# Electrical Circuits Lab. 0903219

## Series RC Circuit Phasor Diagram

### - Simple steps to draw phasor diagram of a series RC circuit without memorizing:

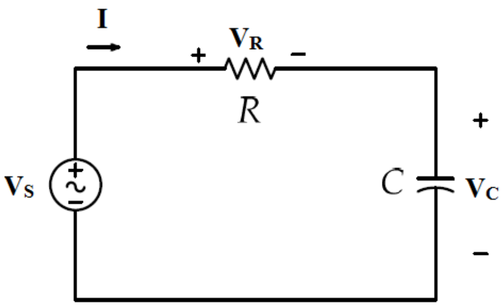


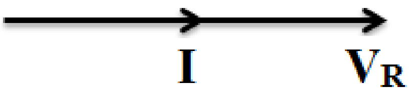

Figure (1) Series RC circuit

* Start with the quantity (voltage or current) that is common for the resistor **R** and the capacitor **C**, which is here the source current **I** (because it passes through both **R** and **C** without being divided).

**Step1**

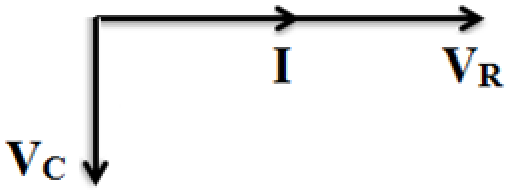

* Now we know that **I** and resistor voltage $\mathbf{V_R}$ are in phase or have the same phase angle (there zero crossings are the same on the time axis) and $\mathbf{V_R}$ is greater than **I** in magnitude.

**Step2**




* Since **I** equal the capacitor current $\mathbf{I_C}$ and we know that $\mathbf{I_C}$ leads the capacitor voltage $\mathbf{V_C}$ by 90 degrees, we will add $\mathbf{V_C}$ on the phasor diagram as follows:

**Step 3**




* Now, the source voltage $\mathbf{V_S}$ equals the <u>vector summation</u> of $\mathbf{V_R}$ and $\mathbf{V_C}$:

**Step4**

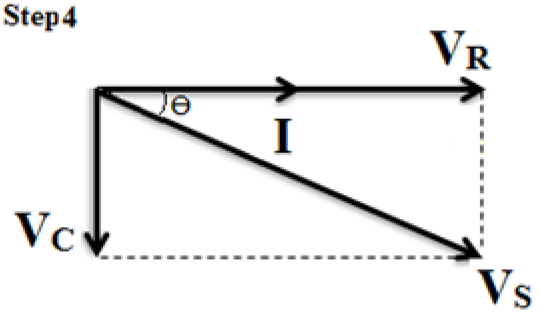



**Figure (2) Series RC circuit Phasor Diagram**

## - Important notes on the phasor diagram of series RC circuit shown in figure (2):

**A-** All the vectors are rotating in the same angular speed **ω**.

**B-** This circuit acts as a capacitive circuit and **I** leads $\mathbf{V_S}$ by a phase shift of **Ɵ** (which is the current angle $\angle\mathbf{I}$ if the source voltage is the reference signal).

**Ɵ** ranges from $0^o$ to $90^o$ ($0^o$ < **Ɵ** <$90^o$). If **Ɵ**=$0^o$ then this circuit becomes a resistive circuit and if **Ɵ**=$90^o$ then the circuit becomes a pure capacitive circuit.

**C-** The phase shift between the source voltage and its current **Ɵ** is important and you have two ways to find its value:

**a-** $\theta = \tan^{-1}\frac{V_C\ (imaginary\ part\ of\ VS)}{V_R\ (real\ part\ of\ vs)}$

**b-** $\theta = \angle\mathbf{I} = -\angle\mathbf{Z} = -\tan^{-1}\frac{1/\omega C\ (imaginary\ part\ of\ Z)}{R\ (real\ part\ of\ Z)}$

**D-** Using the phasor diagram, you can find all needed quantities in the circuit like all the voltages magnitude and phase and all the currents magnitude and phase.

