



The Shirpur Education Society's
R. C. Patel College of Engineering and Polytechnic, Shirpur
Department of Electrical Engineering

Notes

Unit - II

Single Phase A.C Parallel Circuits

NAME OF COURSE: - ELECTRICAL CIRCUITS AND NETWORK

CODE OF COURSE: - 313332

SEMESTER: - SYEE-3K

SUBJECT TEACHER: - Mr. Jayesh M. Suryawanshi

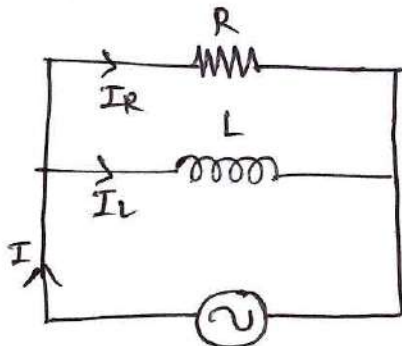
Unit 2 : Single Phase A.C. Parallel Circuit

(12 Marks)

Prepared by: Mr. J.M. Suryawanshi

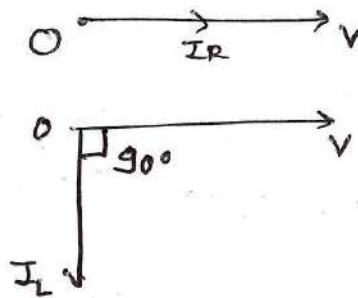
Subject: ECN (313332)

RL Parallel Circuit



AC source

$$V = V_m \sin(\omega t)$$



In parallel circuit resistance (R) & inductance (L) are connected in parallel across AC voltage source. Due to this source current I flowing through circuit

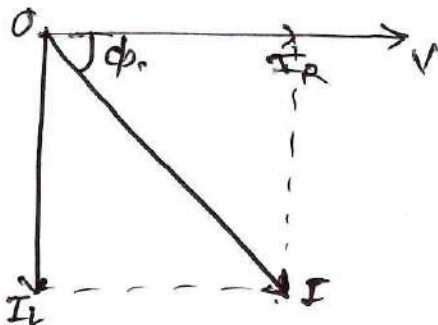
Current flowing through resistance R is I_R

$$I_R = \frac{V}{R}$$

Current flowing through inductance L is I_L

$$I_L = \frac{V}{X_L}$$

Phasor diagram



The supply current I is equal to phasor addition of

I_R & I_L

$$\vec{I} = \vec{I}_R + \vec{I}_L$$

$$\vec{I} = \frac{V}{R} + \frac{V}{X_L}$$

Impedance

Impedance of RL parallel circuit

$$Z_1 = R + j0 = R \angle 0^\circ$$

$$Z_2 = 0 + jX_L = X_L \angle 90^\circ$$

Equivalent Impedance

$$Z = Z_1 \parallel Z_2 = \frac{Z_1 Z_2}{Z_1 + Z_2}$$

$$= \frac{(R \angle 0^\circ) (X_L \angle 90^\circ)}{(R + j0 + 0 + jX_L)}$$

$$= \frac{RX_L \angle 90^\circ}{R + jX_L}$$

$$\text{Polar form} = R + jX_L = \sqrt{R^2 + X_L^2} \angle \tan^{-1}\left(\frac{X_L}{R}\right)$$

$$= \frac{RX_L \angle 90^\circ}{\sqrt{R^2 + X_L^2} \angle \tan^{-1}(X_L/R)}$$

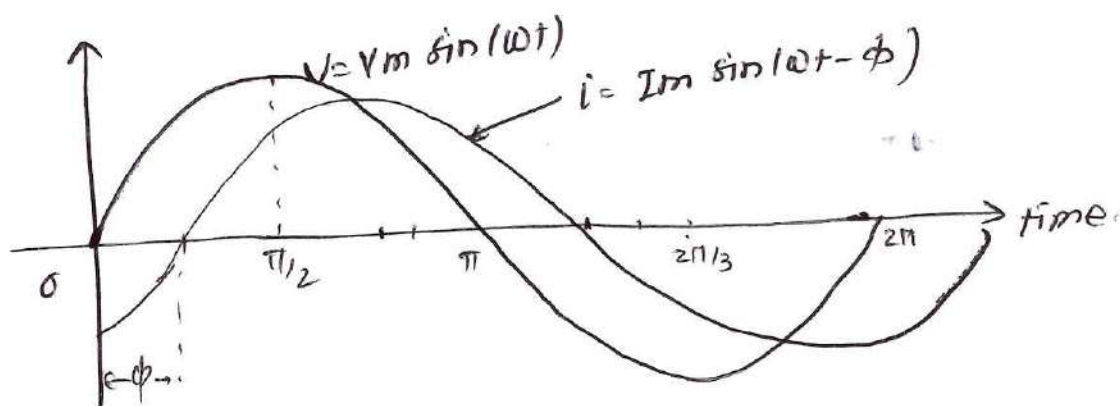
$$Z = \frac{RX_L}{\sqrt{R^2 + X_L^2}} \angle \left[90^\circ - \tan^{-1}\left(\frac{X_L}{R}\right) \right]$$

Voltage & Current waveform (Response)

