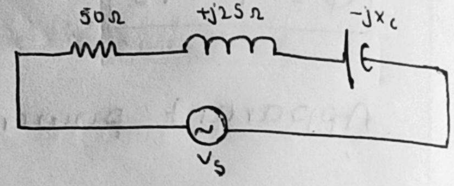
Unit-4

Q. For the circuit shown in figure, calculate reactance of capacitor, & impedance when the circuit is in resonance &



A. $R = 50\Omega$

$X_L = 25\Omega$

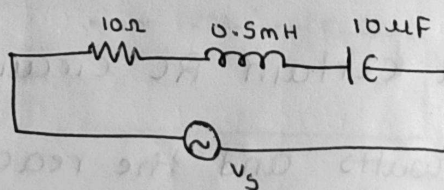
X_c = unknown

Impedance at Resonance is

$Z = R = 50\Omega$

At resonance $X_L = X_c = 25\Omega$

Q. Determine resonant frequency of circuit shown in figure



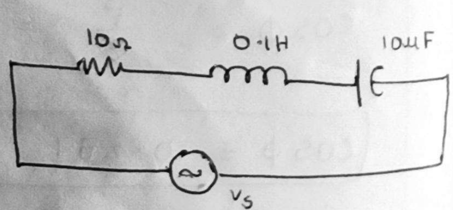
A. $L = 0.5 mH$

$C = 10 \mu F$

$$f_r = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.5\times10^{-3}\times10\times10^{-6}}}$$

$f_r = 2.250$ kHz

Q. From the circuit shown in figure, determine the impedance & resonant frequency, resonant frequency above 10Hz and below 10Hz, when the circuit is in Resonance.



A 1) At resonanke frequken , $Z = R = 10\,\Omega$

2) $f_r = \dfrac{1}{2\pi\sqrt{LC}} = \dfrac{1}{2\pi\sqrt{0.1 \times 10 \times 10^{-6}}}$

$f_r = 159.15\ Hz$

3) 10 Hz above resoønant frequency = 169.15 Hz

4) 10 Hz below resonant frequency = 149.15 Hz

Q Determine the quality factor of a coil for a series circuit, consisting of $R = 10\,\Omega$, $L = 0.1\,H$, $C = 10\,\mu F$

A $R = 10\,\Omega$

$L = 0.1\,H$

$C = 10\,\mu F$

Quality factor $= \dfrac{f_r}{B.W} = \dfrac{\text{resonant frequency}}{\text{Band width.}}$

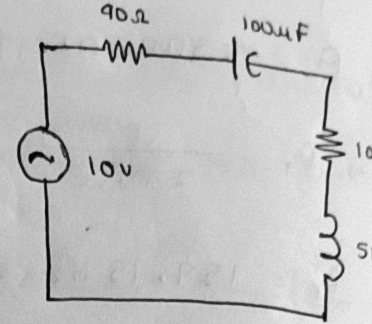
$f_r = \dfrac{1}{2\pi\sqrt{LC}} = \dfrac{1}{2\pi\sqrt{0.1 \times 10 \times 10^{-6}}} = 159.15\ Hz$

$B.W = \dfrac{R}{2\pi L} = \dfrac{10}{2\pi(0.1)} = 15.9\ Hz$

Quality factor $= \dfrac{159.15\ Hz}{15.9\ Hz} = \boxed{10}$

Q For the circuit, shown in figure, Determine Q at resonance and determine Band width of the circuit. {Q is quality factor}

$$Q = \frac{f_r}{BW}$$



$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

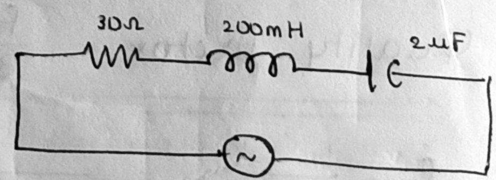
$$= \frac{1}{2\pi\sqrt{5 \times (100\times10^{-6})}}$$

$$= \cancel{7.183\ Hz} \quad \{ f_r = 7.117\ Hz \}$$

$$Q = \frac{X_L}{R} = \frac{2\pi f L}{R} = \frac{2\pi(7.117)(5)}{100}$$

$$\boxed{Q = 2.23} \rightarrow B.W = \frac{f_r}{Q} = \frac{7.117}{2.23} = \boxed{3.18\ Hz}$$

Q For the circuit shown in figure, determine resonant frequency, Band width, quality factor, impedance at resonance, maximum current in the circuit



A) 1) Resonant frequency

$$F_1 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{20\times10^{-3}\times2\times10^{-6}}} = 796.17\ Hz$$

2) Band width

$$\text{Band width} = \frac{R}{2\pi L} = \frac{30}{2\pi(20\times10^{-3})} = 238.85$$

3) Quality.

