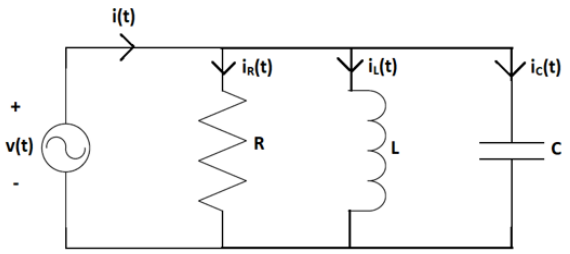
NOTES -Class 30

Analysis of Parallel RLC circuits

Parallel RLC Circuit:



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

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

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

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

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

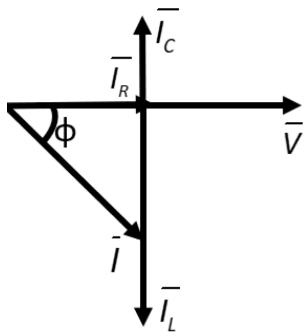
Case 1: $B_L > B_C$

If $B_L > B_C$ then $VB_L > VB_C$

i.e., $|\bar{I}_L| > |\bar{I}_C|$

The circuit behaves effectively as inductive circuit i.e., parallel RL type.

Phasor Diagram:



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

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

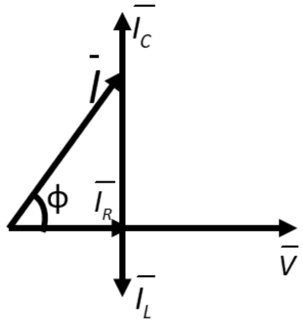
Case 2: $B_C > B_L$

If $B_C > B_L$ then $VB_C > VB_L$

i.e., $|\overline{I_C}| > |\overline{I_L}|$

The circuit behaves effectively as a capacitive circuit i.e., parallel RC type.

Phasor Diagram:



$$\phi = Tan^{-1}\left(\frac{|\overline{I_L}| - |\overline{I_C}|}{|\overline{I_R}|}\right) = Tan^{-1}\left(\frac{I_L - I_C}{I_R}\right)$$

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

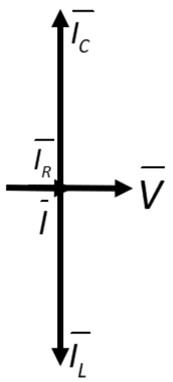
Note: ϕ will be negative in this case since $B_L < B_C$

Case 3: $B_L = B_C$

If $B_L = B_C$ then $VB_L = VB_C$ i.e., $|\overline{I_L}| = |\overline{I_C}|$

The circuit behaves effectively as a purely resistive circuit. This case is called **'Parallel Resonance'** case.

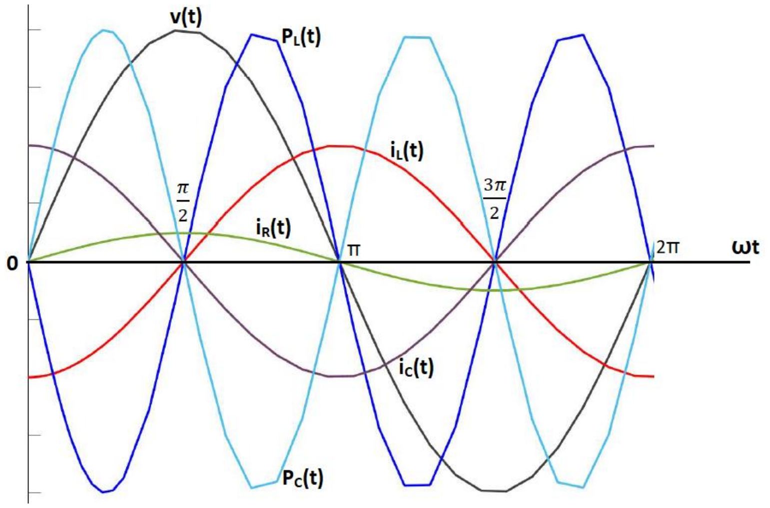
Phasor Diagram:



$$\bar{I} = \overline{I_R}$$

$$Y = G$$

$$\phi = 0°$$



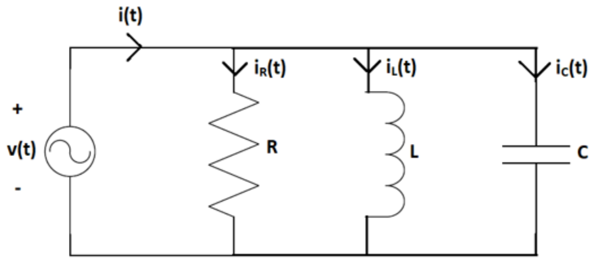
Question 12:

Three circuit elements R=2.5Ω, X_L=4Ω and X_C=10Ω are connected in parallel, the reactance being at 50Hz.

a) Determine the admittance of each element and hence obtain the input admittance.

b) If this circuit is connected across a 10V, 50Hz AC source, determine the current in each branch and the total input current.

Solution:



i) Admittance of branch1, $Y_1 = \frac{1}{Z_1} = \frac{1}{R} = G = 0.4S$

Admittance of branch2, $Y_2 = \frac{1}{Z_2} = \frac{1}{jX_L} = -jB_L = -j0.25S$

Admittance of branch3, $Y_3 = \frac{1}{Z_3} = \frac{1}{-jX_C} = jB_C = j0.1S$

Input Admittance $Y_{in} = Y_T = Y_1 + Y_2 + Y_3 = (0.4 - j0.15)S$

ii) Taking supply voltage as reference, $\overline{V} = 10\angle 0^\circ V$

current in branch 1, $\overline{I_R} = \dfrac{\overline{V}}{Z_1} = \overline{V}Y_1 = 10\angle 0°*0.4 = 4\angle 0°A$

current in branch 2, $\overline{I_L} = \overline{V}Y_2 = 10\angle 0°*(-j0.25) = 2.5\angle -90°A$

current in branch 3, $\overline{I_C} = \overline{V}Y_3 = 1\angle 90°A$

Input current, $\overline{I_S} = \overline{I_R} + \overline{I_L} + \overline{I_C} = 4.27\angle -20.55°A$