For a series **RC** circuit, if the magnitude of $\mathbf{V_C}$ and $\mathbf{V_R}$ was measured in Lab. (as a peak value from an oscilloscope or rms value from a digital multimeter), then we can find the magnitude of $\mathbf{V_S}$ as follows:

$|\boldsymbol{V_S}| = \sqrt{|\boldsymbol{V_C}|^2 + |\boldsymbol{V_R}|^2}$

**E-** You can find all leading or lagging voltages and currents in this circuit with respect to a reference signal like the source voltage $\mathbf{V_S}$.

For example, it is clearly shown by the phasor diagram that **I** leads $\mathbf{V_S}$ by **Ɵ** degrees, $\mathbf{V_R}$ leads $\mathbf{V_S}$ by **Ɵ** degrees (since it is in phase with **I**) and $\mathbf{V_C}$ lags $\mathbf{V_S}$ by **$90^o$- Ɵ**.

**F-** The phasor diagram helps in finding the change in current and voltage (magnitude and phase) with voltage source frequency ***f*** changing.

With frequency ***f*** increasing, the capactive reactance $\mathbf{X_C}$ will decrease and $\mathbf{V_C}$ will decrease too, the the resistor **R** will not be affected by the change of ***f***, then by voltage division rule $\mathbf{V_R}$ will increase (to prevent $\mathbf{V_S}$ from changing since $\mathbf{V_S}$ is a voltage source). Since $\mathbf{X_C}$ decrease and **R** is constant the total impedance **Z** will decrease and the source current **I** will increase. $\measuredangle\mathbf{I}$ and $\measuredangle\mathbf{Z}$ will decrease because $\measuredangle\mathbf{I} = -\measuredangle\mathbf{Z} = \theta = \tan^{-1}\frac{V_C}{V_R} = -\tan^{-1}\frac{(\frac{1}{\omega C})}{R}$ and the $\tan^{-1}$ function is increasing on the interval from 0 to 90°.

In a concise way:
$f\uparrow$ | $\mathbf{X_C}$ |↓ |**Z**|↓ |**I**|↑ |$\mathbf{V_R}$|↑ |$\mathbf{V_C}$|↓ **Θ**↓ .

**G-** Figure (3) below shows a time domain representation for all the vectors shown on the phasor diagram:

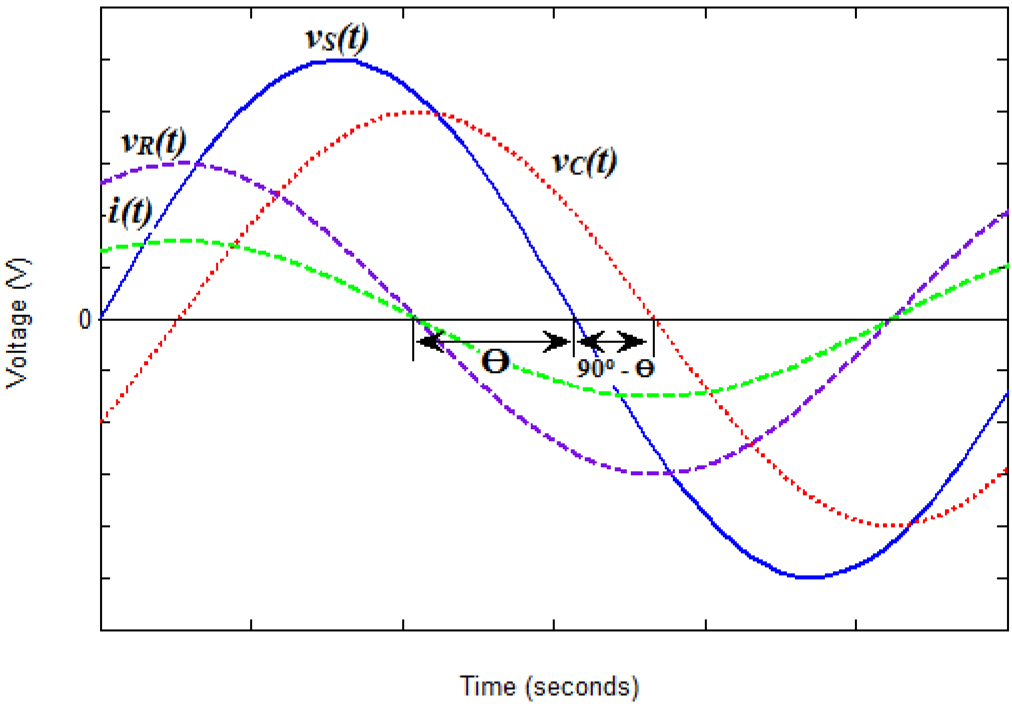



**Figure (3) Series RC Circuit Time Domain Representation**

# Electrical Circuits Lab. 0903219

## Parallel RC Circuit Phasor Diagram

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### - Simple steps to draw phasor diagram of a parallel RC circuit without memorizing:

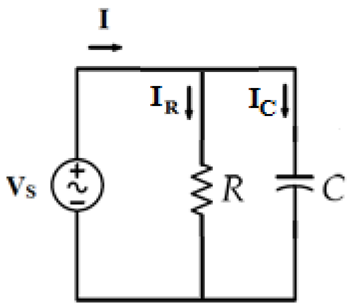



**Figure (1) Parallel RC**

* Start with the quantity (voltage or current) that is common for the resistor **R** and the capacitor **C**, which is here the source Voltage $\mathbf{V_S}$ (because it is parallel with both **R** and **C** without being divided).

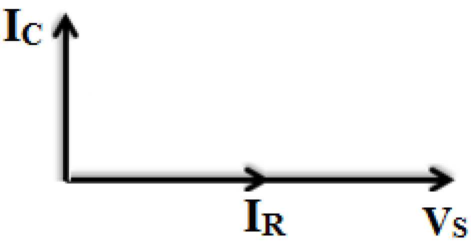
**Step1**


* Now we know that resistor current $\mathbf{I_R}$ and resistor voltage $\mathbf{V_R}$ (which equals $\mathbf{V_S}$) are in phase or have the same phase angle (there zero crossings are the same on the time axis) and $\mathbf{V_R}$ is greater than $\mathbf{I_R}$ in magnitude.

**Step2**


* Since $\mathbf{V_S}$ equal the voltage $\mathbf{V_C}$ and we know that $\mathbf{V_C}$ lags the capacitor current $\mathbf{I_C}$ by 90 degrees, we will add $\mathbf{I_C}$ on the phasor diagram as follows:

**Step 3**




* Finally, the source current **I** equal the <u>vector summation</u> of $\mathbf{I_R}$ and $\mathbf{I_C}$:

**Step 4**

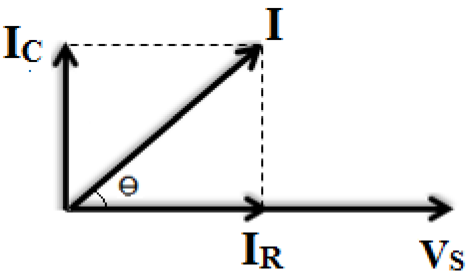



**Figure (2) Parallel RC circuit Phasor Diagram**

## - Important notes on the phasor diagram of Parallel RC circuit shown in figure (2):

**A-** All the vectors are rotating in the same angular speed **ω**.

**B-** This circuit acts as a capacitive circuit and **I** leads $\mathbf{V_S}$ by a phase shift of **ϴ** (which is the current angle $\angle\mathbf{I}$ if the source voltage is the reference signal).

**ϴ** ranges from $0^o$ to $90^o$ ($0^o$ < **ϴ** <$90^o$). If **ϴ**=$0^o$ then this circuit becomes a resistive circuit and if **ϴ**=$90^o$ then the circuit becomes a pure capacitive circuit.

**C-** The phase shift between the source voltage and its current **ϴ** is important and you have two ways to find its value:

$$\theta = \tan^{-1}\frac{I_C\ (imaginary\ part\ of\ V_S)}{I_R\ (real\ part\ of\ V_S)}$$

$$\theta = \angle\mathbf{I} = \angle\mathbf{Y} = \tan^{-1}\frac{B_C\ (imaginary\ part\ of\ Y)}{G\ (real\ part\ of\ Y)}$$

**D-** Using the phasor diagram, you can find all needed quantities in the circuit like all the voltages magnitude and phase and all the currents magnitude and phase.

