UNIVERSITY SOLVED QUESTIONS

1. Three inductive coils each having resistance of 16Ω and reactance of $j12\Omega$ are connected in star across a $400V$, 3ϕ , $50Hz$ supply. Calculate phase voltage. Nov. / Dec. 2012

$$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{400}{\sqrt{3}} = 230 volts$$

2. A three phase motor can be regarded as a balanced Y load. A three phase motor draws $5.6kW$, when the line voltage is $220V$ and the line current is $18.2A$. Determine the power factor of the motor. Nov. / Dec. 2012

$$P_{3-\phi} = 5.6 \text{ x } 10^3 W$$

$$V_L = 220V$$

$$I_L = 18.2A$$

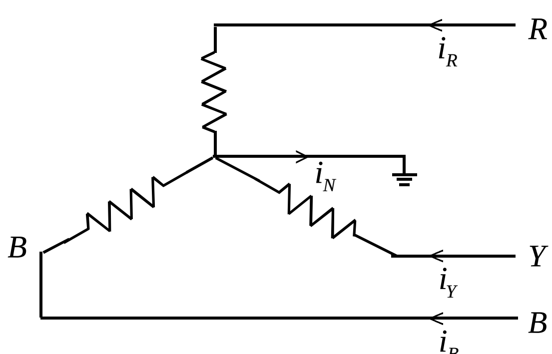
$$P_{3-phase} = \sqrt{3} V_L \cdot I_L \cdot \cos\theta = 5.6 \text{ x } 10^3$$

$$\Rightarrow \cos\theta = \frac{5.6 \text{ x } 10^3}{\sqrt{3} \text{ x } 220 \text{ x } 18.2} = 0.81$$

$$\text{Power factor } = 0.81$$

3. What is meant by neutral current ? When does it occur in a three phase star connected system?

Neutral current is the summation of all 3 line currents in a $3-\phi$ star connected load.



$$i_N = i_R + i_Y + i_B$$

Fig 5.48 Three phase load with neutral grounded

It occurs if the $3-\phi$ star connected load or $3-\phi$ source is unbalanced.

4. A three phase motor can be regarded as a balanced Y load. A three phase motor draws $5.6kW$ when the line voltage is $220V$ and the line current is $18.2A$. Determine the power factor of the motor.

$$P_{3-\phi} = \sqrt{3} \cdot V_L I_L \cdot \cos\theta$$

$$\Rightarrow Power \quad factor = \frac{P_{3-\phi}}{\sqrt{3} \cdot V_L I_L} = \frac{5.6 \text{ x } 10^3}{\sqrt{3} \cdot (220)(18.2)}$$

$$\cos\theta = 0.81$$

5. In a three phase balanced delta system, the voltage across R and Y is $400\angle 0^0 V$. What will be the voltage across Y and B ? Assume RYB phase sequence.

Voltage across Y and B

$$V_{YB} = 400\angle -120^0$$

6. Three inductive coils each having resistance of 16Ω and reactance of $j12\Omega$ are connected in star across a $400V$, 3ϕ, $50Hz$ supply. Calculate phase voltage.

$$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{400}{\sqrt{3}} = 230 volts$$

7. In the circuit shown in figure below, find the rms value of line current and phase voltage.

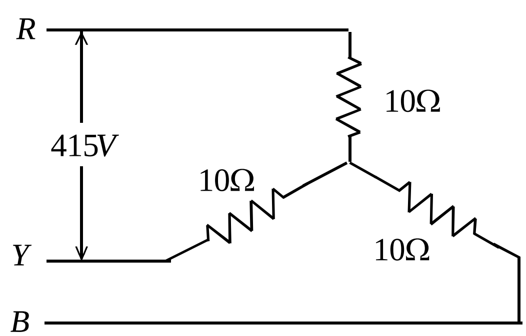


Fig 5.49 Balanced star connected load

Phase voltage $V_{ph} = \left(\frac{V_L}{\sqrt{3}}\right) = \frac{415}{\sqrt{3}} = 240V$

Phase current, $I_{ph} = \left(\frac{V_{ph}}{Z_{ph}}\right) = \frac{240}{10} = 24A$

Second Approach:

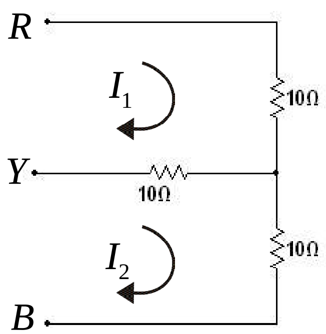


Fig 5.50

By Maxwell's mesh method, we have,

$$\begin{bmatrix} 20 & -10 \\ -10 & 20 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 415\angle 30^0 \\ 415\angle -90^0 \end{bmatrix}$$

$$\begin{bmatrix} 20 & -10 \\ -10 & 20 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 415\angle 30^0 \\ 415\angle -90^0 \end{bmatrix} = \begin{bmatrix} 360 + j207 \\ -j415 \end{bmatrix}$$

$$\Delta = \begin{vmatrix} 20 & -10 \\ -10 & 20 \end{vmatrix} = 400 - 100 = 300$$