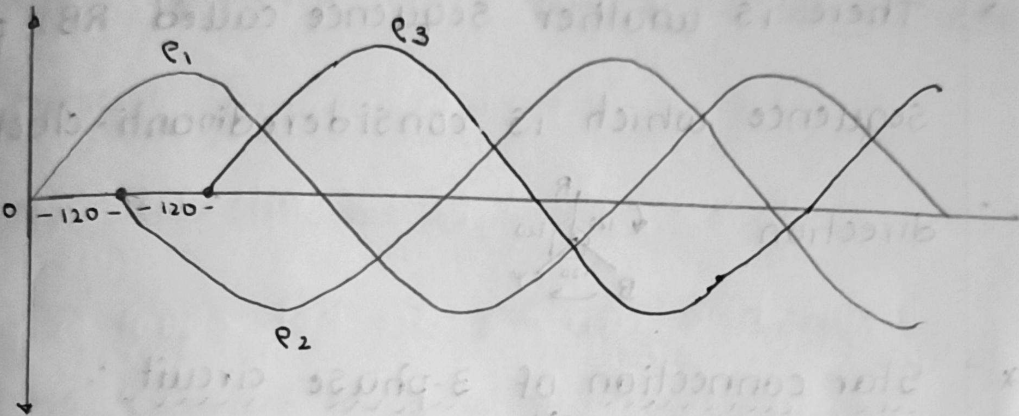
$$Q = \frac{Fr}{B.W} = \frac{796.17}{238.85} = 3.33$$

4) Impedance at resonance

$z = 30\Omega$

5) Current in the circuit $I = 90/30 = 3A$

Three phase circuits



we have $e_1 = e_m \sin\omega t$

$$e_2 = e_m \sin(\omega t - 120)$$

$$e_3 = e_m \sin(\omega t - 240)$$

The difference (ϕ difference) between each wave (here) is 120 "electrical degrees".

{These waves can be different currents wave}

i.e → $i_1 = i_m \sin\omega t$

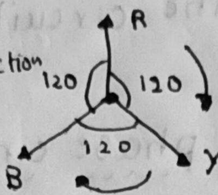
$$i_2 = i_m \sin(\omega t - 120)$$

$$i_3 = i_m \sin(\omega t - 240)$$

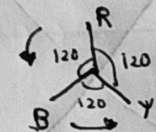
* Generally in three phase circuits, we use a sequence called RYB phase sequence which is used to calculate the different parameters of

