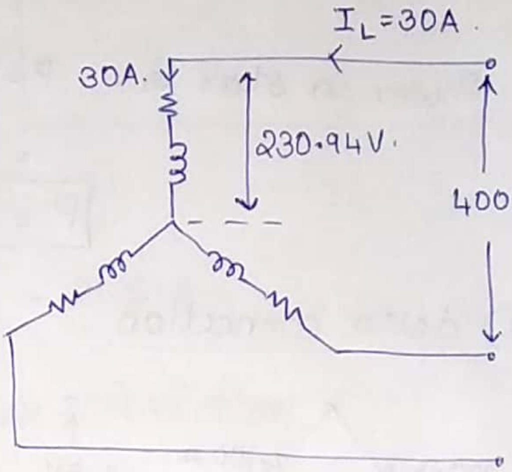
Additional Problems on 3ϕ circuits

Problems on 3ϕ circuits.

1. A balanced star-connected load is supplied from a balanced 3ϕ, 400V, 50Hz system. The current in each phase is 30A and lags 30° behind the phase voltage. Find the total power, phase voltage. Also draw the phasor diagram. What is the phase impedance?

Sol^n:



$$Z_{ph} = \frac{V_{ph}}{I_{ph}} = \frac{(V_L/\sqrt{3})}{I_{ph}}$$

$$= \frac{(400/\sqrt{3})}{30}$$

$$\Rightarrow \boxed{Z_{ph} = 7.698\,\Omega}$$

The phase voltage is

$$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{400}{\sqrt{3}} \Rightarrow \boxed{V_{ph} = 230.94V}$$

Total power is

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

$$= \sqrt{3} * 400 * 30 * \cos(30^\circ)$$

$$\boxed{P = 18kW}$$

2. Three $100\,\Omega$ resistors are connected first in star & then in delta across a 415V, 50Hz, 3ϕ supply. Calculate the line & phase currents in each & also the power taken from the source.

Sol^n:

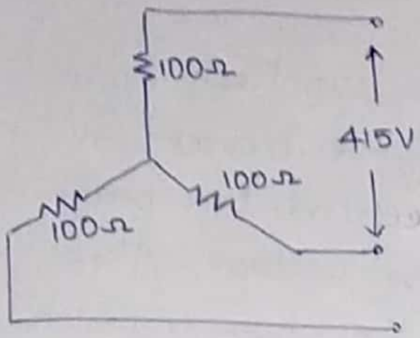
$V_L = 415V$

$f = 50Hz$

$Z_{ph} = R_{ph} = 100\,\Omega$.

$$\cos\phi = \frac{R_{ph}}{Z_{ph}} = \frac{100}{100} = 1$$

(i) Star connection



$V_{ph} = \frac{V_L}{\sqrt{3}} = 239.6V.$

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{239.6}{100}$

$\Rightarrow \boxed{I_{ph} = 2.396A}$

For star connection, $I_L = I_{ph}$.

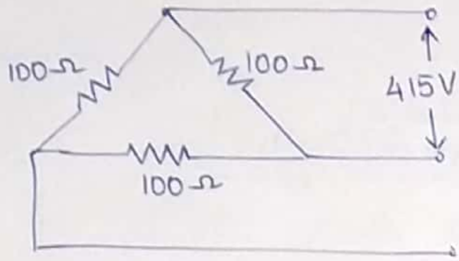
$\therefore \boxed{I_L = 2.396A}$

Power in star is, $P = \sqrt{3}\, V_L I_L \cos\phi$.

$= \sqrt{3} * 415 * 2.396 * 1$

$\boxed{P = 1722.24W}$

(ii) delta connection.