$$\Delta I_1 = \begin{vmatrix} 360 + j207 & -10 \\ -j415 & 20 \end{vmatrix} = 20(360 + j207) - j4150 \;\; = 7200 + j4140 - j4150$$
$$= 7200 - j10$$

$$\Delta I_2 = \begin{vmatrix} 20 & 360 + j207 \\ -10 & -j415 \end{vmatrix} = -j415(20) + 10(360 + j207)$$
$$= 3600 - j6230$$

$$I_1 = \frac{\Delta I_1}{\Delta} = \frac{7200 - j10}{300} = 24 - j0.034$$

$$I_2 = \frac{\Delta I_2}{\Delta} = \frac{3600 - j6230}{300} = 12 - j20.8$$

$$I_R = 24A$$

RMS value of line current = 24A

8. In the circuit shown in figure 10, find the total power consumed by the 3ϕ load.

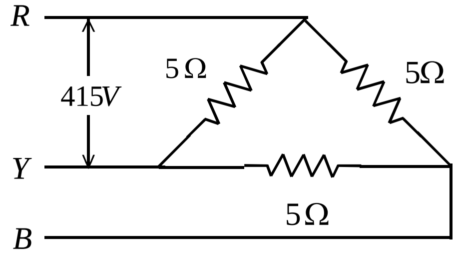


Fig 5.51 Three phase delta load

For Delta load,

$$V_{ph} = V_L; \qquad I_L = \sqrt{3} I_{ph}$$

$$I_{ph} = \frac{V_{ph}}{R} = \frac{415}{5} = 83$$

$$I_L = \sqrt{3} I_{ph} = 144A$$

$$P_{3-\phi} = \sqrt{3} \cdot V_L \cdot I_L \cdot \cos\theta$$

For a purely resistive load, $\cos\theta = 1$

$$P_{3-\phi} = \sqrt{3} \cdot (415) \cdot (144) = 103.5KW$$

9. A 3 phase 400 volts supply is given to a balanced star connected load of impedance $8 + j6$ Ohms in each branch. Find the line current.

For star connected load, $V_{ph} = \left(\frac{V_L}{\sqrt{3}}\right)$

$$I_{ph} = I_L; \qquad V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{400}{\sqrt{3}} = 230 volts$$

$$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{230}{8 + j6} = \frac{230}{10\angle 36.8} = 23\angle -36.8$$

$$I_L = 18.4 - j13.8$$

LONG ANSWERS

1. Derive the expression for the total power in a 3 phase balanced circuit using two wattmeters.The power input to a 2000V, 50 Hz, 3-phase motor is measured by two wattmeters which indicate 300kW and 100kW respectively. Calculate the input power, power factor and the line current.

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$$W_1 = 300KW \qquad W_2 = 100KW$$

Total input power $= W_1 + W_2 = 400 \text{ x } 10^3 \, watts$

(ie) $\sqrt{3} \cdot V_L \cdot I_L \cdot \cos\theta = 400 \text{ x } 10^3 \, watts$

$$\tan\theta = \sqrt{3}\left[\frac{W_2 - W_1}{W_2 + W_1}\right] = \sqrt{3}\left[\frac{300-100}{300+100}\right]$$

$$\tan\theta = 0.866$$

$$\theta = 40.89$$

Power factor $= \cos\theta = 0.76$

$$\Rightarrow I_L = \frac{400 \text{ x } 10^3}{\sqrt{3} \text{ x } 2 \text{ x } 10^3 \text{ x } 0.76} = 151.9A$$ ....(from equation (1))

$$I_L = 151.9A$$

2. If W_1 and W_2 are the readings of the two wattmeters, which measures power in the three phase balanced system and if $W_1/W_2 = a$, show that the power factor of the circuit is given by

$$\cos\theta = \frac{a+1}{2\sqrt{a^2 - a + 1}}$$

Nov. / Dec. 2011

$$\tan\theta = \frac{\sqrt{3}(W_2 - W_1)}{(W_2 + W_1)}$$ ....(1)

Dividing equation (1) by W_2, in Numerator and Denominator, we get,

$$\tan\theta = \frac{\sqrt{3}\left[1-\left(W_1/W_2\right)\right]}{\left(1+W_1/W_2\right)} = \frac{\sqrt{3}(1-a)}{1+a}$$

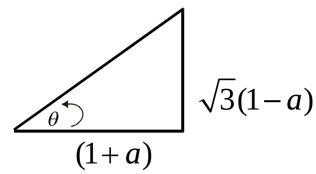

Fig 5.52

$$\tan\theta = \frac{\sqrt{3}(1-a)}{1+a} = \frac{Opp}{Adj}$$

$$hypotenus = \sqrt{\left[\sqrt{3}(1-a)\right]^2 + (1+a)^2}$$

$$= \sqrt{3(1-a)^2 + (1+a)^2} \quad = \sqrt{3(1-a^2-2a)+(1+a^2+2a)}$$

$$Hyp = \sqrt{3+3a^2-6a+1+a^2+2a}$$

$$hyp = \sqrt{(4+4a^2-4a)}\ ; \qquad hyp = \sqrt{4(1+a^2-a)} \quad = 2\sqrt{(a^2-a+1)}$$

$$\cos\theta = \frac{Adj}{hyp} = \frac{(1+a)}{2\sqrt{(a^2-a+1)}}$$

3. Determine the line currents and the total power for the unbalanced Δ - connected load shown in fig. below. A 3 phase supply, with an effective line voltage of 240V is given to the circuit.