Three phase circuits. RYB sequence is consid-

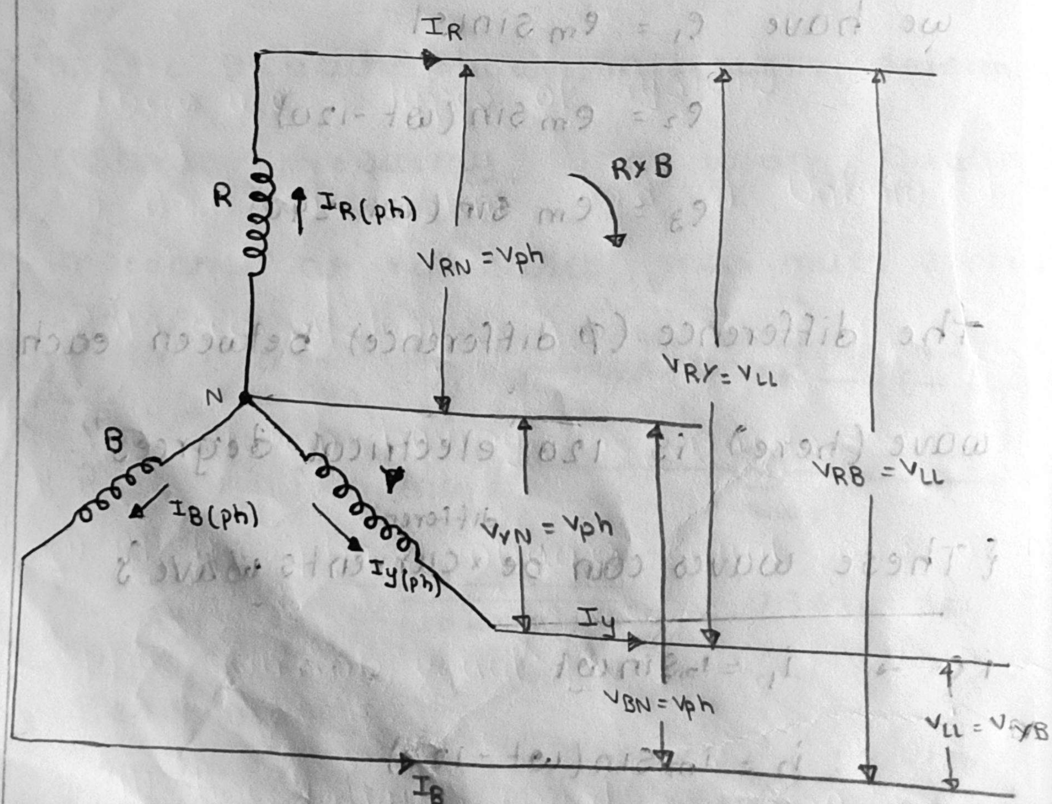
-d in clockwise direction



* There is another sequence called RBY phase sequence which is considered in anti-clockwise direction



* Star connection of 3-phase circuit :-



Neutral point(N): A point is said to be neutral when its electrical potential is zero. and also it is a point which joins all 3 conductors in a star.

Line voltage: (V_{LL}) The voltage between two conductors is known as line current (V_{LL})

phase voltage (V_{ph}):- The voltage between the main conductor and neutral is called phase current (V_{ph}).

* The current in R-phase is $I_{R(ph)}$
* The current in Y-phase is $I_{Y(ph)}$
* The current in B-phase is $I_{B(ph)}$

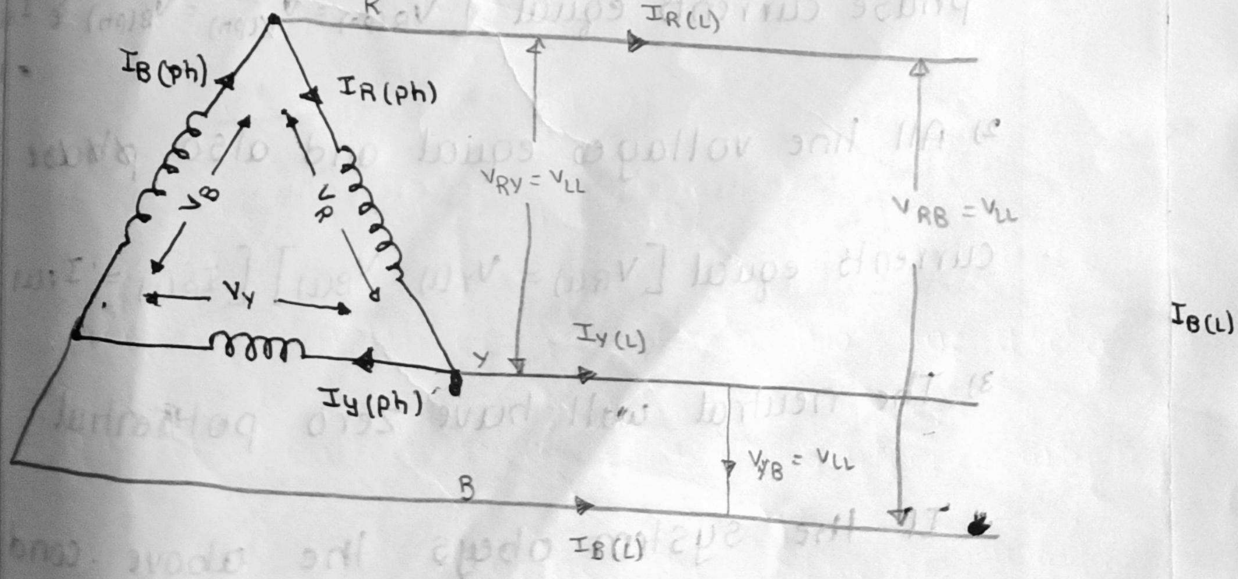
* In star connection of 3-phase circuit, we have

→ line currents = phase currents {only for balanced systems}

i.e $I_L = I_{ph}$

→ But phase voltages are not equal to line voltages.