For delta connection,

$V_L = V_{ph} = 415V$

$\therefore I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{415}{100}$

$\Rightarrow \boxed{I_{ph} = 4.15A}$

$I_{ph} = (I_L/\sqrt{3}) \Rightarrow I_L = \sqrt{3}\, I_{ph} = \sqrt{3} * 4.15$

$\Rightarrow \boxed{I_L = 7.188A}$

Power in delta is, $P = \sqrt{3}\, V_L I_L \cos\phi$

$= \sqrt{3} * 415 * 7.188$

$\boxed{P = 5166.74W}$

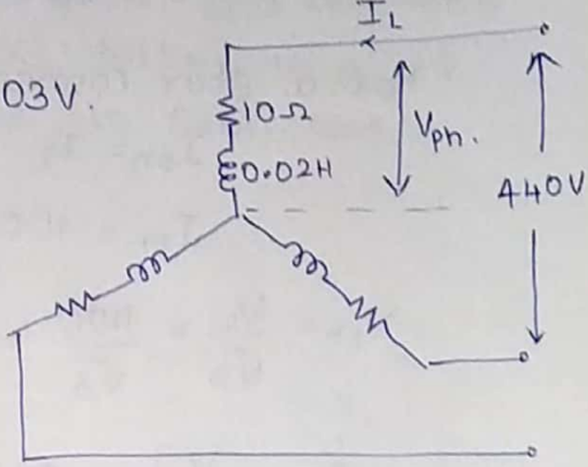
3). Three coils, each having a resistance of 10Ω and an inductance of 0.02H are connected in star across a 440V, 3φ supply. Calculate the line current and the total power consumed. At what angle does the phase current lag the phase voltage?

Sol^n:

$X_{L_{ph}} = 2\pi f L_{ph} = 2\pi * 50 * 0.02 = 6.283\Omega.$

$\phi = \tan^{-1}\left(\frac{X_L}{R}\right) = \tan^{-1}\left(\frac{6.283}{10}\right) \Rightarrow \boxed{\phi = 32.14^\circ}$

Thus, I_{ph} lags V_{ph} by $32.14°$.



Now,

$$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{440}{\sqrt{3}} = 254.03V.$$

$$Z_{ph} = \sqrt{R_{ph}^2 + X_{Lph}^2}$$

$$= \sqrt{10^2 + 6.283^2}$$

$$Z_{ph} = 11.81\,\Omega$$

∴ Phase current is,

$$I_p = \frac{V_{ph}}{Z_{ph}} = \frac{254.03}{11.81} = 21.51A.$$

Since $I_L = I_{ph}$ for star-connection,

$$\boxed{I_L = 21.51A}$$

The total power consumed is,

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

$$= \sqrt{3} * 440 * 21.51 * \cos(32.14°)$$

$$= 13880.63W$$

$$\boxed{P = 13.88kW}$$

4. A balanced 3Φ, star-connected load of 150kW takes a leading current of 100A with line voltage of 1100V, 50Hz. Find the circuit constants of the load per phase.

Solⁿ.

$$I_L = 100A$$

$$V_L = 1100V$$

$$f = 50Hz.$$

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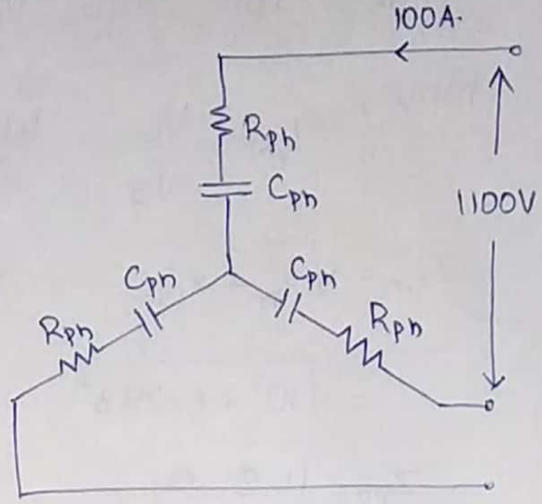
Since current is leading, each phase is a series R-C circuit.