Nov. / Dec. 2009

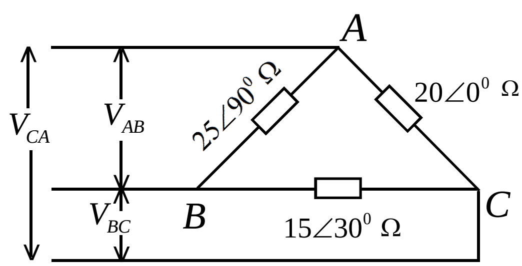

Fig 5.53 Unbalanced Delta Load

Line voltage $V_L = 240V$

for a delta connected load, $V_L = V_{ph}$

Let's find the phase currents,

$$i_{ab} = \frac{V_{ab}}{Z_{ab}} = \frac{240}{25\angle 90} = 9.6\angle -90^0 = -j9.6$$

$$i_{bc} = \frac{V_{bc}}{Z_{bc}} = \frac{240}{15\angle 30} = 16\angle -30^0 = 13.85 - j8$$

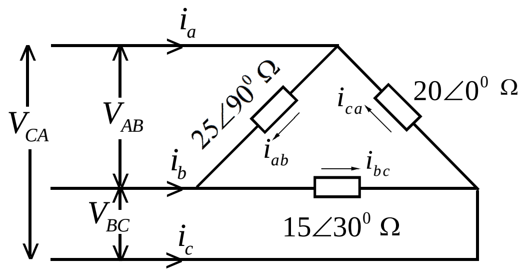

Fig 5.54 Unbalanced Delta Load

$$i_{ca} = \frac{V}{Z_{ca}} = \frac{240}{20\angle 0} = 12\angle 0 = 12$$

$$i_a = i_{ab} - i_{ca} = -j9.6 - 12$$

$$i_a = i_{ab} - i_{ca} = -j9.6 - 12 = -12 - j9.6 = 15.36\angle -141^0$$

$$i_b = i_{bc} - i_{ab} = 13.85 - j8 + j9.6 = 13.85 + j1.6 = 13.94\angle 6.6^0$$

$$i_c = i_{ca} - i_{bc} = 12 - 13.85 + j8 = -1.85 + j8 = 8.2\angle 103^0$$

$$Z_{ab} = 25\angle 90^0 = j25$$

$$Z_{bc} = 15\angle 30^0 = 13 + j7.5$$

$$Z_{ca} = 20\angle 0^0 = 20$$

$$P_{3-\phi} = I^2 R = (16)^2 (13.8) + (12)^2 20 = 6412.8W = 6.42KW$$

4. Two wattmeters are connected to measure the power in a 3ϕ, 3 wire balanced load. Determine the total power and power factor, if the two wattmeters read (1) 1000W each, both positive (2) 1000W each, of opposite sign. June 2010

$$W_1 = V_L I_L \cos(30 + \theta)\ ; \qquad W_2 = V_L I_L \cos(30 - \theta)$$

When $W_1 = W_2$ and both are positive $\Rightarrow \theta = 0^0$;

(ie) power factor $= \cos\theta = \cos 0 = 1$

Total power = $W_1 + W_2 = 2000$

When $W_1 = -W_2$ (ie) wattmeter readings are equal and opposite, we have, $W_1 + W_2 = 0$ and $\theta = 90^0$

(ie) power factor = $\cos\theta = \cos 90 = 0$

Total power = $W_1 + W_2 = 0$

5. Determine the line currents for the unbalanced delta connected load shown in fig. (ii) phase sequence is RYB. June 2010

