sinusoidal current is usually referred to as *alternating current* (*ac*). Such a current reverses at regular time intervals and has alternately positive and negative values.

Phase Difference is used to describe the difference in degrees or radians when two or more alternating quantities reach their maximum or zero values.

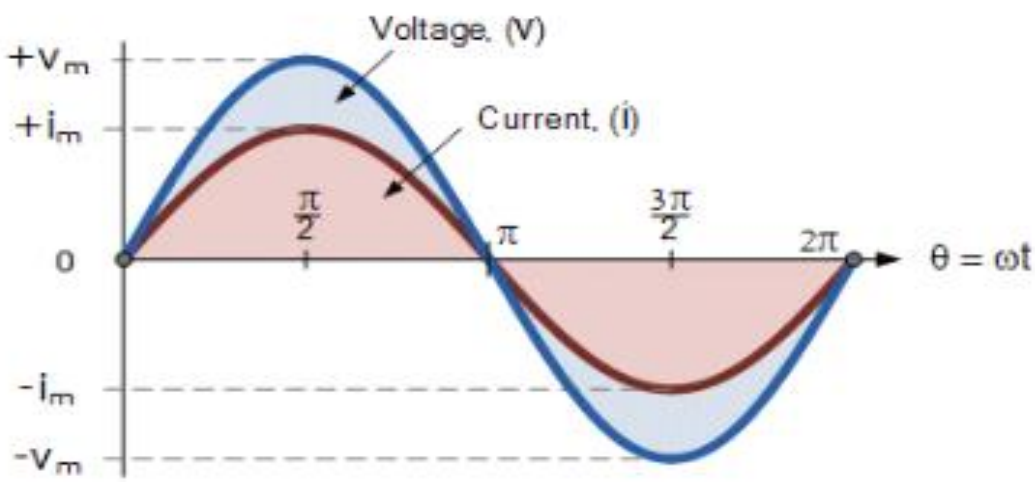

Figure 1 (two sinusoid with no phase difference)

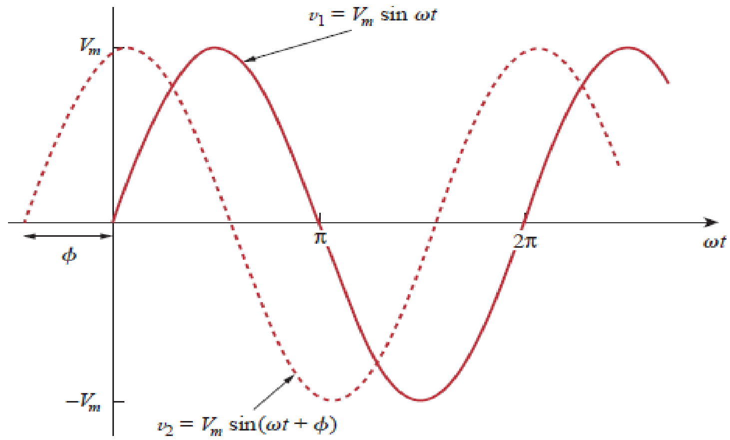

Figure 2 (two sinusoid with phase difference)

The starting point of v_2 in Fig.2 occurs first in time. Therefore, we say that V_2 *leads* V_1 by φ or that V_1 *lags* by V_2 by φ . If $\varphi = 0$ then ***V1*** & V_2 are said to be *in phase*
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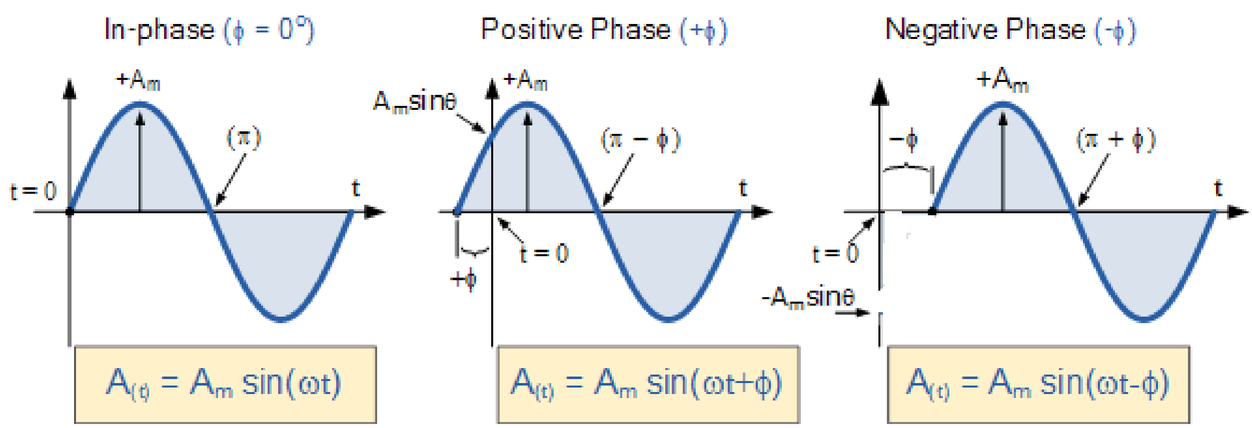