For a star connection,

$$I_{ph} = I_L$$

$$\therefore I_{ph} = 100A.$$

$$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{1100}{\sqrt{3}} = 635.08V.$$

$$\therefore Z_{ph} = \frac{V_{ph}}{I_{ph}} = \frac{635.08}{100} = 6.351A.$$

A power of 150kW is consumed in the resistances.

$\therefore$ Power consumed by the resistances of each phase is,

$$P_{ph} = \frac{P}{3} = \frac{150}{3} = 50kW.$$

Also, $$P_{ph} = I_{ph}^2 R_{ph}$$

$$\Rightarrow R_{ph} = \frac{P_{ph}}{I_{ph}^2} = \frac{P_{ph}}{(V_{ph}/Z_{ph})^2} = \frac{50 * 10^3}{(635.08/6.351)^2}$$

$$\cancel{\Rightarrow R_{ph} = 500.015\,\Omega}.$$

$$\Rightarrow \boxed{R_{ph} = 5\,\Omega}$$

$$X_{ph} = \sqrt{Z_{ph}^2 - R_{ph}^2} = \sqrt{6.351^2 - 5^2} = 3.916\,\Omega$$

$$\Rightarrow X_{cph} = \frac{1}{2\pi f C_{ph}} = 3.916$$

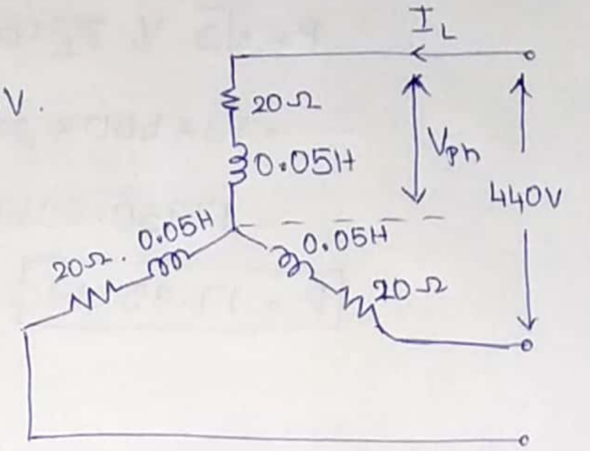
$$\Rightarrow C_{ph} = \frac{1}{2\pi f * 3.916} = \frac{1}{2\pi * 50 * 3.916}$$

$$\Rightarrow \boxed{C_{ph} = 812.84\mu F}$$

5. Three identical coils each of R = 20 Ω and L = 0.05 H are connected in (i) star, (ii) delta, to a 3ϕ, 440V, 50Hz supply. Calculate, in each case:-
(i) the line current
(ii) the total power consumed.

Solⁿ:

Star connection



$$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{440}{\sqrt{3}} = 254.03V.$$

$$Z_{ph} = \sqrt{R_{ph}^2 + X_{ph}^2}$$

$$= \sqrt{20^2 + (2\pi * 50 * 0.05)^2}$$

$$Z_{ph} = 25.431 \Omega$$

$$\therefore I_{ph} = V_{ph}/Z_{ph} = 254.03/25.431 = 9.988 A$$

Since $I_L = I_{ph}$ for star connection,

$$\boxed{I_L = 9.988 A}$$

The total power consumed is

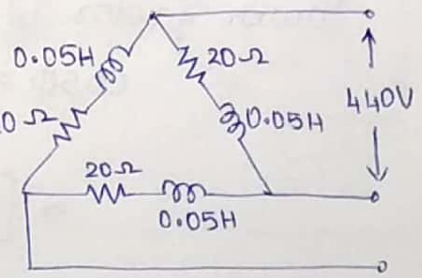
$$P = \sqrt{3} V_L I_L \cos\phi$$

$$= \sqrt{3} V_L I_L \left(\frac{R_{ph}}{Z_{ph}}\right) \qquad \because \cos\phi = R_{ph}/Z_{ph}$$

$$= \sqrt{3} * 440 * 9.988 * \frac{20}{25.431}$$

$$\boxed{P = 5986.298 W} \text{ or } \boxed{P = 5.986 kW}$$

Delta Connection



$$V_{ph} = V_L = 440V$$

$$Z_{ph} = 25.431 \Omega$$

$$\cos\phi = R_{ph}/Z_{ph} = 0.786.$$

$$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{440}{25.431} = 17.3801\ A.$$