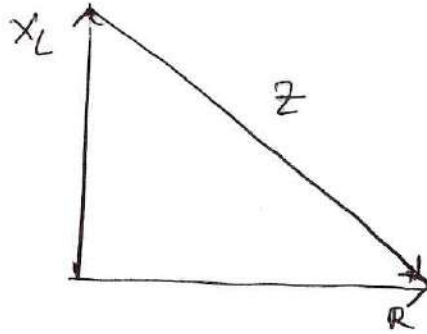
voltage & current equations

$$V = V_m \sin(\omega t)$$

$$i = I_m \sin(\omega t - \phi)$$



Impedance triangle



Power factor: power factor of parallel RL circuit is lagging

Inductive Reactance

The reactance offered by pure inductor to the alternating current is called inductive reactance, which is denoted by X_L

$$X_L = 2\pi fL \quad \Omega$$

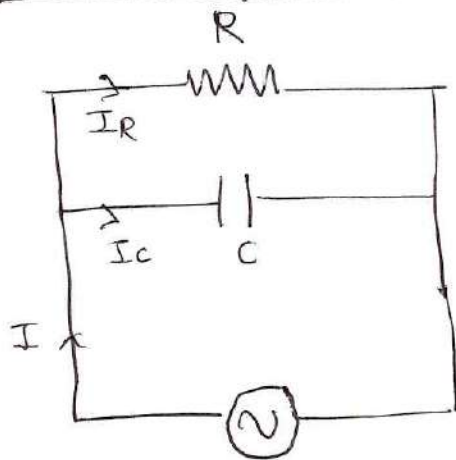
Where,

X_L = inductive Reactance in Ω

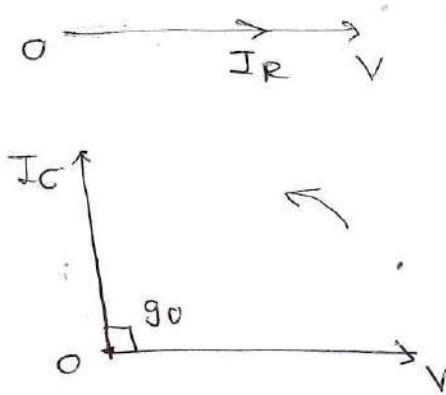
f = frequency in Hz

L = Inductance in Henry

RC Parallel Circuit



AC source
 $V = V_m \sin(\omega t)$



The combination of Resistance (R) & capacitance (C) are connected in parallel across AC voltage source the current flowing through the circuit.

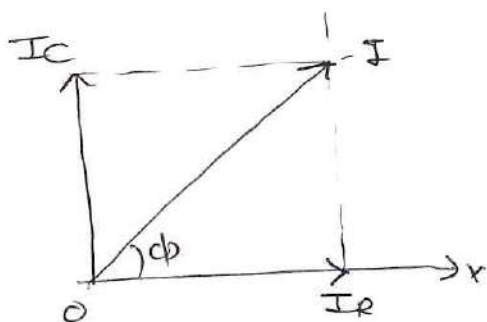
Current flowing through R is I_R

$$I_R = \frac{V}{R}$$

Current flowing through C is I_C

$$I_C = \frac{V}{X_C}$$

Phasor diagram



The supply current I is equal to phasor addition of I_R & I_C

$$\vec{I} = \vec{I}_R + \vec{I}_C$$

$$\vec{I} = \frac{V}{R} + \frac{V}{X_C}$$

Impedance

Impedance of RC Parallel circuit

$$Z_1 = R + j0 = R \angle 0^\circ$$

$$Z_2 = 0 - jX_C = X_C \angle -90^\circ$$

equivalent Impedance

$$\begin{aligned} Z_{eq} &= Z_1 \parallel Z_2 = \frac{Z_1 Z_2}{Z_1 + Z_2} \\ &= \frac{(R \angle 0^\circ)(X_C \angle -90^\circ)}{R + j0 + 0 - jX_C} \\ &= \frac{RX_C \angle -90^\circ}{R - jX_C} \end{aligned}$$

$$\text{Polar form} = R - jX_C = \sqrt{R^2 + X_C^2} \angle \tan^{-1}\left(\frac{-X_C}{R}\right)$$

$$= \frac{RX_C \angle -90^\circ}{\sqrt{R^2 + X_C^2} \angle \tan^{-1}\left(\frac{-X_C}{R}\right)}$$

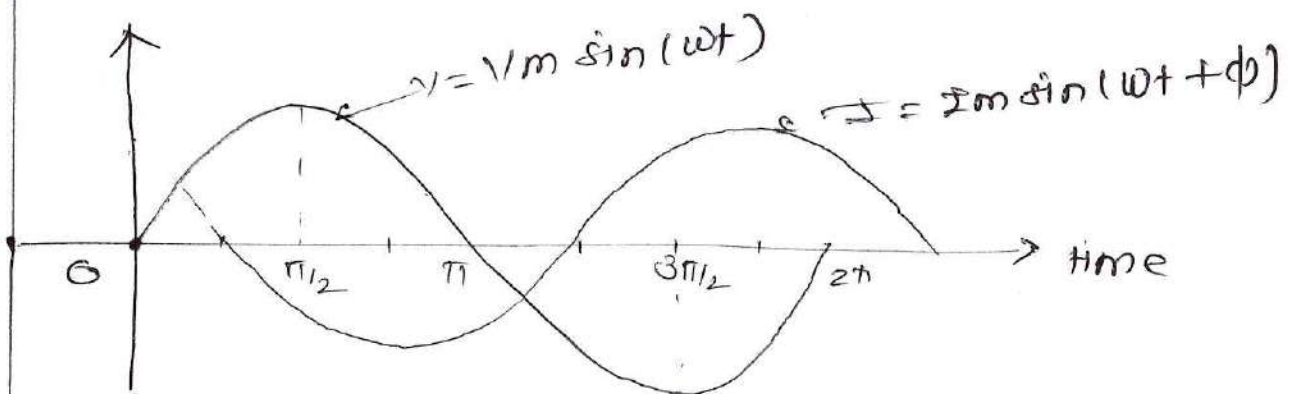
$$Z_{eq} = \frac{RX_C}{\sqrt{R^2 + X_C^2}} \angle \left[-90^\circ + \tan^{-1}\left(\frac{X_C}{R}\right) \right]$$

voltage & current waveform

voltage & current equation

$$v = V_m \sin(\omega t)$$

$$i = I_m \sin(\omega t + \phi)$$

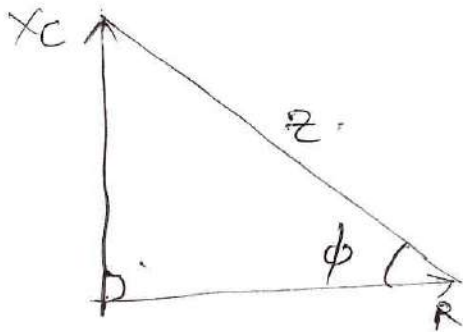


Power factor

Power factor is defined by the cosine angle between voltage & current

Power factor is leading for RC parallel circuit.

