ELEMENTS OF ELECTRICAL ENGINEERING (UE24EE141B)

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Unit 2 – Lectures 30 & 31 - Analysis of Parallel RL and Parallel RC Circuits ; Numerical examples

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Admittance

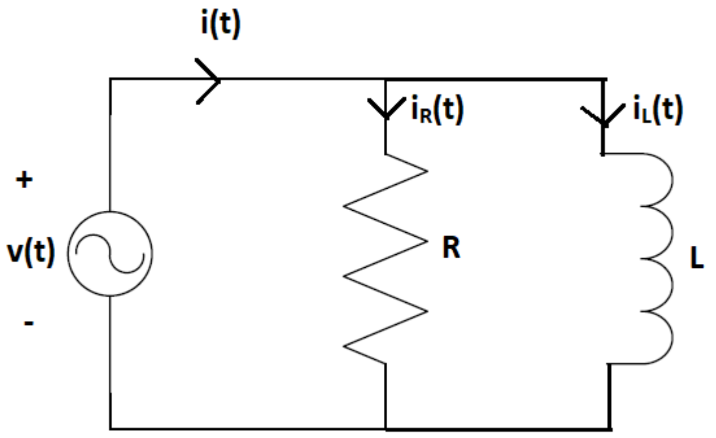
Admittance of an element is equal to the reciprocal of its impedance.

Admittance, $Y = \frac{1}{Z}$

It is measured in Siemens (S) or Mho (℧)

Element	Impedance (Z)	Admittance (Y)	Remarks
Resistor (R)	R	$\frac{1}{R} = G$	G is the conductance
Inductor (L)	jX_L	$\frac{1}{jX_L} = -jB_L$	B_L is the Inductive Susceptance
Capacitor (C)	$-jX_C$	$\frac{1}{-jX_c} = jB_c$	B_C is the Capacitive Susceptance

Parallel RL Circuit



By KCL, $i(t) = i_R(t) + i_L(t)$

In Phasor form, $\dot{I} = \bar{I}_R + \bar{I}_L$

$$\bar{I}_R = \bar{V} * G \qquad \bar{I}_L = \bar{V} * (-jB_L)$$

$$\bar{I} = \bar{V} * (G - jB_L)$$

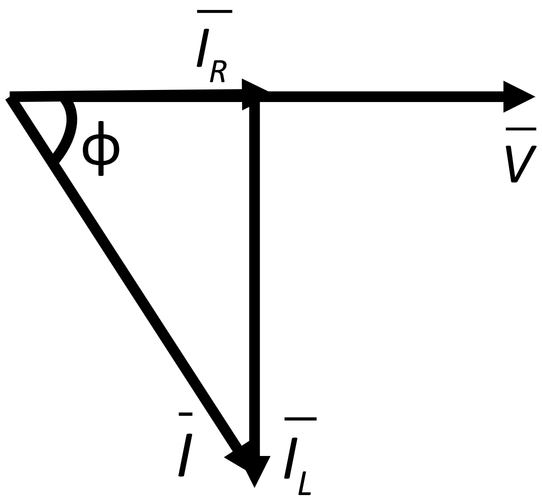
$$Y_T = \frac{\bar{I}}{\bar{V}} = (G - jB_L) = \sqrt{G^2 + B_L^2} \angle -\mathrm{Tan}^{-1}\left(\frac{B_L}{G}\right)$$

Parallel RL Circuit

In a parallel circuit, the total admittance is equal to the sum of individual branch admittances.

Phasor Diagram:

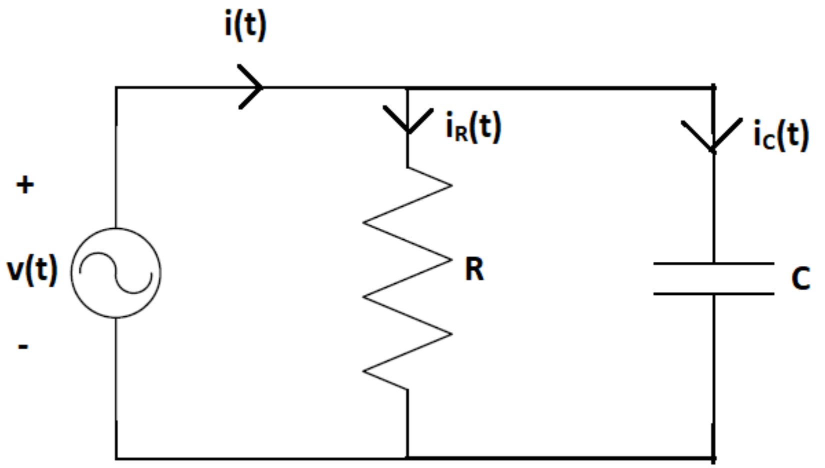
Note: In parallel AC circuits, it is preferable to consider the supply voltage as reference phasor while drawing phasor diagram.