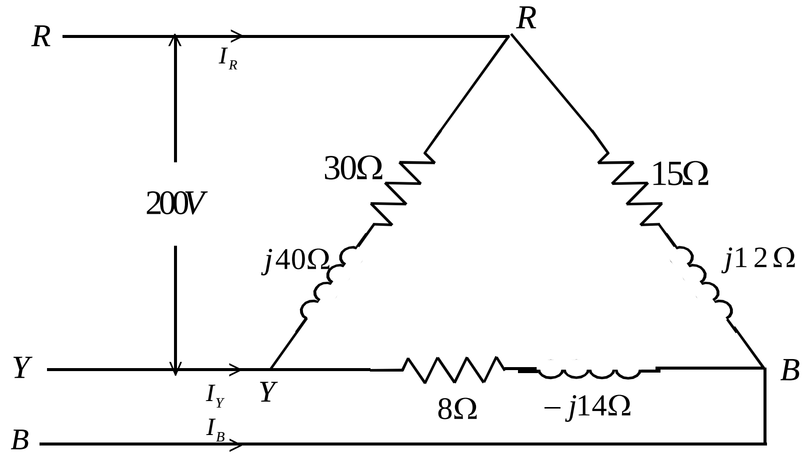

Fig 5.55 Unbalanced delta load

Let's find the phase current I_{RY}, I_{YB} and I_{BR}

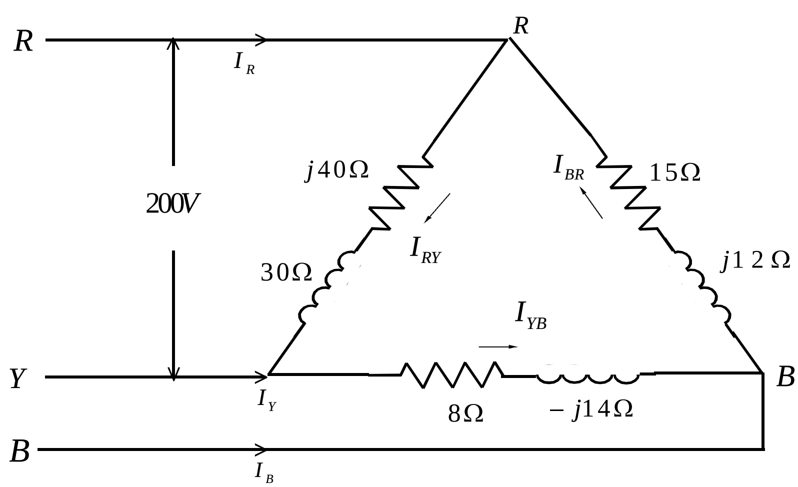

Fig 5.56 Unbalanced delta load

$$I_{RY} = \frac{V_{RY}}{Z_{RY}} = \frac{200\angle 0^0}{30 + j40} = 2.4 - 3.2j$$

$$I_{YB} = \frac{V_{YB}}{Z_{YB}} = \frac{200\angle -120^0}{8 - j14} = \frac{(-100 - j173.2)}{(8 - j14)} = 6.25 - 10.7j$$

$$I_{BR} = \frac{V_{BR}}{Z_{BR}} = \frac{200\angle +120^0}{15 + j12} = \frac{-100 + j173.2}{15 + j12} = 1.57 + 10.3j$$

Let's find the line currents now,

$$I_R = I_{RY} - I_{BR} = 0.83 - 13.5j$$

$$I_Y = I_{YB} - I_{RY} = 3.85 - 7.5j$$

$$I_B = I_{BR} - I_{YB} = -4.68 + j21$$

NOTE: For the analysis of 3ϕ unbalanced load, voltage phasors must be used to find current phasors.

6. Determine the line current, power factor and total power, when a 3-phase 400V supply is given to a balanced load of impedance $(8 + j6)\Omega$ in each branch is connected in Star. Nov. / Dec. 2010

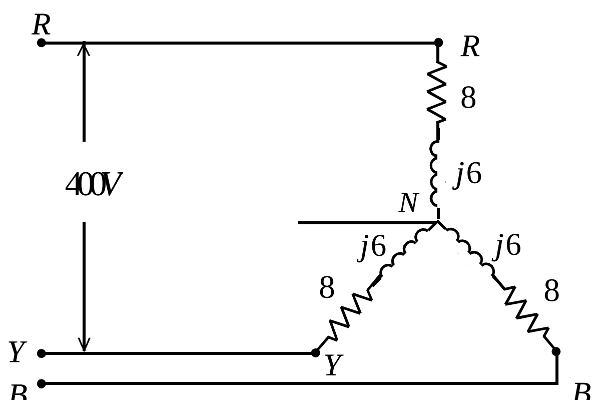

Fig 5.57 Balanced star load

For a Star connected load,

$$V_{ph} = \left(\frac{V_L}{\sqrt{3}}\right) = \frac{400}{\sqrt{3}} = 230V$$

$$I_{ph} = I_L$$

$$I_L = I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{230.94}{8 + j6} = 18.48 - j13.86$$

$$I_{ph} = 23.1\angle -36.9$$

$$pf = \cos\theta = \frac{Adj}{hyp} = \left(\frac{8}{10}\right) = 0.8$$

$$P_{3-\phi} = I^2 \text{R x } 3 = (23.1)^2 (8)(3) = 12.8KW$$

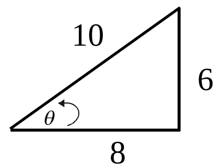

Fig 5.58

7. A three phase four-wire $120V$ ABC system feeds an unbalanced Y-connected load with $Z_A = 5\angle 0^0 \Omega$, $Z_B = 10\angle 30^0 \Omega$ and $Z_C = 20\angle 60^0 \Omega$. Obtain the four line currents.

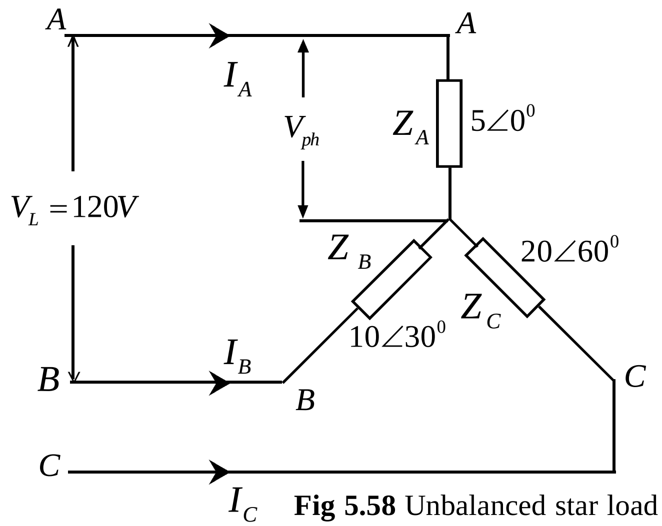

Fig 5.58 Unbalanced star load

$$Z_A = 5\angle 0^0 = 5; \qquad Z_B = 10\angle 30^0 = 8.66 + j5$$

$$Z_C = 20\angle 60^0 = 10 + j17.32$$

This is an analysis of $3-\phi$ unbalanced load, and hence voltage phasors must be used to find current phasors. [Voltage phasors are voltage with phase angle. Current phasors are current with phase angle].

