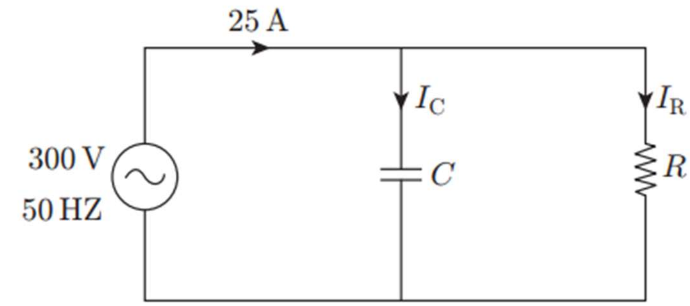
Tutorial 7

1. A circuit, having 159.23 μF capacitor in parallel with a resistance R, draws current of 25 A from a 300 V, 50 Hz mains. Using phasor relations, find the frequency (f) at which circuit draws the same current from a 360 Volts mains.



Solution-

from the ckt, we have

$$I_c = \frac{V}{Z_c}.$$

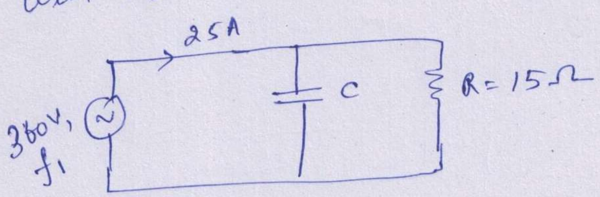
$$|I_c| = \omega C V = 300 \times 2\pi \times 50 \times 159.23 \times 10^{-6}$$

$$= 15 A$$

$$I_R = \sqrt{I^2 - I_c^2} = \sqrt{(25)^2 - (15)^2} = 20 A.$$

$$R = \frac{V_R}{I_R} = \frac{300}{20} = 15 \Omega$$

With 360 V mains, the circuit is



$$I_R = \frac{360}{15} = 24 A$$

$$|I_c| = \sqrt{25^2 - 24^2} = 7 A$$

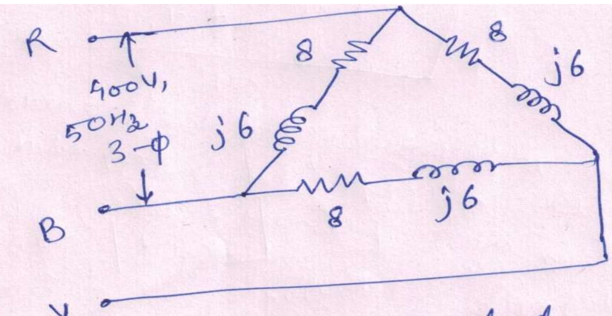
$$|I_c| = V \omega C$$

$$7 = 360 \times 2\pi \times f_1 \times 159.23 \times 10^{-6}$$

$$\boxed{f_1 = 19.4 Hz}$$

2. A balanced delta connected load of (8 + j6)Ω per phase is connected to a 400 V, 50 Hz, 3-phase supply lines. If the input power factor is to be improved to 0.9 by connecting a bank of star connected capacitors, Find required kVAR of the capacitor bank.

Solution-



Power factor angle of load

$$\phi = \tan^{-1}\left(\frac{6}{8}\right) = 36.86^\circ$$

Active power consumed by the delta connected balanced load is-:

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

$$= 3 \times 400 \times \frac{400}{\sqrt{8^2+6^2}} \times \cos 36.86 = 38400\ W$$

Reactive power consumed by Δ- connected balanced load is-:

$$Q_1 = 3 \times V_{ph} \times I_{ph} \times \sin\phi$$

$$= 3 \times 400 \times \frac{400}{\sqrt{8^2+6^2}} \times \sin 36.86$$

$$= \underline{28793.36\ VAR}$$

Active power remains same even after capacitor bank is connected. Reactive power consumed by Δ- connected load at a p.f of 0.9 will be-:

$$Q_2 = \frac{P}{0.9} \sin(\cos^{-1} 0.9)$$

$$= \frac{38400}{0.9} \times \sin(25.84)$$

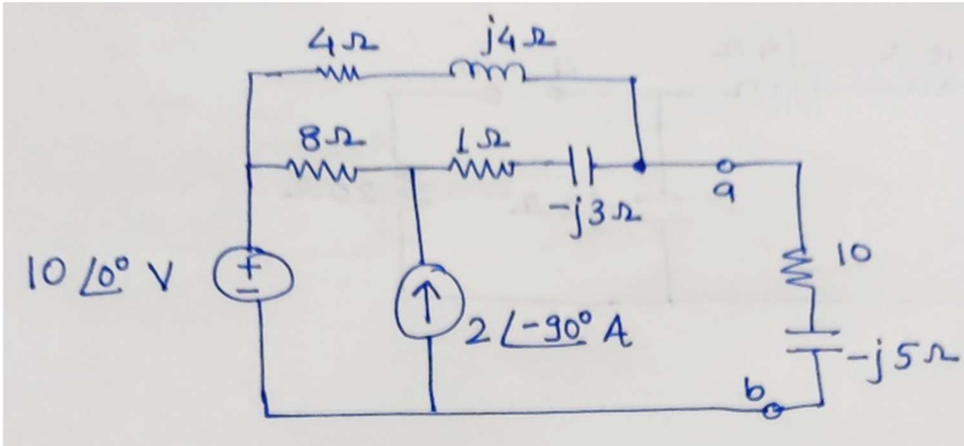
$$= 18597.96\ VAR$$

$$\therefore Q_2 = 18597.96\ VAR.$$

Reactive power supplied by Y- connected capacitor bank $= Q_1 - Q_2 = 28793.36 - 18597.96$

$$= 10195 \simeq 10.2\ KVAR$$

3. For the circuit shown, find the Norton's Equivalent between points a & b.



Solution –

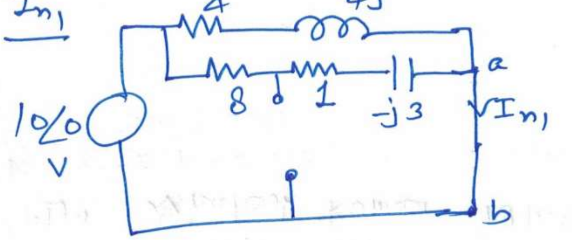
$$Z_n = (4+4j) \parallel (8+1-j3) = \frac{(4+4j)(9-j3)}{4+4j+9-j3}$$

$$Z_n = \frac{48+j24}{13+j}$$

Now,

I_n can be calculated by taking one source at a time.

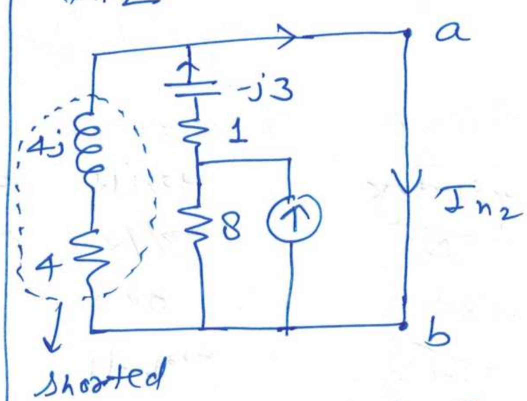
I_{n_1}



$$I_{n_1} = \frac{10\angle 0^\circ}{(4+4j)\parallel(9-j3)}$$

$$= (2.25 - 0.916j)\ A.$$

I_{n_2}



$$\therefore I_{n_2} = \frac{2\angle -90^\circ \times 8}{8+1-j3} \quad \text{(Current division)}$$

$$I_n = (0.533 - 1.6j)\ A$$

$$I_n = I_{n_1} + I_{n_2}$$

$$= 2.783 - j\,2.516\ A = 3.751\angle -42.11^\circ\ A$$

4.

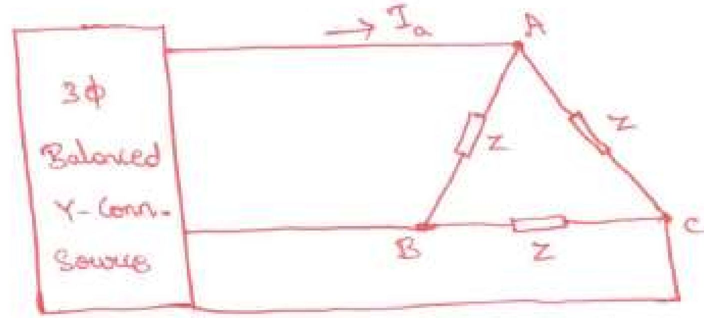
Q) A three-phase balanced Y-connected source supplies a balanced delta connected load. The impedance per phase of the delta load is $Z = 12 + j9 \, \Omega$. If the line impedance is zero and the line current in 'a' phase is $I_a = 24 \angle 16.27$ A, load voltage V_{AB} is

a) $208 \angle 83.13$ V

b) $120 \angle 83.13$ V

c) $150 \angle 53.13$ V

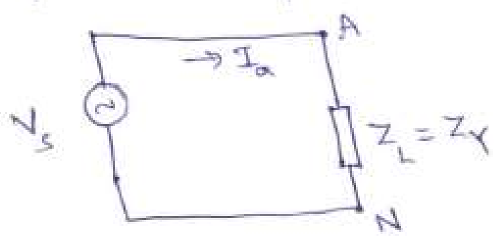
d) $208 \angle 53.13$ V



Converting delta connected load into eq. Y configuration,

$$Z_Y = \frac{Z_\Delta}{3} = \frac{12 + j9}{3} = 4 + j3 \, \Omega = 5 \angle 36.86$$

