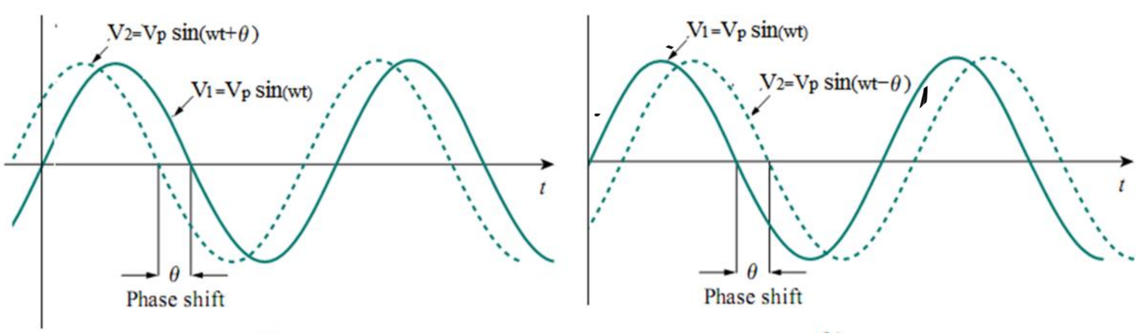
Experiment No.2

Phasor Diagram for RC Circuits

Theory

To understand the relationships among the sinusoidal voltages, and currents in any linear circuit, we represent the various waveforms as two-dimensional vectors called phasors. A phasor is used to represent a sinusoidal wave, taking into account both its amplitude and phase angle.



(a) (b)

V_2 leads V_1 by θ degree V_2 lags V_1 by θ degree

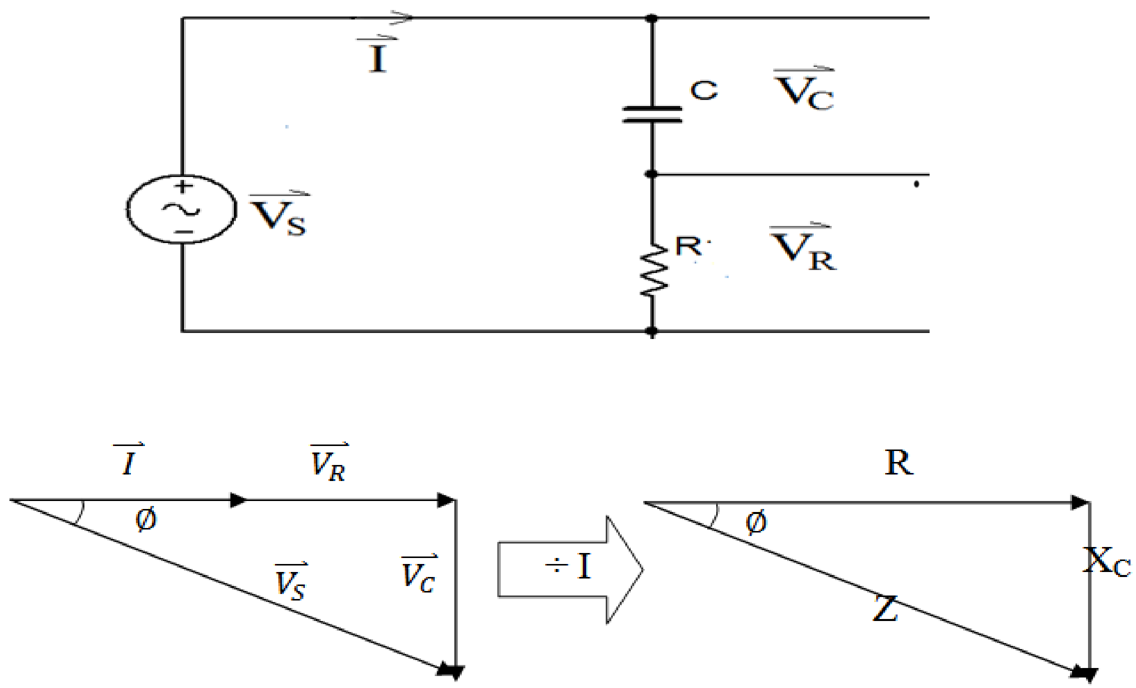
Such phasor drawings are very helpful in analyzing circuits and understanding the relationships of the various voltages and currents. The algebra of complex numbers can then be used to perform arithmetic operations on the sinusoidal waves. Adding voltages or currents in an AC circuit without taking account of phase angles will lead to confusing and wrong results.