Impedance triangle



Reactance (Capacitive Reactance)

It is defined as the opposition offered by the capacitance to alternating current is known as Capacitive Reactance.

It is denoted by X_C . SI Unit is ohm(Ω)

$$X_C = \frac{1}{2\pi fC} \quad \Omega$$

Where

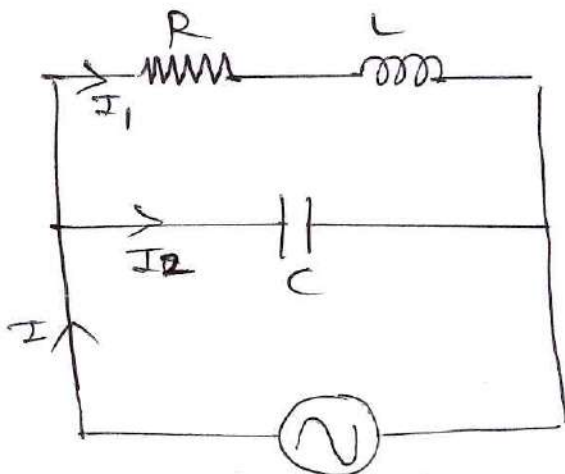
X_C = Capacitive reactance in Ω

f = frequency in Hertz

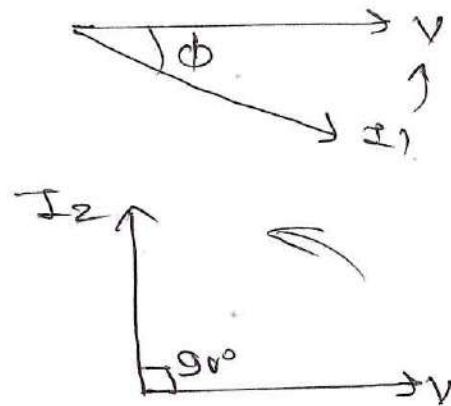
C = Capacitance in farad

RLC Parallel circuit

Series combination of R & L in parallel with capacitor C



AC source
 $V = V_m \sin(\omega t)$



From above circuit series combination of R & L is connected in parallel with capacitor & across AC supply voltage.

Let Z_1 be the impedance of RL series.

$$Z_1 = R + jX_L = |Z_1| \angle \phi_1$$

$$\text{where } |Z_1| = \sqrt{R^2 + X_L^2} \quad \phi_1 = \tan^{-1}\left(\frac{X_L}{R}\right)$$

Let Z_2 be the impedance of capacitor

$$Z_2 = 0 - jX_C = |Z_2| \angle \phi_2$$

$$\text{where } |Z_2| = X_C \quad \phi_2 = -90^\circ$$

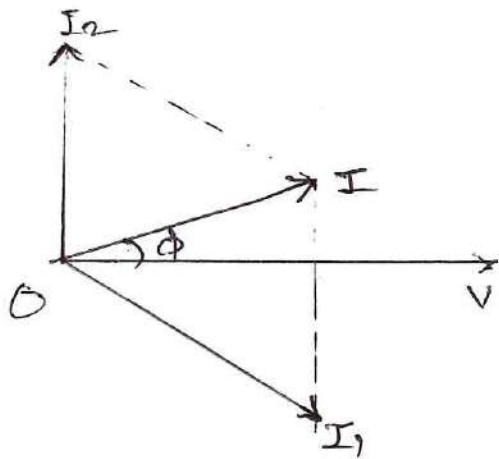
Let I_1 be the current through RL is

$$I_1 = \frac{V}{Z_1}$$

Let I_2 be the current through C is

$$I_2 = \frac{V}{Z_2}$$

Phasor diagram:



I is the phasor addition of I_1 & I_2

$$I = \overline{I_1} + \overline{I_2}$$

$$= \frac{V}{Z_1} + \frac{V}{X_C}$$

Impedance: It is the combination of resistance, inductance, & capacitance. Its unit is ohm which is denoted by Z

$$Z_1 = R + jX_L = |Z_1| \angle \phi_1$$

$$Z_2 = 0 - jX_C = X_C \angle -90^\circ$$

$$Z_{eq} = Z_1 \parallel Z_2 = \frac{Z_1 Z_2}{Z_1 + Z_2}$$

$$= \frac{(Z_1 \angle \phi_1) (X_C \angle -90^\circ)}{R + j(X_L - X_C)}$$

Power factor: It is the cosine angle between voltage & current

power factor of RLC parallel circuit depends on ϕ .

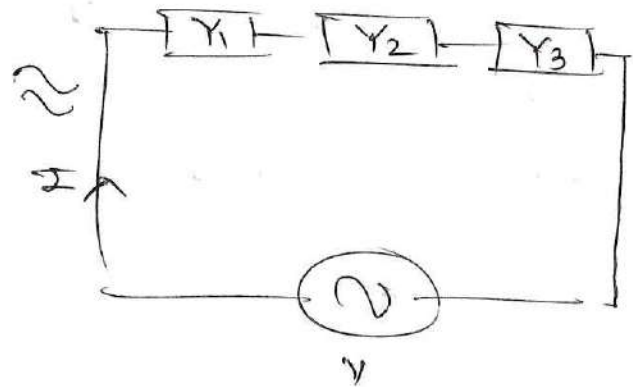
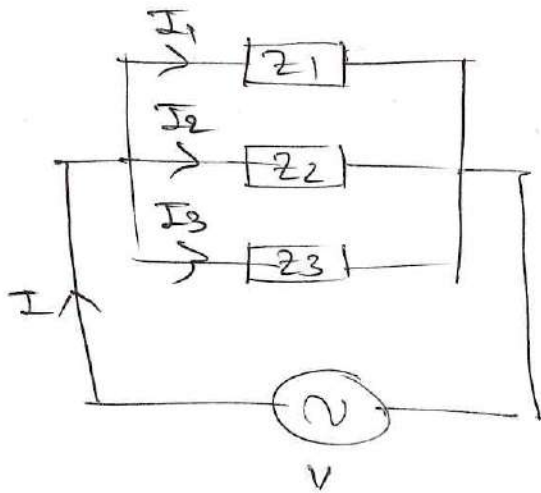
ϕ (Angle)	Power factor
Negative (-ve) \longrightarrow	lagging
Zero (0) \longrightarrow	Unity
Positive (+ve) \longrightarrow	leading.