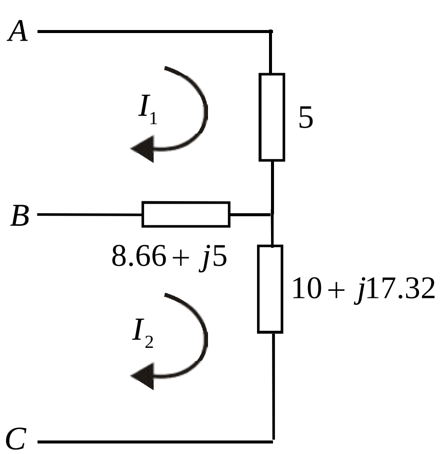

Fig 5.59 Maxwell's mesh analysis

By applying Maxwell's mesh equation, we have,

$$\begin{bmatrix} 13.66 + j5 & -(8.66 + j5) \\ -(8.66 + j5) & 18.66 + j22.32 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} V_{AB} \\ V_{BC} \end{bmatrix}$$

$$= \begin{bmatrix} 120\angle 30^0 \\ 120\angle -90^0 \end{bmatrix} = \begin{bmatrix} 103.9 + j60 \\ 0 - j120 \end{bmatrix}$$

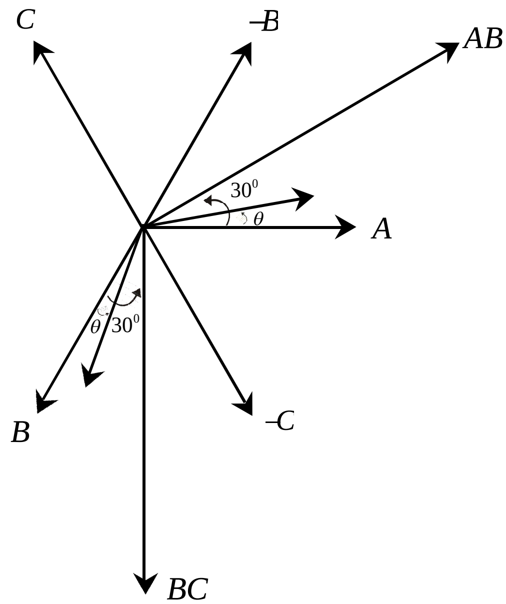

Fig 5.60 Phasor diagram

$$\Delta = \begin{vmatrix} 13.66 + j5 & -(8.66 + j5) \\ -(8.66 + j5) & 18.66 + j22.32 \end{vmatrix} = (13.66 + j5)(18.66 + j22.32) - (8.66 + j5)^2$$
$$= 143.3 + j398.2 - [50 + j86.6] = 93.3 + j311.6$$

$$\Delta I_2 = \begin{vmatrix} 13.66 + j5 & 103.9 + j60 \\ -(8.66 + j5) & -j120 \end{vmatrix} = -j(120)[13.66 + j5] + (8.66 + j5)(103.9 + j60)$$
$$= 600 - j1639.2 + 600 + j1039.1 = 1200 - j600$$

$$\Delta I_1 = \begin{vmatrix} 103.9 + j60 & -(8.66 + j5) \\ -j120 & 18.66 + j22.32 \end{vmatrix} = (103.9 + j60)(18.66 + j22.32) - j120(8.66 + j5)$$
$$= 600 + j3438.65 + 600 - j1039.2 = 1200 + j2400$$

$$\Delta I_1 = 1200 + j2400$$

$$I_1 = \frac{\Delta I_1}{\Delta} = \frac{1200 + j2400}{93.3 + j311.6} = 8.13 - j1.42$$

$$I_2 = \left(\frac{\Delta I_2}{\Delta}\right) = \frac{1200 - j600}{93.3 + j311.6} = -0.71 - j4.1$$

$$I_A = I_1 = 8.13 - j1.42$$

$$I_B = I_2 - I_1 = -0.71 - j4.1 - 8.13 + j1.42 = -8.84 - j2.7$$

$$I_C = -I_2 = 0.71 + j4.1$$

$$I_N = I_A + I_B + I_C = 0 + j0 = 0$$

The four line currents are given above.