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

$$= \sqrt{3} * 17.301$$

$$\boxed{I_L = 29.967\ A}$$

Power consumed is

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

$$= \sqrt{3} * 440 * 29.967 * 0.786$$

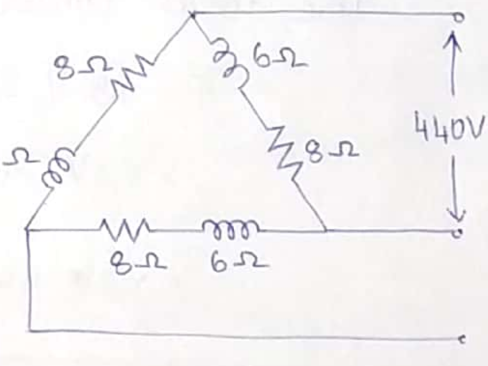
$$= 17950.60\ W$$

$$\boxed{P = 17.95\ kW}$$

6. A balanced delta connected load of $(8+j6)\ \Omega$ per phase is supplied from a 3ϕ, 440V source. Find the line current, power factor, power per phase and total power. Draw the phasor diagram.

Sol^n:

$$Z_{ph} = \sqrt{8^2 + 6^2} = 10\ \Omega$$



$$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{440}{10} = 44\ A.$$

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

$$= \sqrt{3} * 44$$

$$\boxed{I_L = 76.21\ A}$$

Power factor is

$$\cos\phi = \frac{R}{Z} = \frac{8}{10}$$

$$\Rightarrow \boxed{\cos\phi = 0.8} \Rightarrow \phi = 36.86^\circ$$

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Total power is,

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

$$= \sqrt{3} * 440 * 76.21 * 0.8$$

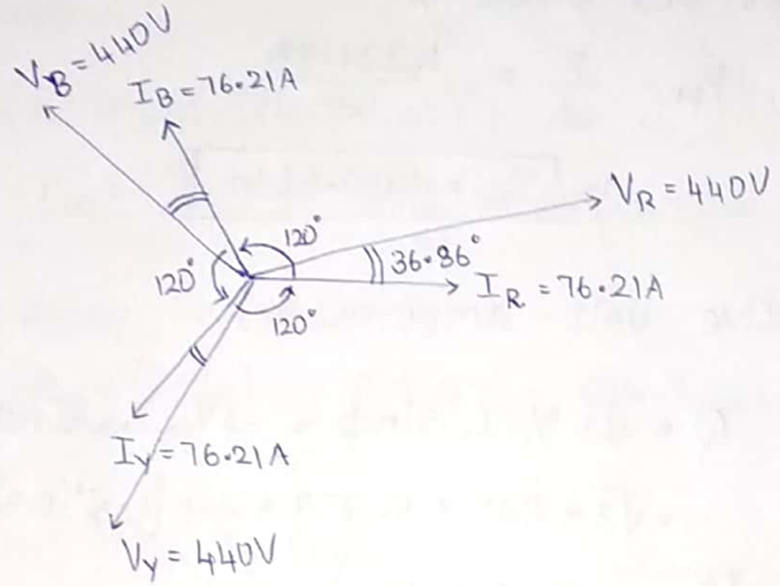
$$\boxed{P = 46463.85\ W}$$

Power per phase is,

$$P_{ph} = \frac{P}{3} = \frac{46463.85}{3}$$

$$\Rightarrow \boxed{P_{ph} = 15487.95\ W}$$

#.