Per phase Y-Y eq. circuit,



Per phase load voltage, $V_{AN} = I_a \cdot Z_L = 24 \angle 16.27 \times 5 \angle 36.86$

$$= 120 \angle 53.13^\circ \text{ V}$$

Line voltage, $V_{AB} = \sqrt{3} \, V_{AN} \angle 30^\circ$

$$= \sqrt{3} \times 120 \angle 83.13^\circ$$

$$= 208 \angle 83.13^\circ \text{ V}$$

5.

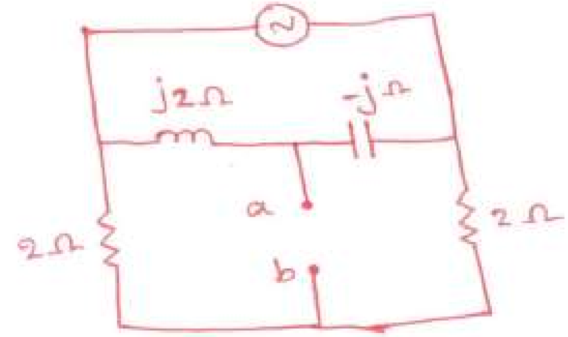
Q) What impedance Z_L should be connected between 'a' and 'b' so that a maximum average power will be absorbed by it?

a) $1 + j0\ \Omega$

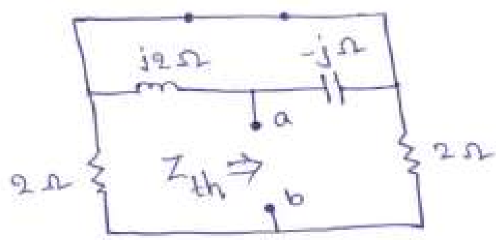
b) $4 + j2\ \Omega$

c) $4 - j2\ \Omega$

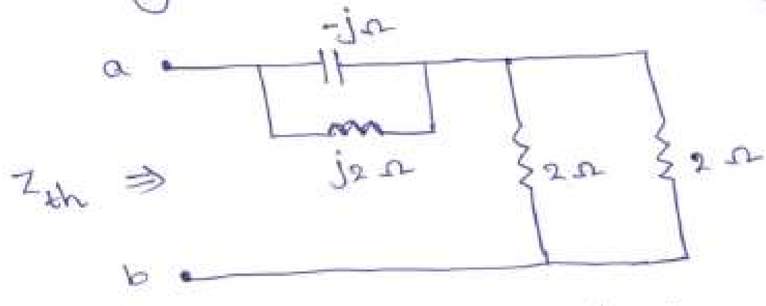
d) $1 + j2\ \Omega$



Obtain thevenin impedance from terminal a, b



Redrawing the circuit in a simpler way



$$Z_{th} = (-j \| j2) + (2 \| 2)$$

$$= 1 - j2\ \Omega$$

For maximum power transfer, $Z_L = Z_{th}^*$

$$Z_L = 1 + j2\ \Omega$$

6. Three star-connected impedances Z1 = 20+j37.7 Ω per phase are connected in parallel with three delta-connected impedances Z2 = 30-j159.3 Ω per phase. The line voltage is 398 V. Find the active power taken by the combination.

$$Z_Y = Z_1 = 20 + j37.7\,\Omega$$

$$Z_\Delta = Z_2 = 30 - j159.3\,\Omega$$

We have to convert the whole arrangement into its equivalent star config.

$$Z_{equv.} = \left(Z_1^{-1} + \left(\frac{Z_2}{3}\right)^{-1} \right)^{-1}$$

[delta to star conversion]

$$= \left(\frac{1}{20 + j37.7} + \frac{1}{10 - j53.1} \right)^{-1} \Omega = 68.37\angle 9.92^\circ\,\Omega$$

$$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{398/\sqrt{3}}{68.37\angle 9.92} = 3.36\angle -9.92\,\Omega = I_{line}$$

$$P = \sqrt{3}\, V_{Line}\, I_{line} \cos\phi = \left(\sqrt{3} \times 398 \times 3.36 \times \cos 9.92\right) W$$

$$= \underline{2281.6\ W}\ (\bar{A})$$