The concept Admittance

The admittance is define as the reciprocal of impedance

It is denoted by Y & its SI unit is Siemens (S)

$$\therefore Y = \frac{1}{Z}$$



(a) Impedances in parallel (b) Admittance in Series

From fig (a)

$$I = I_1 + I_2 + I_3 \quad \text{--- (1)}$$

substituting value of I_1 & I_2, I_3 we get

$$I = \frac{V}{Z_1} + \frac{V}{Z_2} + \frac{V}{Z_3}$$

By using definition of Admittance

$$Y_1 = \frac{1}{Z_1}, \quad Y_2 = \frac{1}{Z_2}, \quad Y_3 = \frac{1}{Z_3}$$

$$I = V Y_1 + V Y_2 + V Y_3$$

$$I = V (Y_1 + Y_2 + Y_3)$$

Total admittance $Y = Y_1 + Y_2 + Y_3$

Conductance (G)

It is defined as the ratio of the resistance R & square of impedance (Z^2).

It is denoted by G, SI Unit is Siemens.

$$G = \frac{R}{Z^2} \text{ --- Siemens}$$

Susceptance (B)

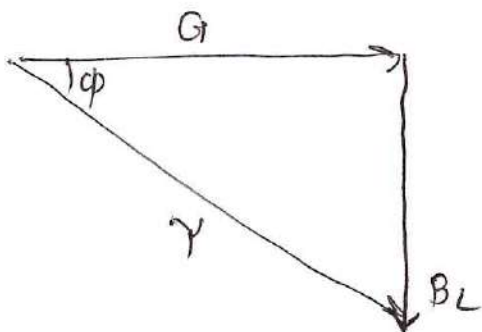
It is defined as the ratio of the reactance ($\mp X$) & square of Impedance (Z^2)

It is denoted by B, SI Unit is Siemens.

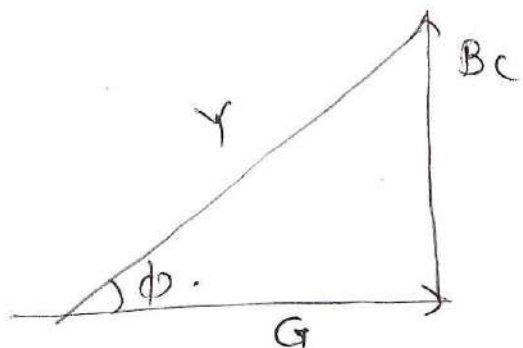
$$B = \frac{X}{Z^2} \text{ --- Siemens}$$

$$\boxed{Y = G \mp jB}$$

Admittance triangle.



(a) -B inductive susceptance



(b) +B capacitive susceptance.

Q. An impedances of $(2+j6)$ is connected in parallel $(10+j5)$ & which are in series with $(15-j9)$ whole circuit is connected to 230 V. Calculate total current, Power factor of circuit

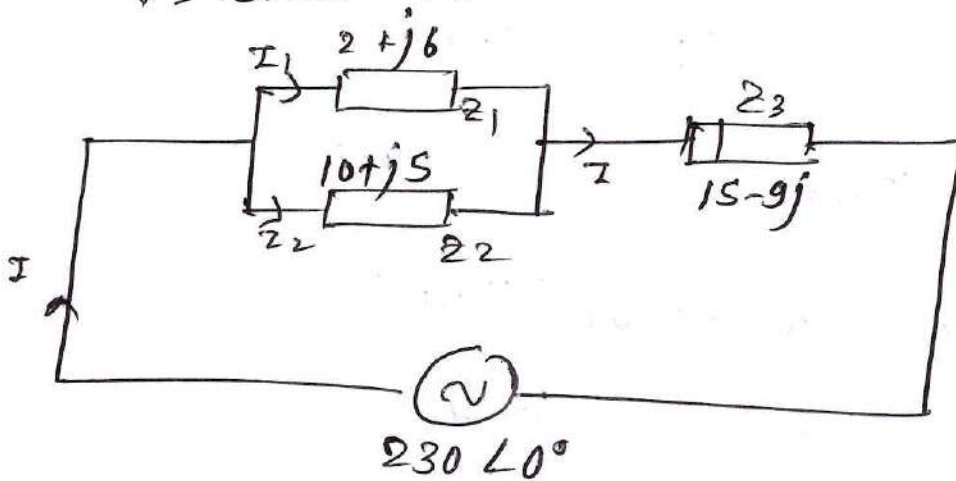
Given things.