Fig. 3 Phase Relationship of a Sinusoidal Waveform

Phase Difference Equation

$$\boldsymbol{A_{(t)} = A_{max} \times \sin(\omega t \pm \varphi)}$$

or

$$\boldsymbol{V} = V_m \times \mathbf{sin}(\omega t \pm \varphi)$$

Where:

- Vm or Am is the amplitude of the waveform.
- ωt is the angular frequency of the waveform in radian/sec.
- Φ (phi) – is the phase angle in degrees or radians that the waveform has shifted either left or right from the reference point.

Phase Difference between a Sine wave and a Cosine wave

$$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$$
$$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$$

$$\mathbf{\sin(\omega t \pm 90) = \pm \cos \omega t}$$

$$\mathbf{\cos(\omega t \pm 90) = \mp \sin \omega t}$$

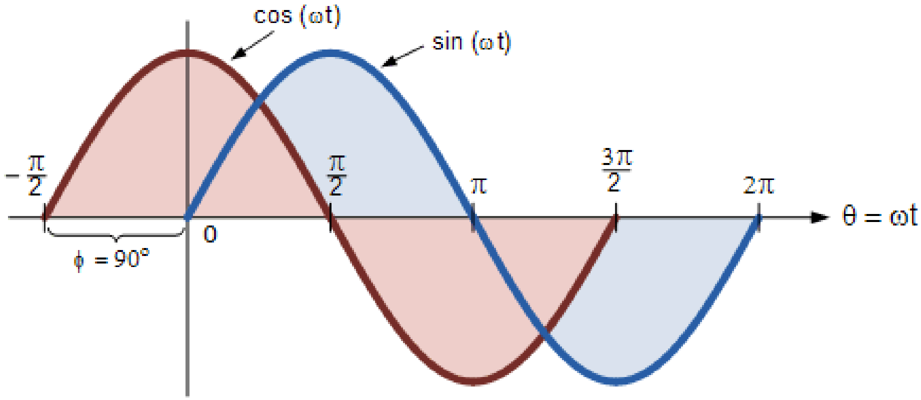


Figure 4. Sine and Cosine Wave

Phase-Shifters

A phase-shifting circuit is often employed to correct an undesirable phase shift already present in a circuit or to produce special desired effects. An RC circuit is suitable for this purpose because its capacitor causes the circuit current to lead the applied voltage. Two commonly used RC circuits are shown in Fig. 5 (a & b)

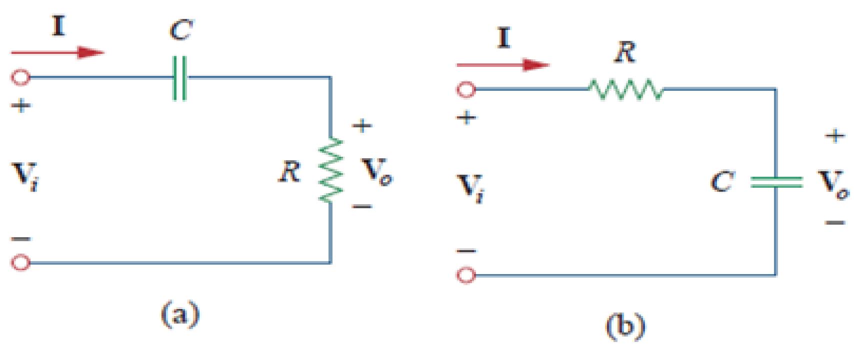


Figure 5 (Series RC shift circuits: (a) leading output, (b) lagging output.

Phase shift is given by

$$\theta = \tan^{-1}\frac{Xc}{R}$$

This shows that the amount of phase shift depends on the values of *R*, *C*, and the operating frequency. Since the output voltage $\mathbf{V}_o$ across the resistor is in phase with the current, $\mathbf{V}_o$ leads (positive phase shift) $\mathbf{V}_i$ as shown in Fig. 6 (a). In Fig. 6 (b), the output is taken across the capacitor. The current **I** leads the input voltage $\mathbf{V}_i$ by θ but the output voltage $v_o(t)$ across the capacitor lags (negative phase shift) the input voltage $v_i(t)$ as illustrated in Fig. 6 (b).