8. Three impedance $Z_1 = (17.32 + j10)$, $Z_2 = (20 + j34.64)$ and $Z_3 = (0 - j10)$ ohms are delta connected to a $400V$, three phase system. Determine the phase currents, line currents and total power consumed by the load. Nov. / Dec. 2010 & Nov. / Dec. 2012

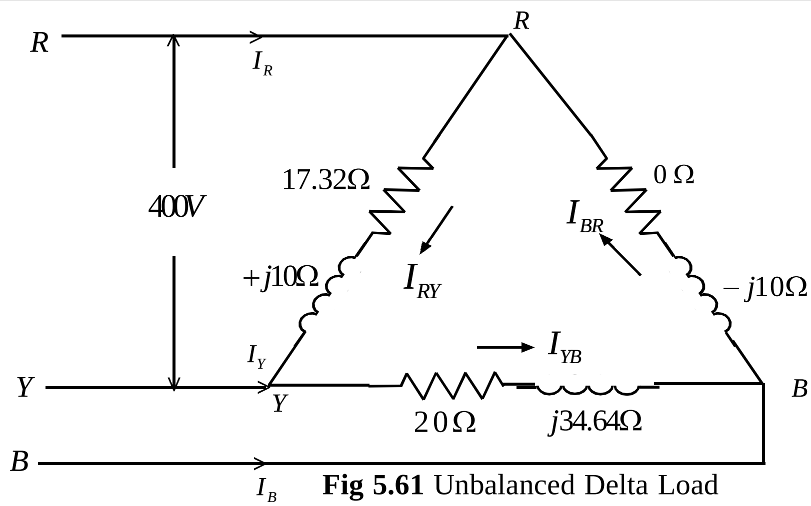

Fig 5.61 Unbalanced Delta Load

As we are analysing $3-\phi$ unbalanced load, we need to use $3-\phi$ voltage phasors [voltage with angle] to find current phasors [current with angle]

Let take "RY" as reference

$$V_{RY} = 400\angle 0; \qquad V_{YB} = 400\angle -120^0; \qquad V_{BR} = 400\angle +120^0$$

$$I_{RY} = \frac{V_{RY}}{Z_{RY}} = \frac{400\angle 0}{20\angle 30} = 20\angle -30^0 = 17.32 - j10$$

$$Z_{RY} = 17.32 + j10 = 20\angle 30$$

$$Z_{YB} = 20 + j34.64 = 40\angle 60$$

$$Z_{BR} = -j10 = 10\angle -90$$

$$I_{YB} = \frac{V_{YB}}{Z_{YB}} = \frac{400\angle -120}{40\angle 60} = 10\angle -180 = -10$$

$$I_{BR} = \frac{V_{BR}}{Z_{BR}} = \frac{400\angle +120}{10\angle -90} = 40\angle +210 = -34.6 - j20$$

$$I_R = I_{RY} - I_{BR} = 31.92 - j10$$

$$I_Y = I_{YB} - I_{RY} = -27.32 + j10$$

$$I_B = I_{BR} - I_{YB} = -24.6 - j20$$

Total power consumed by the $3-\phi$ load, $P_{3-\phi} = (20)^2(17.32) + (10)^2(20) + 0$

$$P_{3-\phi} = 8928W$$

9. Obtain readings of two wattmeters connected to a three-phase three wire $120V$ system feeding a balanced Δ-connected load with a load impedance of $12\angle 30^0\,\Omega$. No.v / Dec. 2011

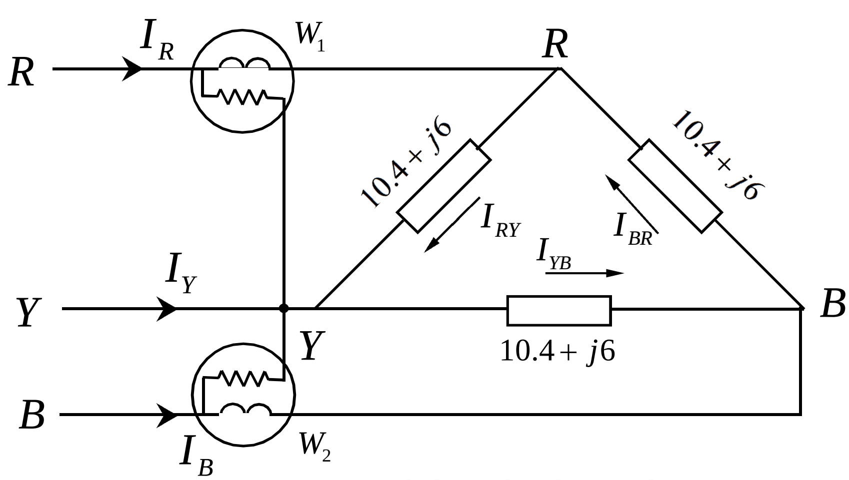

Fig 5.62 Unbalanced Delta Load

$W_1 = V_L I_L \cos(30+\theta)$; $W_2 = V_L I_L \cos(30-\theta)$

$I_{ph} = \frac{V_{ph}}{Z_{ph}}$ (In Delta connection $V_L = V_{ph}$)

$I_{ph} = \frac{120}{10.4 + j6} = 8.66 - j5 = 10\angle -30$

$I_L = \sqrt{3} I_{ph} = 17.32 \angle -30^0$

$V_L = 120$

$3-\phi$ power , $P_{3-\phi} = \sqrt{3} V_L I_L \cos\theta = \sqrt{3}(120)(17.32)\cos 30 = 3.12KW$