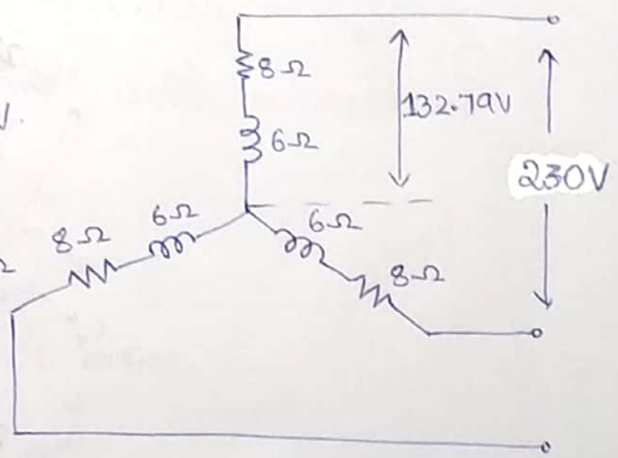


7. Repeat problem - 6 if the load is connected in star to a 3ϕ, 230V supply. Also calculate the reactive and total volt - amperes.

Sol^n.

$V_L = 230V$

$$\Rightarrow V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{230}{\sqrt{3}} = 132.79V.$$



$$Z_{ph} = \sqrt{R_{ph}^2 + X_{ph}^2} = \sqrt{8^2+6^2} = 10\Omega$$

$$\therefore I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{132.79}{10}$$

$$I_{ph} = 13.279A$$

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For star-connection, $I_L = I_{ph}$

$\therefore \boxed{I_L = 13.279\text{ A}}$

$\cos\phi = \frac{R_{ph}}{Z_{ph}} = \frac{8}{10} \Rightarrow \boxed{\cos\phi = 0.8}$

Total power is,

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

$$= \sqrt{3} * 230 * 13.279 * 0.8$$

$$\boxed{P = 4231.98\text{ W}}$$

Power per phase is

$$P_{ph} = \frac{P}{3} = \frac{4231.98}{3}$$

$$\Rightarrow \boxed{P_{ph} = 1410.66\text{ W}}$$

Reactive volt-amperes is,

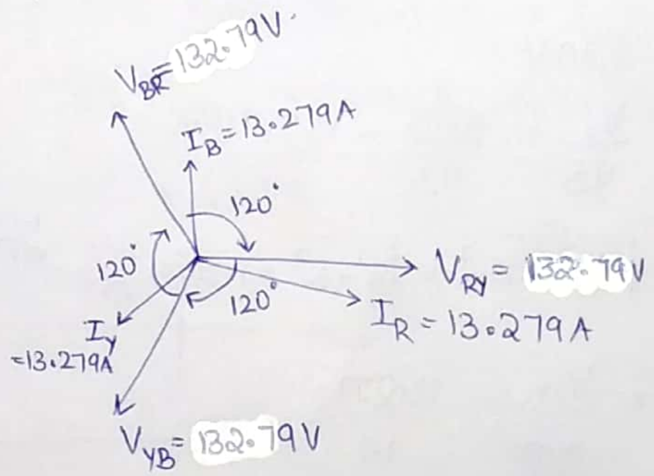
$$Q = \sqrt{3}\, V_L I_L \sin\phi = 3 V_{ph} I_{ph} \sin\phi$$

$$= \sqrt{3} * 230 * 13.279 * \sin[\cos^{-1}(0.8)]$$

$$\boxed{Q = 3173.73\text{ VAr}}$$

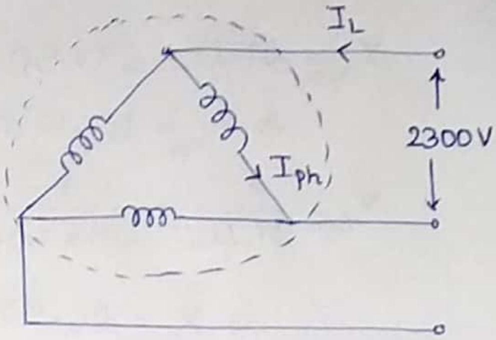
Total volt-amperes is,

$$S = \frac{P}{\cos\phi} = \frac{4231.98}{0.8} \Rightarrow \boxed{S = 5289.97\text{ VAr}}$$