$$Z_1 = 2 + j6 =$$

$$Z_2 = 10 + j5 =$$

$$Z_3 = 15 - j9 =$$

$$V = 230 \angle 0^\circ \text{ Volts.}$$



Total impedance

$$Z_{eq} = (Z_1 \parallel Z_2) + Z_3 = \frac{Z_1 Z_2}{Z_1 + Z_2} + Z_3$$

$$Z_1 + Z_2 = 2 + j6 + 10 + j5 = 12 + j11 = 16.27 \angle 42.51^\circ$$

$$\frac{Z_1 Z_2}{Z_1 + Z_2} = \frac{(6.32 \angle 71.56^\circ) \times (11.18 \angle 26.56^\circ)}{16.27 \angle 42.51^\circ}$$

$$= \frac{(6.32 \times 11.18) \angle (71.56^\circ + 26.56^\circ)}{16.27 \angle 42.51^\circ}$$

$$= \frac{70.657 \angle (98.12^\circ)}{16.27 \angle 42.51^\circ}$$

$$= \frac{70.657}{16.27} \angle (98.12^\circ - 42.51^\circ)$$

$$= 4.342 \angle 52.61^\circ$$

$$= 2.636 + j3.449$$

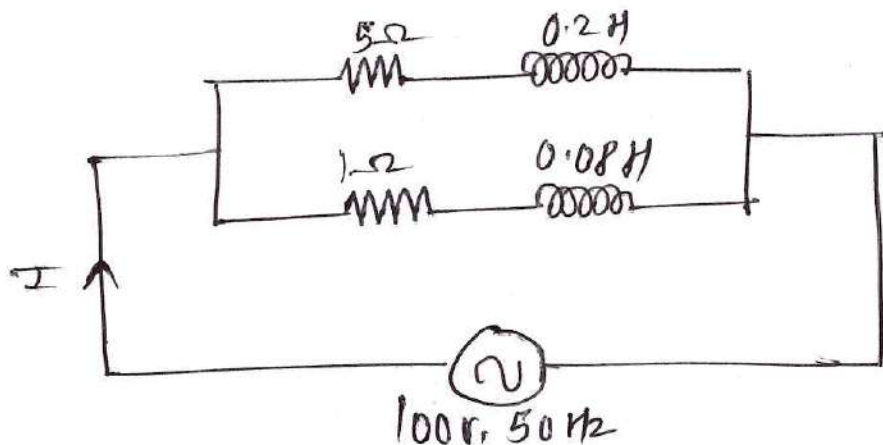
$$\begin{aligned}
 Z_{eq} &= \left(\frac{Z_1 Z_2}{Z_1 + Z_2} \right) + Z_3 \\
 &= 2.636 + j3.449 + 15 - j9 \\
 Z_{eq} &= 17.636 - j5.551 \Omega \\
 \theta &= 18.488 \angle -17.47^\circ
 \end{aligned}$$

Total current

$$\begin{aligned}
 I &= \frac{V}{Z_{eq}} = \frac{230 \angle 0^\circ}{18.488 \angle -17.47^\circ} \\
 &= \frac{230}{18.488} \angle [0^\circ - (-17.47^\circ)] \\
 I &= 12.440 \angle +17.47^\circ \text{ Amp}
 \end{aligned}$$

$$\begin{aligned}
 \text{Power factor} &= \cos \phi = \cos (17.47^\circ) = \\
 &= 0.953 \text{ (leading)}
 \end{aligned}$$

- Q. A coil having resistance 5Ω & inductance of 0.2H is arranged in parallel with another coil having resistance of 1Ω & inductance of 0.08H . Calculate current through combination & power absorbed when voltage of 100V , 50Hz is applied.



Given $R_1 = 5\Omega$, $L_1 = 0.2\text{H}$
 $R_2 = 1\Omega$, $L_2 = 0.08\text{H}$

Find current & power absorbed.

$$Z_1 = R_1 + jX_{L1}$$

$$X_{L1} = 2\pi fL_1 = 2\pi \times 50 \times 0.2 = 62.831 \Omega$$

$$Z_1 = 5 + j62.831 \Omega$$

$$Z_1 = 63.029 \angle 85.450^\circ$$

$$Z_2 = R_2 + jX_{L2}$$

$$X_{L2} = 2\pi fL_2 = 2\pi \times 50 \times 0.08 = 25.132 \Omega$$

$$Z_2 = 1 + j25.132 \Omega$$

$$Z_2 = 25.151 \angle 87.721^\circ$$

$$\begin{aligned} Z_{eq} &= \frac{Z_1 Z_2}{Z_1 + Z_2} = \frac{(63.029 \angle 85.450^\circ)(25.151 \angle 87.721^\circ)}{5 + j62.831 + 1 + j25.132} \\ &= \frac{(63.029 \times 25.151) \angle (85.450^\circ + 87.721^\circ)}{6 + j87.963} \\ &= \frac{1585.242 \angle 173.171^\circ}{6 + j87.963} \\ &= \frac{1585.242 \angle 173.171^\circ}{88.167 \angle 86.097^\circ} \\ &= \left(\frac{1585.242}{88.167} \right) \angle (173.171^\circ - 86.097^\circ) \\ &= 17.979 \angle 87.074^\circ \end{aligned}$$

$$\text{Total current } I = \frac{V}{Z_{eq}} = \frac{100 \angle 0^\circ}{17.979 \angle 87.074^\circ}$$

$$= \left(\frac{100}{17.979} \right) \angle (0^\circ - 87.074^\circ)$$

$$I = 5.562 \angle -87.074^\circ \text{ Amp}$$

Calculate power absorbed

$$P = VI \cos \phi = 100 \times 5.562 \times \cos(-87.074^\circ)$$

$$P = 28.391 \text{ watt}$$

Active, Reactive, Apparent power of RL, RC, RLC parallel ckt

Active power: (P)

Active power is defined as the product of voltage & current & cosine angle between voltage & current which is denoted by P & SI unit is watt or kilo-watt.

$$P = V I \cos \phi \quad \text{Watt or kilo-watt}$$

Reactive power (Q)

It is defined as the product of voltage, current & sine angle between voltage & current which is denoted by Q & SI unit is VAR or KVAR.