For a parallel **RC** circuit, if the magnitude of $\mathbf{I_C}$ and $\mathbf{I_R}$ was measured in Lab. (as a peak value from an oscilloscope or rms value from a digital multimeter), then we can find the magnitude of **I** as follows:

$$|\mathbf{I}| = \sqrt{|\boldsymbol{I_C}|^2 + |\boldsymbol{I_R}|^2}$$

**E-** You can find all leading or lagging quantities in this circuit with respect to a reference signal like the source voltage $\mathbf{V_S}$.

For example, it is clearly shown by the phasor diagram that **I** leads $\mathbf{V_S}$ by **ϴ** degrees, $\mathbf{I_R}$ lags **I** by **ϴ** degrees and $\mathbf{I_C}$ leads **I** by **$90^o$- ϴ**.

**F-** The phasor diagram helps in finding the change in quantities (magnitude and phase) with voltage source frequency ***f*** changing.

With frequency $f$ increasing, the capacitive reactance $\mathbf{X_C}$ will decrease and so $\mathbf{I_C}$ will increase, the the resistor **R** will not be affected by the change of $f$ and $\mathbf{I_R}$ will not change with frequency. Since $\mathbf{X_C}$ decrease and **R** is constant the total impedance **Z** will decrease, the source current **I** will increase and the admittance **Y** will increase. $\angle\mathbf{I}$ and $\angle\mathbf{Y}$ will increase because $\angle\mathbf{I} = \angle\mathbf{Y} = \Theta = \tan^{-1}\frac{I_C}{I_R} = \tan^{-1}\frac{\omega C}{1/R}$ and the $\tan^{-1}$ function is increasing on the interval from 0 to 90°.

In a concise way:

$\boldsymbol{f}\uparrow\ |\mathbf{X_C}|\downarrow\ |\mathbf{Z}|\downarrow\ |\mathbf{Y}|\uparrow\ |\mathbf{I}|\uparrow\ |\mathbf{I_C}|\uparrow\ \boldsymbol{\Theta}\uparrow\ |\mathbf{I_R}|$**constant.**

**G-** Figure (3) below shows a time domain representation for all the vectors shown on the phasor diagram:

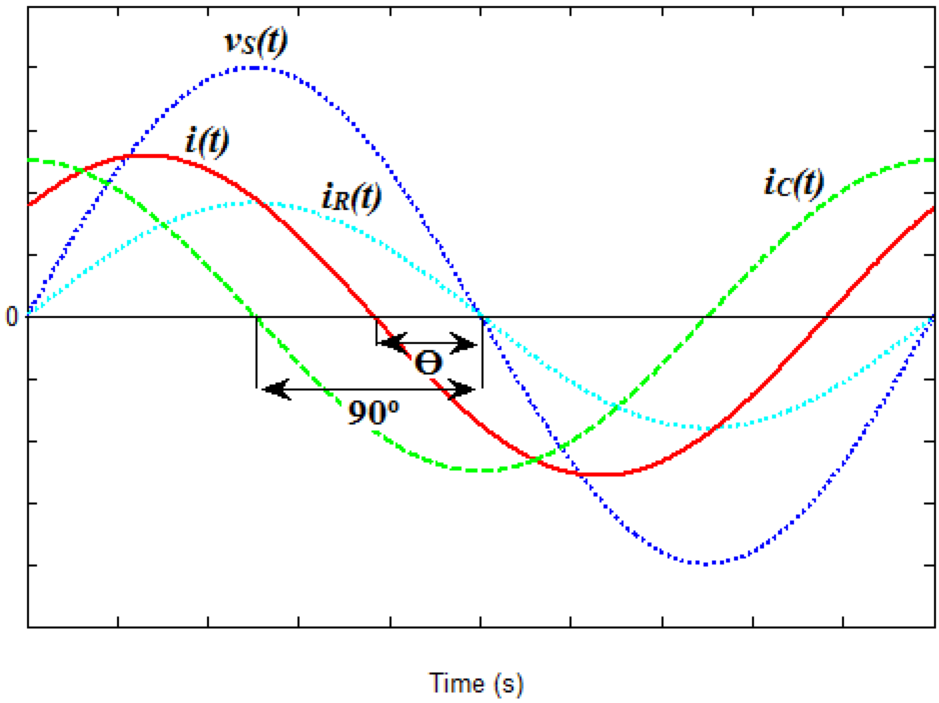



**Figure (3) Parallel RC Circuit Time Domain Representation**