8. Calculate the current flowing into each terminal & in each phase of the winding of a 3ϕ delta-connected induction motor developing an output of 250HP, at 2300V between the terminals at at power factor of 0.75 and efficiency of 85%.

Sol^n:



$V_L = 2300V$

$P_{out} = 250HP$

$\cos\phi = 0.75$

$\eta = 0.85$.

The motor input (electrical) power is,

$$P_{in} = \frac{P_{out}}{\eta} = \frac{250}{0.85} = 294.117\,HP$$

Expressing in kW,

$$P_{in} = (294.117 * 0.7457) = 219.32\,kW.$$

Now,

$$P_{in} = 3 V_{ph} I_{ph} \cos\phi$$

$$\Rightarrow I_{ph} = \frac{P_{in}}{3 V_{ph} \cos\phi} = \frac{219.32 * 10^3}{3 * 2300 * 0.75}$$

$\boxed{I_{ph} = 42.38\,A}$ .... current in each phase.

Current flowing into each terminal $= I_L$

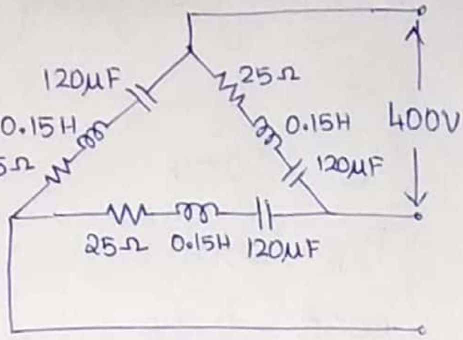
$\therefore I_L = \sqrt{3}\, I_{ph}$ ...delta connection

$\therefore I_L = \sqrt{3} * 42.38$

$\boxed{I_L = 73.4\,A}$

9. A three-phase, 400V, 50Hz AC source is feeding a three-phase delta connected load with each phase having $R = 25\Omega$, $L = 0.15H$ and $C = 120\mu F$, in series. Calculate the line current, volt-amperes, active power & reactive volt-amperes.

Sol^n:



$X_{L_{ph}} = 2\pi f L = 2\pi * 50 * 0.15$

$\Rightarrow X_{L_{ph}} = 47.12\,\Omega$

$X_{C_{ph}} = \frac{1}{2\pi f C} = \frac{1}{2\pi * 50 * 120 * 10^{-6}}$

$\Rightarrow X_{C_{ph}} = 26.525.$

$X_L > X_C$

$\therefore Z_{ph} = R_{ph} + j(X_{L_{ph}} - X_{C_{ph}}) = 25 + j(47.12 - 26.525)$

$Z_{ph} = 25 + j20.595$ $\Rightarrow \cos\phi = \frac{R_{ph}}{Z_{ph}} = \frac{25}{32.39}$

$\therefore |Z_{ph}| = \sqrt{25^2 + 20.595^2} = 32.39\,\Omega.$

$\Rightarrow \cos\phi = 0.771$

The phase current is,

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{400}{32.39} = 12.35A.$

The line current is,

$I_L = \sqrt{3}\, I_{ph} = \sqrt{3} * 12.35$

$\Rightarrow \boxed{I_L = 21.38A}$

The volt-amperes are,

$S = \sqrt{3}\, V_L I_L = \sqrt{3} * 400 * 21.38 = 14812.49VA$

$\Rightarrow \boxed{S = 14.812\,kVA}$

The active power is,

$P = \sqrt{3}\, V_L I_L \cos\phi = S\cos\phi = 14.812 * 0.771$

$\Rightarrow \boxed{P = 11.42kW}$

The reactive volt-amperes are

$Q = \sqrt{S^2 - P^2} = \sqrt{14.812^2 - 11.42^2} \Rightarrow \boxed{Q = 9.43kVAr}$

Problems on two wattmeters method.