PART ONE: Series RC Circuit

For RC circuit shown in Fig.(1).

$$\overrightarrow{V_S} = \overrightarrow{V_R} + \overrightarrow{V_C}$$

But there is 90° phase shift between resistance and capacitance voltages, so we must first draw phasor diagram .In series circuits current can be consider as reference vector. Phasor diagram for circuit in Fig.(1) can be drawing by consider current I is the reference vector (X-axis). The vector for resistance voltage $\overrightarrow{V_R}$ is shown along the (X) axis (the current and voltage through and across the resistor will be in same phase), while the capacitor voltage $\overrightarrow{V_C}$ is shown in the (Y) axis, since its voltage lags its current by 90°. The source voltage $\overrightarrow{V_S}$ is the directional sum of these two voltages.



Figure(1) Series RC circuit and its phasor diagram

The following relationships could be obtaining using phasor diagram.

For voltages	For impedance
$\|V_R\| = \|V_S\| \times \cos(\emptyset)$	$R = \|Z\| \times \cos(\emptyset)$
$\|V_C\| = \|V_S\| \times \sin(\emptyset)$	$\|X_C\| = \|Z\| \times \sin(\emptyset)$
$\|V_s\| = \sqrt{\|V_R\|^2 + \|V_C\|^2}$	$\|Z\| = \sqrt{R^2 + \|X_C\|^2}$

Phase angle between ***source voltage*** and ***resistance voltage*** can be measured directly using two channels oscilloscope as shown in Fig.(2) where:

Phase angle in degree: $\emptyset = \frac{t}{T} \times 360^o$ Where T, t is distance in any length scale.