$$Q = V I \sin \phi \quad \text{VAR or KVAR}$$

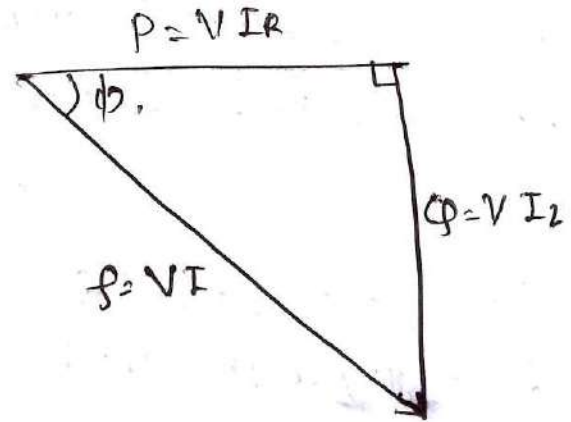
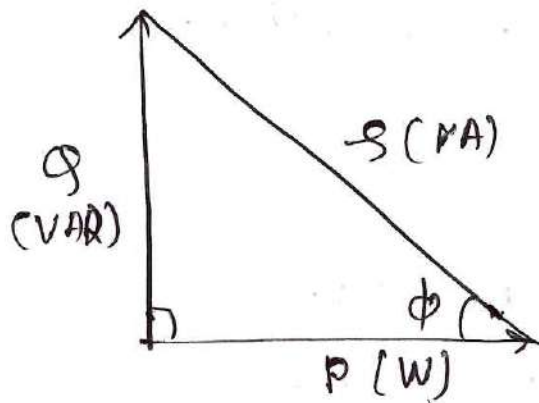
Apparent power (S)

It is defined as the product of voltage & current which is denoted by S & SI unit is VA or KVA

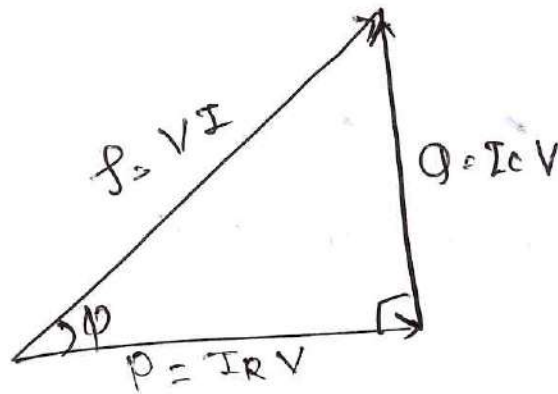
$$S = V I \quad \text{VA or KVA}$$

Power triangle of RL, RC & RLC circuit.

1) RL parallel circuit.



2) RC parallel circuit



Resonance in RLC parallel circuit.

Resonance at particular frequency occur that frequency called resonant frequency (f_0). At this frequency applied voltage & total current are inphase.

Resonant frequency (f_0)

The frequency at which resonance occur in RLC parallel circuit is known as resonant frequency

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \text{ Hz}$$

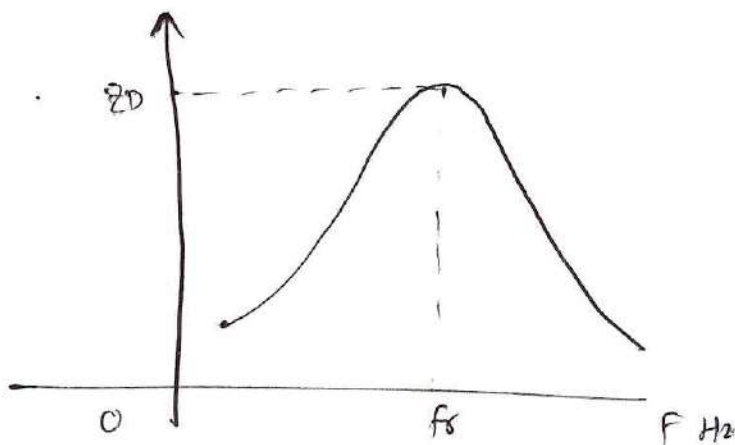
Dynamic Impedance (Z_D)

The dynamic impedance is defined as the impedance offered by RLC parallel circuit at resonance.

$$Z_D = \frac{L}{RC} \quad \Omega$$

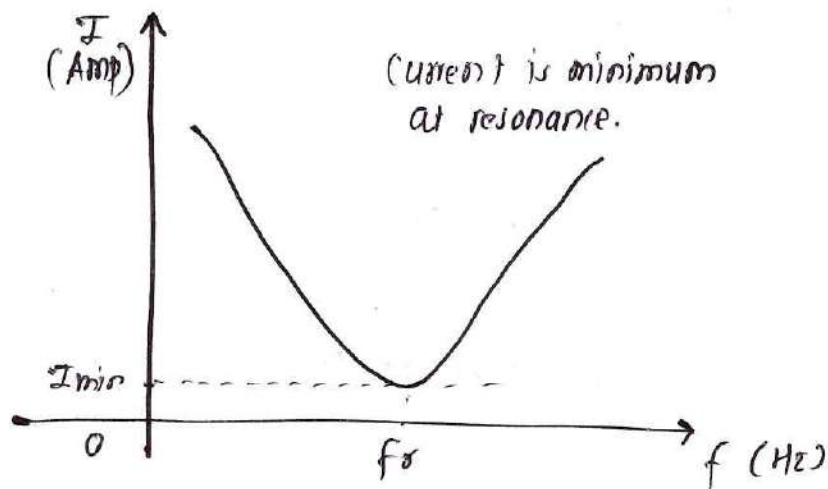
Properties:

- 1) dynamic impedance is purely resistive.
- 2) dynamic impedance represent maximum value of impedance of parallel circuit.



Resonance Curve

The Graphical representation in which Graph plot Current (I) versus frequency (f)



Q factor

Quality factor is defined as for parallel circuit as the current magnification provided at resonance.

As parallel circuit magnifies the current is also called current resonance circuit.