* Delta connection of 3-phase circuit:



* Current through line of R phase is $I_{R(L)}$

* Current through line of Y phase is $I_{Y(L)}$

* Current through line of B phase is $I_{B(L)}$

* In delta connection of 3-phase connection ~~is~~,

we have {only for balanced system}

→ Line voltages = phase voltages $\{V_L = V_{ph}\}$

→ But line currents are not equal to phase currents.

* There are 2 types of systems

1) Balanced system and 2) Unbalanced system.

→ Balanced system :-

The system having the conditions.

1) All the phase voltages equal and also phase currents equal $[V_{R(ph)} = V_{Y(ph)} = V_{B(ph)}$ & $I_{R(ph)} = I_{Y(ph)} = I_{B(ph)}]$

2) All line voltages equal and also ~~phase~~ line currents equal $[V_{R(L)} = V_{Y(L)} = V_{B(L)}]$ $[I_{R(L)} = I_{Y(L)} = I_{B(L)}]$

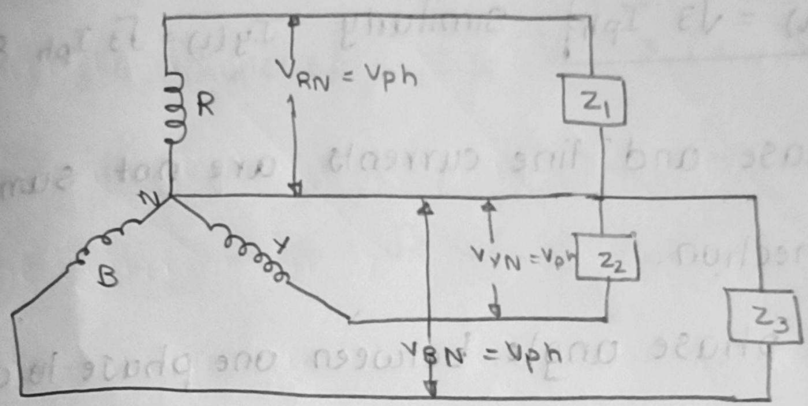
3) The neutral will have zero pothential.

* If the system obeys the above conditions

then the system is known as Balanced system.

* **Note**: The balanced system should also have equal amount of pow loads, on each phase.

i.e $z_1 = z_2 = z_3$ orelse it is unbalanced



~~Each phase gives same magnitude of voltage~~

Unbalanced system:

The loads of each phase are not equal

$z_1 \neq z_2 \neq z_3$, then it is unbalanced.

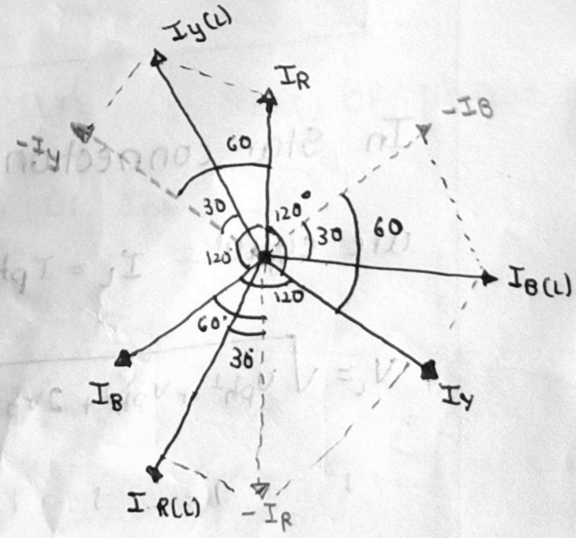
→ In delta connection, line voltages are equal to ~~bal~~ phase voltages $\{V_L = V_{ph}\}$

* In delta connection.