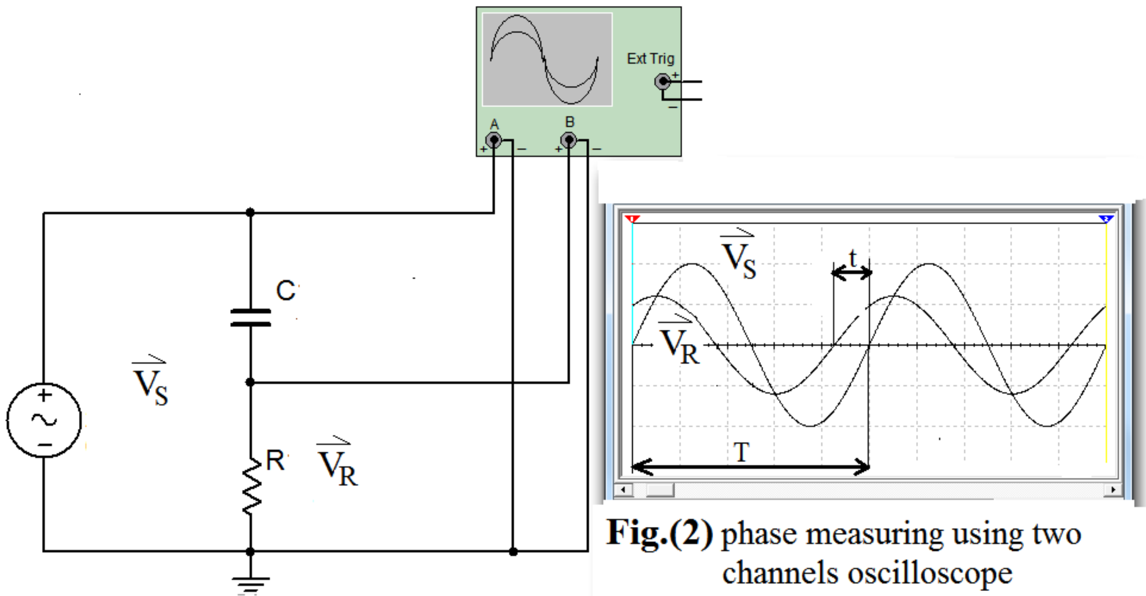


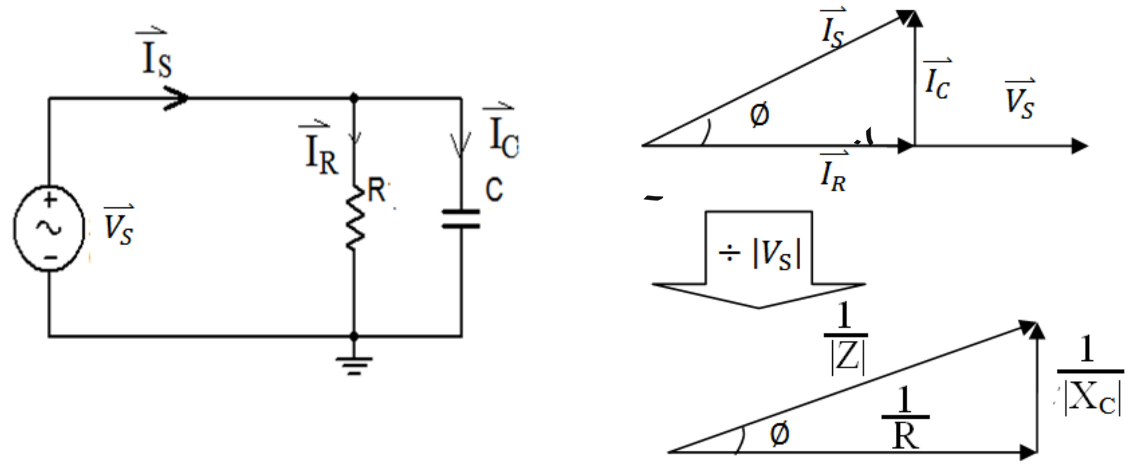
Fig.(2) phase measuring using two channels oscilloscope

<u>PART TWO:</u> Parallel RC Circuits

For parallel RC circuit shown in Fig.(4).

$$\overrightarrow{I_S} = \overrightarrow{I_R} + \overrightarrow{I_C}$$

But there is 90° phase shift between resistance and capacitance currents, so we must first draw phasor diagram .In parallel circuits voltage can be consider as reference vector. Phasor diagram can be drawing as shown in Figure (4) where source voltage VS is the reference vector (X-axis) and resistance current vector $\overrightarrow{I_R}$ is shown along the (X) axis, while the reactance current $\overrightarrow{I_C}$ is shown in the (Y) axis, since its current lead its voltage by 90°.



Figure(3) parallel RC circuit and its phasor diagram

The following relationships could be obtaining using phasor diagram.

For currents	For impedance
$\lvert I_R\rvert = \lvert I_S\rvert \times \cos(\emptyset)$	$1/R = \lvert 1/Z\rvert \times \cos(\emptyset)$
$\lvert I_C\rvert = \lvert I_S\rvert \times \sin(\emptyset)$	$\lvert 1/X_C\rvert = \lvert 1/Z\rvert \times \sin(\emptyset)$
$\lvert I_S\rvert = \sqrt{\lvert I_R\rvert^2 + \lvert I_C\rvert^2}$	$\lvert 1/Z\rvert = \sqrt{(1/R)^2 + (\lvert 1/X_C\rvert)^2}$

We must denoted that in parallel case we can't use oscilloscope in measuring phase angle.

Procedure

Case One Series RC circuits

1- Connect circuit in Fig.(1)

2- Set source frequency=200Hz,R=600Ω and C=1μF

3- Using voltmeter to find VS, VR and VC

4- Find phase angle using

$$\phi = \cos^{-1}\left(\frac{V_R}{V_s}\right) = \sin^{-1}\left(\frac{V_c}{V_s}\right) = \tan^{-1}\left(\frac{V_c}{V_R}\right)$$

5- Using oscilloscope as shown in Fig.(2) to find t,T then :

$$\phi = \frac{t}{T} \times 360^o$$

6- Draw the phasor diagram for circuit then draw waveform for all voltages and current in circuit.