Expression of Q factor

Q factor = current Magnification

$$Q = \frac{\text{Current through inductive branch}}{\text{Resultant current } I}$$

$$= \frac{I_L}{I}$$

$$I_L = \frac{V}{Z_L} = \frac{V}{\sqrt{R^2 + \omega^2 L^2}}$$

$$R^2 + \omega^2 L^2 = \frac{L}{C}$$

$$I_L = \frac{V}{\sqrt{L/C}}$$

$$I = \frac{V}{Z_D} = \frac{V}{L/CR}$$

$$Q = \frac{v}{\sqrt{L/C}} \times \frac{L/CR}{v}$$

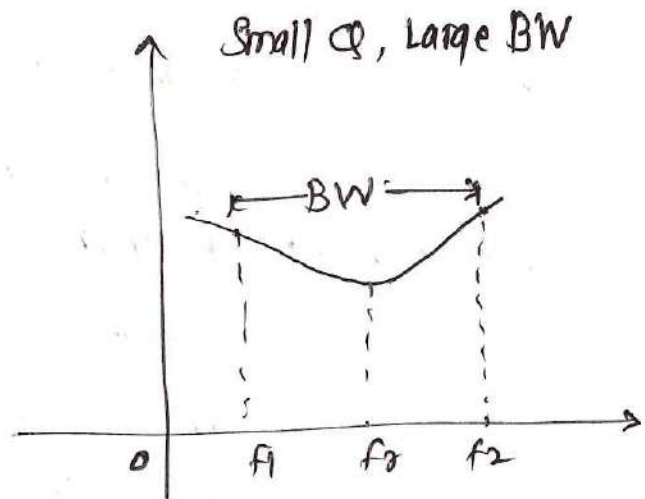
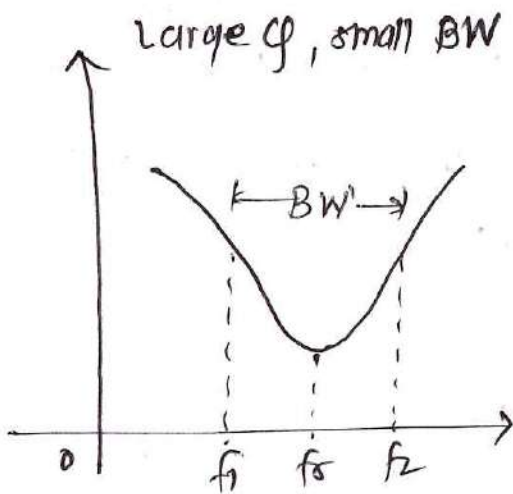
$$Q = \frac{1}{R} \sqrt{\frac{L}{C}}$$

Effect of Q on Bandwidth

The parallel resonance curve becomes sharper with increase in the value of Q

Bandwidth

$$B.W = \frac{f_0}{Q}$$



Q. An inductive coil having resistance of $10\ \Omega$ & inductance of $0.5\ \text{H}$ is connected in parallel with capacitor of $50\ \mu\text{F}$. Determine

- ① Parallel resonant frequency
- ② Quality factor
- ③ Power consumed by circuit at resonance, if supply voltage is $230\ \text{V}$

Given $R = 10\ \Omega$, $L = 0.5\ \text{H}$, $C = 50\ \mu\text{F}$ Parallel ckt
 $V = 230\ \text{V}$

Find :- f_r , Q , P at resonance

① f_r

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.5 \times 50 \times 10^{-6}}}$$

$$f_r = 31.83\ \text{Hz}$$

② Quality factor (Q factor)

$$Q = \frac{1}{R} \sqrt{\frac{L}{C}} = \frac{1}{10} \sqrt{\frac{0.5}{50 \times 10^{-6}}}$$

$$Q = 10$$

③ Power absorbed by coil at resonance.

$$P \text{ absorbed by coil} = P \text{ absorbed by } R = I_L^2 R$$

$$X_L = 2\pi fL = 2\pi \times 31.83 \times 0.5 = 100\ \Omega$$

$$Z_L = \sqrt{(R^2 + X_L^2)} = \sqrt{(10^2 + 100^2)} \\ = 100.5\ \Omega$$

$$I_L = \frac{V}{Z_L} = \frac{230}{100.5} = 2.29\ \text{A}$$

$$P_L = I_L^2 R = (2.29)^2 \times 10 = 52.44\ \text{Watt}$$

Q. A coil with $R = 10\ \Omega$ & $L = 0.25\ \text{H}$ is connected in parallel with a capacitor of $100\ \mu\text{F}$. Find
① Quality factor ② Dynamic Impedance.

Given things

$$R = 10\ \Omega, \quad L = 0.25\ \text{H}, \quad C = 100\ \mu\text{F}$$

Find: - Q , Z_D

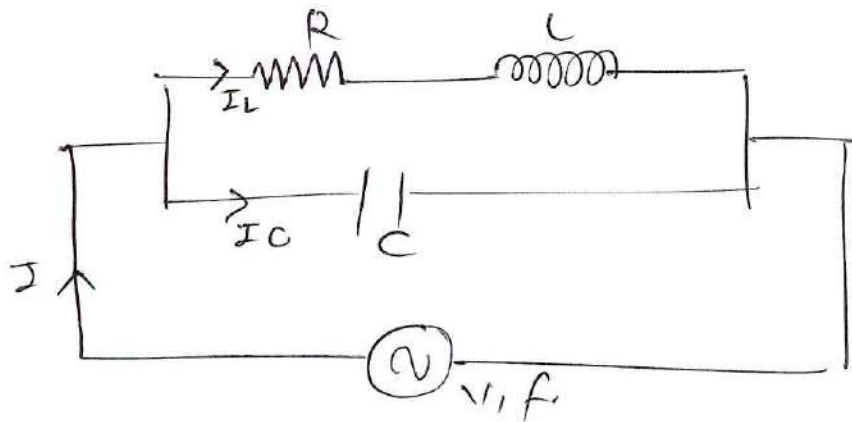
$$\textcircled{1} \quad Q = \frac{1}{R} \sqrt{\frac{L}{C}} = \frac{1}{10} \sqrt{\frac{0.25}{100 \times 10^{-6}}} = 5.$$

② Find Z_D .

$$Z_D = \frac{L}{RC} = \frac{0.25}{10 \times 100 \times 10^{-6}}$$

$$Z_D = 250\ \Omega$$

Current Magnification in Parallel Resonant circuit



Consider parallel resonant circuit. Let V be the AC voltage source & $f = f_0$ resonant frequency.