$I_{R(L)} = I_{B(ph)} - I_{R(ph)}$

$I_{Y(L)} = I_{R(ph)} - I_{Y(ph)}$

$I_{B(L)} = I_{Y(ph)} - I_{B(ph)}$



$$I_{R(L)} = \sqrt{I_{R(ph)}^2 + I_{B(ph)}^2 + 2 I_{R(ph)} I_{B(ph)} \cos 60}$$

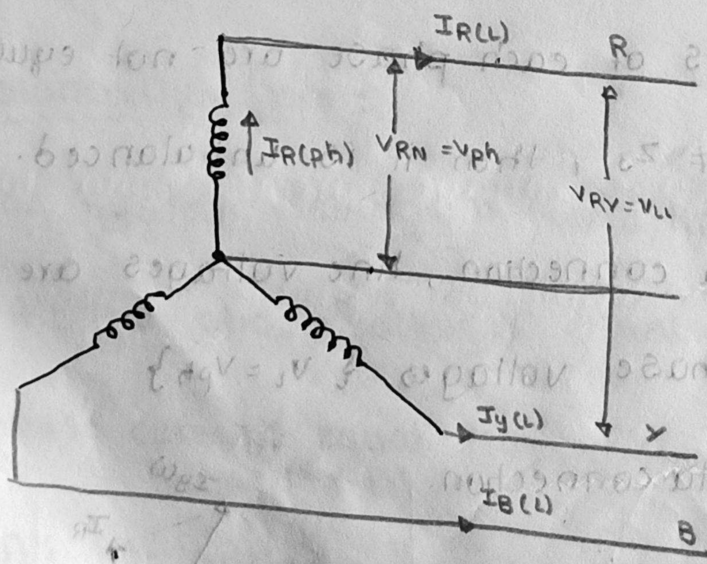
For a balanced supply $I_{R(ph)} = I_{Y(ph)} = I_{B(ph)} = I_{ph}$

$$I_{R(L)} = \sqrt{I_{ph}^2 + I_{ph}^2 + 2 I_{ph}^2 \cos 60}$$

$\boxed{I_{R(L)} = \sqrt{3}\, I_{ph}}$ similarly $I_{Y(L)} = \sqrt{3}\, I_{ph}$ & $I_{B(L)} = \sqrt{3}\, I_{ph}$

phase and line currents are not same in delta connection.

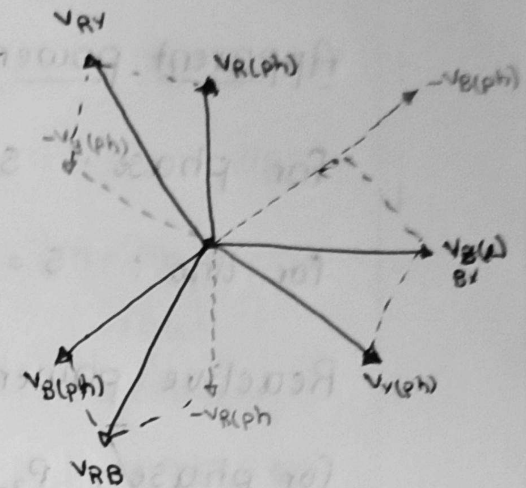
* The phase angle between one phase to other phase is 120° and the phase angle between a phase and its line called 30°



In star connection line currents and phase currents are equal. $I_L = I_{ph}$

$$V_L = \sqrt{V_{ph}^2 + V_{ph}^2 + 2V_{ph}^2 \cos 60}$$

$$V_L = \sqrt{V_{ph}^2 + V_{ph}^2 + 2V_{ph}^2 \cos 60}$$



$$V_L = \sqrt{3}\, V_{ph}$$

$$P = 3 V_{ph} I_{ph} \cos\phi$$

* Power for 3-phase

$$P = 3 V_{ph} I_{ph} \cos\phi$$

* Power for line

$$P = 3 V_L \frac{I_L}{\sqrt{3}} \cos\phi = \sqrt{3} V_L I_L \cos\phi$$

Note-1 :

In 3-phase star connected system, line currents are equal to phase currents i.e $I_L = I_{ph}$ where as the line voltages are $\sqrt{3}$ times of phase voltages ($V_L = \sqrt{3} V_{ph}$ or $V_{ph} = \frac{V_L}{\sqrt{3}}$)

Note-2 :

In 3-phase delta connected system line voltages are equal to phase voltages ($V_L = V_{ph}$) whereas line currents are $\sqrt{3}$ times of phase currents (i.e $I_L = \sqrt{3} I_{ph}$ or $I_{ph} = \frac{I_L}{\sqrt{3}}$)

Real power

for phase : $P_{3-\phi} = 3 V_{ph} I_{ph} \cos\phi$

for line : $P_{3-\phi} = \sqrt{3} V_L I_L \cos\phi$

Apparent power :-

for phase : $S = 3 V_{ph} I_{ph}$

for line : $S = \sqrt{3}\, V_L I_L$

Reactive power:

for phase : $P_{3-\phi} = 3 V_{ph} I_{ph} \sin\phi$

for line : $P_{3-\phi} = \sqrt{3}\, V_L I_L \sin\phi$