$W_1 = V_L I_L \cos(30+\theta) = 120 \text{ x } 17.32 \text{ x } \cos 60 = 1039.2W$

$W_2 = V_L I_L \cos(30-\theta) = 120 \text{ x } 17.32 \text{ x } \cos 0 = 2078.4$

(ie) $W_1 + W_2 = P_{3-\phi} = 3.12KW$

10. A balanced Δ -connected load has one phase current $I_{BC} = 2\angle -90^0 A$. Find the other phase current and the three line currents if the system is an ABC system. If the line voltage is $100V$, what is the load impedance? April / May 2011

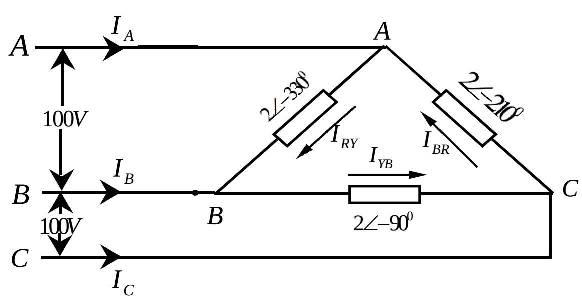

Fig 5.63 Unbalanced delta load

Since it is a balanced load, the phase current and line currents are equally displaced.

$I_{BC} = 2\angle -90 = -j2$

$I_{CA} = 2\angle(-90-120) = 2\angle -210 = -1.73 + j1$

$I_{AB} = 2\angle -330 = 1.73 + j1$

Let's take V_{AB} as reference (ie) $V_{AB} = 100\angle 0^0$ ($\because$ for delta $V_L = V_{ph}$)

$$I_{AB} = \frac{V_{AB}}{Z_{AB}}; \quad \Rightarrow Z_{AB} = \frac{V_{AB}}{I_{AB}} = \frac{100\angle 0^0}{2\angle -330^0}$$

$$Z_{AB} = 50\angle +330^0 = (43.3 - j25)$$

$$Z_{AB} = Z_{BC} = Z_{CA} = 43.3 - j25$$

$$I_L = I_A = I_B = I_c = \sqrt{3} I_{ph}$$

$$I_A = I_{ab} - I_{ca} = 1.73 + j1 - (-1.73 + j1) = 3.46A$$

$$I_B = I_{bc} - I_{ab} = -j2 - 1.73 - j1 = -1.73 - j3 = 3.46\angle 240 = 3.46\angle -120$$

$$I_C = 3.46\angle 120$$

11. The power consumed in a three phase balanced star connected load is $2kW$ at a power factor of 0.8 lagging. The supply voltage is $400V$, $50Hz$. Calculate the resistance and reactance of each phase. April / May 2011

$$V_L = 400; \quad f = 50Hz; \quad \cos\theta = 0.8$$

$$P_{3-\phi} = 2KW = 2000$$

$$\sqrt{3} V_L I_L \cos\theta = 2000 \qquad I_L = \frac{2000}{\sqrt{3}\cdot(400)(0.8)} = 3.6$$

$$V_L = \sqrt{3} V_{ph} \qquad \Rightarrow V_{ph} = \frac{V_L}{\sqrt{3}} \qquad V_{ph} = \frac{400}{\sqrt{3}} = 230$$

$$I_L = I_{ph}$$

$$Z_{ph} = \frac{V_{ph}}{I_{ph}} = \frac{230}{3.6} = 63.89$$

$$\cos\theta = 0.8 \qquad \Rightarrow \theta = 36.87$$

$$Z_{ph} = 63.89[\cos(36.87) + j\sin(36.87)] = 51.11 + j38.33$$

$$Z_{ph} = 51.11 + j38.33$$

12. A three phase, $220V$, $50Hz$, $11.2kW$ induction motor has a full load efficiency of 88% and draws a line current of $38A$ under full load, when connected to three phase, $220V$ supply. Find the reading on two wattmeters connected in the circuit to measure the input to the motor. Determine also the power factor at which the motor is operating. Apr / May 2011

Input voltage $= 220V$

Output power $= 11.2KW$

$\eta = 88\%$

$I_L = 38A$

Input power $= \dfrac{output}{\eta} = \dfrac{11.2}{0.88} = 12.73KW$

$$\sqrt{3}V_L I_L \cos\theta = 12.73 \text{ x } 10^3$$

$$\cos\theta = \frac{12.73 \text{ x } 10^3}{\sqrt{3}\cdot(220)\cdot(38)} = 0.88 \qquad \Rightarrow \theta = 28.5$$

Wattmeter readings

$$W_1 = V_L I_L \cos(30-\theta) = 220 \text{ x } 38\cdot\cos(30-28.5) \quad = 8.36KW$$

$$W_2 = V_L I_L \cos(30+\theta) = (220)(38)\cdot\cos(30+28.5) \quad = 4.36KW$$

$$W_1 = 8.36KW \;; \quad W_2 = 4.36KW \;; \quad pf = 0.88$$

13. For the circuit shown below, calculate the line current, the power and the power factor. The value of R, L and C in each phase are 10Ω, $1H$ and $100\mu F$ respectively.