$$\phi = \mathrm{Tan}^{-1}\left(\frac{|\bar{I}_L|}{|\bar{I}_R|}\right) = \mathrm{Tan}^{-1}\left(\frac{I_L}{I_R}\right)$$

$$= \mathrm{Tan}^{-1}\left(\frac{B_L}{G}\right)$$

Parallel RC Circuit



By KCL, $i(t) = i_R(t) + i_C(t)$

In Phasor form, $\bar{I} = \bar{I}_R + \bar{I}_C$

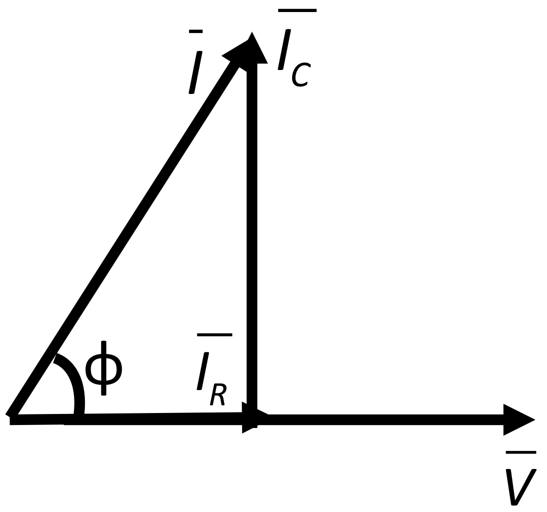
$$\bar{I}_R = \bar{V} * G \qquad \bar{I}_C = \bar{V} * (jB_C)$$

$$\bar{I} = \bar{V} * (G + jB_C)$$

Parallel RC Circuit

$$Y_T = \frac{\bar{I}}{\bar{V}} = (G+jB_C) = \sqrt{G^2+B_C^2}\,\angle \mathrm{Tan}^{-1}\left(\frac{B_C}{G}\right)$$

Phasor Diagram:



$$\phi = -\mathrm{Tan}^{-1}\left(\frac{|\bar{I}_C|}{|\bar{I}_R|}\right) = -\mathrm{Tan}^{-1}\left(\frac{I_C}{I_R}\right)$$

$$= -\mathrm{Tan}^{-1}\left(\frac{B_C}{G}\right)$$

Note: Phase Angle of a network is equal to impedance angle (or) negative of admittance angle.

Numerical Example 1

Question:

The terminal voltage and current for a parallel circuit are 141.4sin 2000t V and 7.07sin $(2000t+36^0)$A.
Obtain the simplest two element parallel circuit, which would have the above relationship.

Numerical Example 1

Solution: To find the elements in a network, use the impedance form if it is a series network and use the admittance form if it is a parallel network.

$$v(t) = 141.4\sin(2000t)\ \text{V} \quad \Rightarrow \bar{V} = \frac{141.4}{\sqrt{2}}\angle 0°\ \text{V}$$

$$i(t) = 7.07\sin(2000t+36°)\ \text{A} \quad \Rightarrow \bar{I} = \frac{7.07}{\sqrt{2}}\angle 36°\ \text{A}$$

$$\text{Admittance, } Y = \frac{\bar{I}}{\bar{V}} = 0.05\angle 36° \text{S} = (0.04 + j0.029)\ \text{S}$$

Comparing with the standard form ($G+jB_C$),

$G = 0.04$S ; $B_C = 0.029$S

Hence, it is a parallel RC network

$$R = \frac{1}{G} = 25\Omega \text{ and } C = \frac{B_C}{\omega} = \frac{0.029}{2000} = 14.5\mu\text{F}$$

Numerical Example 2

Question:

A resistor of 30Ω and a capacitor of unknown value are connected in parallel across a 110V, 50Hz Supply. The combination draws a current of 5A from the supply. Find the value of unknown Capacitance.

Numerical Example 2

Solution:

$$|Y_T| = \frac{|I|}{|V|} = \frac{5}{110} = 0.045\ S \quad \text{-----}\ (1)$$

For a parallel RC network, $|Y_T| = \sqrt{G^2 + B_C^{\,2}}$ ----- (2)

$$G = \frac{1}{R} = 0.033S$$

Substituting G in (2) and equating (1) & (2),

$B_C = 0.0306S$

$$C = \frac{B_C}{\omega} = \frac{0.0306}{100\pi} = 97.38\mu F$$

Numerical Example 2

Q9. A parallel RL circuit has R=4Ω, X_L=3Ω. Obtain its series equivalent such that the series circuit draws the same current and power at a given voltage.

Text Book & References

Text Book:

"Electrical and Electronic Technology" E. Hughes (Revised by J. Hiley, K. Brown & I.M Smith), 11th Edition, Pearson Education, 2012.

Reference Books:

1. "Basic Electrical Engineering - Revised Edition", D. C. Kulshreshta, Tata- McGraw-Hill, 2012.
2. "Basic Electrical Engineering", K Uma Rao, Pearson Education, 2011.
3. "Engineering Circuit Analysis", William Hayt Jr., Jack E. Kemmerly & Steven M. Durbin, 8th Edition, McGraw-Hill, 2012.

THANK YOU

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