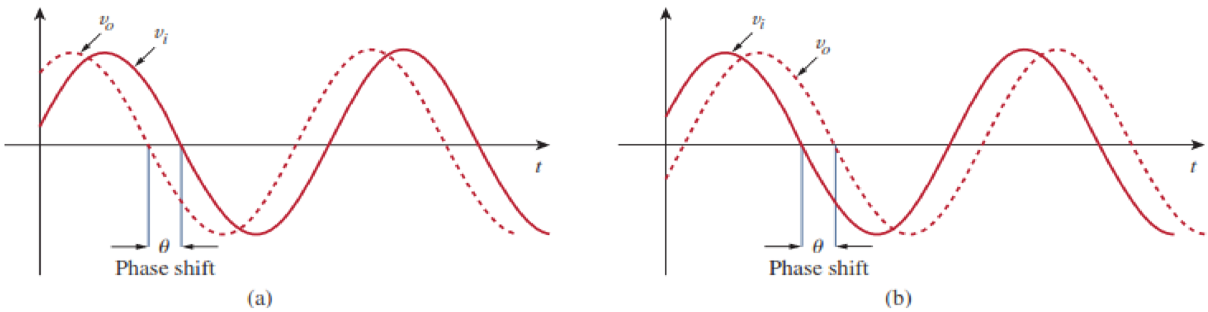


Fig. 6 Phase shift in RC circuits: (a) leading output, (b) lagging output.

Simulation Results

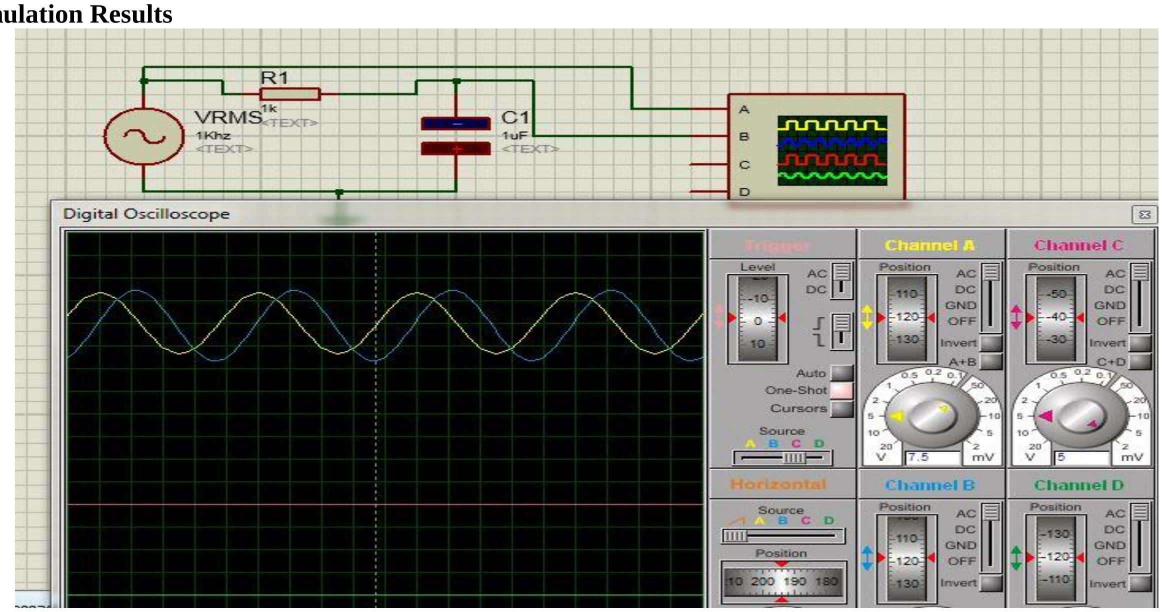
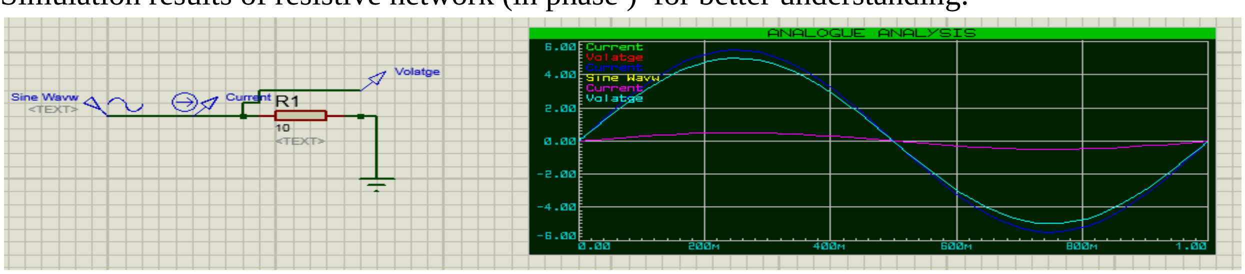


Fig. 7 Simulation results

Simulation results of resistive network (in phase) for better understanding:



Comments & Discussion