Then the voltage across the inductor is given by

$$I_L = \frac{V}{Z_L} = \frac{V}{\sqrt{R^2 + \omega^2 L^2}} \quad \text{--- (1)}$$

But

$$R^2 + \omega^2 L^2 = \frac{L}{C}$$

Substitute value of L/C in equation (1)

$$I_L = \frac{V}{\sqrt{L/C}}$$

But $Z_D = \frac{L}{RC}$ & $V = I \cdot Z_D = I \cdot \left(\frac{L}{RC}\right)$

$$I_L = \frac{I \left(\frac{L}{RC}\right)}{\sqrt{L/C}} = I \left(\frac{1}{R} \sqrt{\frac{L}{C}}\right)$$

But $Q = \frac{1}{R} \sqrt{\frac{L}{C}}$

$$\boxed{I_L = Q \cdot I}$$

Comparison of Series & parallel resonant circuit

Sl No.	Parameter	Series circuit	Parallel circuit
1.	Impedance	Minimum $Z = R$	Maximum $Z = \frac{L}{CR}$
2.	Nature of circuit	Resistive	Resistive
3.	Power factor	Unity	Unity
4.	current drawn from the source	Maximum $I = \frac{V}{R}$	Minimum $I = \frac{V}{\frac{L}{CR}}$
5.	Resonant frequency	$f_0 = \frac{1}{2\pi\sqrt{LC}}$	$f_0 = \frac{1}{2\pi\sqrt{LC}}$
6.	Magnification	voltage Magnification	Current Magnification
7.	Q factor	$Q = \frac{1}{R} \sqrt{\frac{L}{C}}$	$Q = \frac{1}{R} \sqrt{\frac{L}{C}}$
8.	Application	As an Acceptor Circuit	As an Rejector Circuit

UNIT 2 : Single phase AC Parallel circuit

1. State the term "conductance" and "susceptance" in case of single phase parallel circuit. 2 marks (Winter-2024)
2. Define 1) Resonance frequency 2) Q factor 2 marks -- (Summer-2026)
3. Define conductance and susceptance. State its unit. 2 marks (Summer-2025)
4. Define Admittance related to AC circuit. State its SI Unit. 2 marks -- (Winter-2025)
5. State features of parallel resonance circuit. 4 marks (Summer-2026)
6. Compare series and parallel resonance circuit. 4 marks (Winter-2025) (Summer-25) (S-2026)
7. Two impedances $Z_1 = (10 + j5)\Omega$ and $Z_2 = (8 + j6)\Omega$ are joined in parallel and connected across a voltage of $V = 200\angle 0^\circ$ volt. Calculate the circuit current branch current and draw the vector diagram. 4 marks (Summer-2024)
8. Two impedances $Z_1 = (8 + j6)\Omega$ and $Z_2 = (3 - j4)$ are in parallel. If the total current of the combination is 25A, find the current taken and power consumed by each impedance. 4 marks (Winter-2024)
9. Two circuits, the impedances of which are given by $Z_1 = 10 + j15$ and $Z_2 = 6 - j8$ ohm are connected in parallel. If the total current supplied is 15A, What is the power taken by each branch? Find also the P.F. of individual circuits and of combination. Draw vector diagram. 4 marks (Summer-2025)
10. Draw and explain RLC parallel circuit. Find out the equation for resonant frequency. 4marks (Summer-2025)
11. A coil having resistance of ~~5 Ω~~ and an inductance of 0.2 H is connected in parallel with a series combination of 10W resistor and 80 mF capacitor. If supply voltage is 230 V, 50 Hz, determine :- i) Total circuit impedance ii) Total current taken by the circuit iii) Power factor of the circuit. 4marks -- (Winter-2025)
12. Impedance $Z_1 = (10 + j5)\Omega$ and $Z_2 = (8 + j6)\Omega$ are connected in parallel across $V = (200 + j0)$ using the admittance method, calculate the circuit current and branch currents. 4marks (Summer-2025) (W-2024)
13. Explain the "Current Magnification" in parallel resonant circuit consisting of inductive branch (R-L) in parallel with a pure capacitor (C). Derive equation for it. 4marks (Winter-2025)
14. A coil of resistance 20Ω and inductance 200 mH is in parallel with a variable capacitor. (Refer Figure No. 5 This combination is in series with a resistor of 8000Ω . The voltage of the supply is 200 V at a frequency of 106Hz as in Figure No. 5. Calculate: i) The value of C to give resonance ii) The Q of the coil iii) The current in each branch of the circuit at resonance. 6marks (Winter-2024)

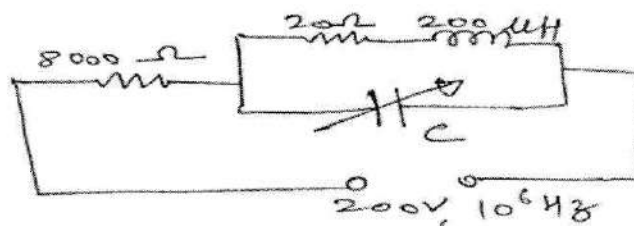


Fig. No. 5

15. Two circuits the impedance of which are given by $Z_1 = (6 + j8)$ ohm and $Z_2 = (8 - j6)$ ohm are connected in parallel. If the applied voltage to the combination is 100 V, Find by impedance method :- i) Current at each branch ii) Overall current iii) Power factor of the combination. 6 marks (Winter-2025)