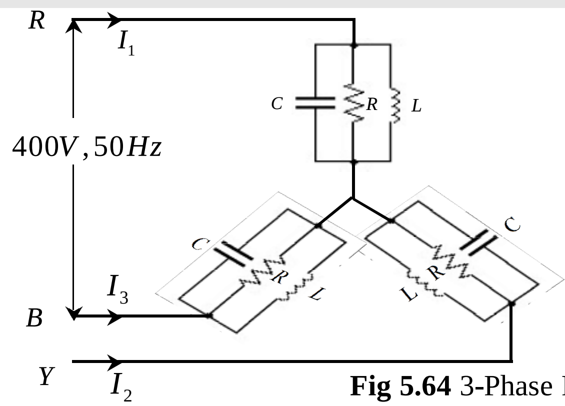

Fig 5.64 3-Phase RLC parallel load.

$$X_L = j\omega L = j2\pi fL = j2\pi(50)(1) = j314.1\Omega$$

$$X_C = \frac{1}{j\omega C} = \frac{-j}{2\pi fC} = \frac{-j}{2\pi(50)100\text{x}10^{-6}} = \frac{-j}{\pi \text{x}10^{-2}}$$

$$X_C = -j31.8\Omega$$

$$R = 10\Omega$$

$$V_{ph} = \frac{400}{\sqrt{3}} = 230V$$

$$Z_1 = 10\,||^{\ell}\; j314.1 = \frac{10\text{ x j}314.1}{10 + j314.1} = \frac{j3141}{10 + j314.1} = 9.98 + j0.318$$

Total Impedance $Z_T = Z_1 \,||^{\ell}\, (-j31.8)$

$$Z_T = (9.98 + j0.318)\,||^{\ell}\,(-j31.8) = \frac{(9.98 + j0.318)\text{ x }(-j31.8)}{9.98 + j0.318 - j31.8}$$

$$Z_T = \frac{10.112 + j(-317.4)}{9.98 - j31.5} = \frac{10.12 - j317.4}{9.98 - j31.5}$$

$$Z_T = 9.25 - j2.61$$

$$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{230}{9.25 - j2.61} = 23.1 + j6.5$$

$\because$ for Y connected load

$$V_{ph} = \frac{V_L}{\sqrt{3}} \text{ and } I_{ph} = I_L$$

$$I_L = I_{ph} = 23.1 + j6.5$$

$$\tan\theta = \frac{6.5}{23.1} = 0.28 \qquad \Rightarrow \theta = 15.71^0$$

Power factor $= \cos\theta = 0.96$

Power $= \sqrt{3}\cdot V_L \cdot I_L \cos\theta = \sqrt{3}(400)(24)\cdot(0.96) = 15.96KW$

14. A 3-phase, 3 wire 120 V RYB system feeds a Δ connected load, whose phase impedance is $30\angle 45^0\,\Omega$. Find the phase and line current in this system and draw the phasor diagram.Dec. 2012

Let's draw the diagram with the given data.

$$Z_{ph} = 30\angle 45^0 = 21.21 + j21.21$$

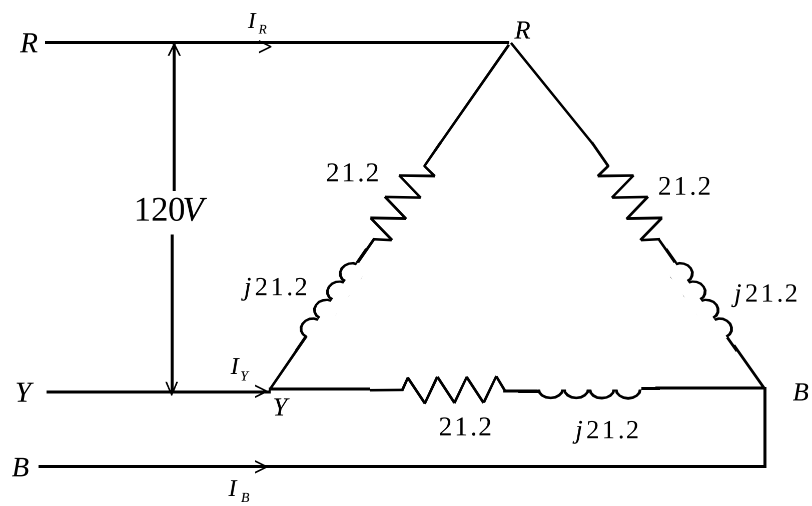

Fig 5.65 3-Phase Balanced Delta load.

For a Delta connected load

$$V_{ph} = V_L$$

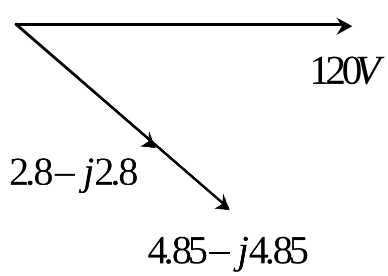

Fig 5.66 Phasor diagram

$$I_L = \sqrt{3} I_{ph}$$

$$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{120}{30\angle 45} = 4\angle -45^0 = 2.8 - j2.8$$

$$I_L = \sqrt{3}[2.8 - j2.8] = 4.85 - j4.85$$