10. The power to a 3ϕ induction motor was measured by two wattmeters method & the readings were 3400 and -1200 watts respectively. Calculate the total power & power factor.

Sol^n:

$$W_1 = 3400W$$

$$W_2 = -1200W.$$

The total power is

$$P = W_1 + W_2$$

$$= 3400 - 1200$$

$$\boxed{P = 2200W}$$

The power factor is $pf = \cos\phi$, where ϕ is

$$\phi = \tan^{-1}\left(\frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2}\right)$$

$$= \tan^{-1}\left(\frac{\sqrt{3}(-1200 - 3400)}{3400 - 1200}\right)$$

$$\phi = -74.565^\circ$$

$$\therefore\ pf = \cos\phi = \cos(-74.565)$$

$$\Rightarrow \boxed{pf = 0.266}$$

11. A 440V, 3ϕ AC motor has an output of 80HP and operates at a power factor of 0.866 with an efficiency of 90%. Calculate

i) the current in each phase of the delta connected motor

ii) the readings of the two wattmeters connected to measure to input power.

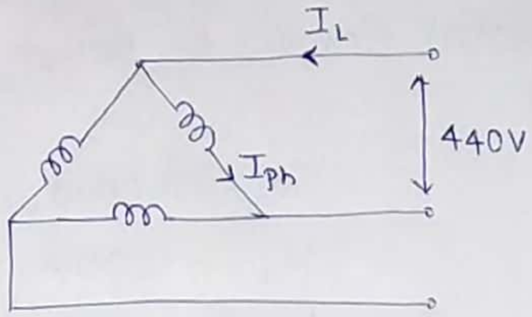
Sol^n Output power is,

$$P_{out} = 80HP = 80 * 0.7457 kW = 59.656 kW.$$

Input power is,

$$P_{in} = \frac{P_{out}}{\eta} = \frac{59.656}{0.9} = 66.28 kW. = W_1 + W_2 \longrightarrow (1)$$

Also,



$$P_{in} = \sqrt{3} V_L I_L \cos\phi$$

$$\Rightarrow I_L = \frac{P_{in}}{\sqrt{3} V_L \cos\phi}$$

$$I_L = \frac{66.28 * 10^3}{\sqrt{3} * 440 * 0.866} = 100.427 A.$$

The current in each phase is,

$$I_{ph} = I_L/\sqrt{3} = 100.427/\sqrt{3}$$

$$\Rightarrow \boxed{I_{ph} = 57.98 A}$$

Method-1 $\phi = \cos^{-1}(0.866) = 30°$

$$W_1 = V_L I_L \cos(30+\phi) = 440 * 100.427 * \cos(30+30°)$$

$$\Rightarrow \boxed{W_1 = 22.093 kW}$$

$$W_2 = V_L I_L \cos(30-\phi) = 440 * 100.427 * \cos(30-30°)$$

$$\Rightarrow \boxed{W_2 = 44.187 kW}$$

Method-2

$$\tan\phi = \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2} = \tan(30°) = 0.5773$$

$$\Rightarrow 0.5773 = \frac{\sqrt{3}(W_2 - W_1)}{66.28} \Rightarrow W_2 - W_1 = 22.079 \longrightarrow (2).$$

Solving (1) & (2), we get

$\boxed{W_2 = 44.1795 kW}$ and $\boxed{W_1 = 22.1005 kW}$

12. Two wattmeters are used to measure power in a 3ϕ balanced system. What is the power factor when

i) both meters read equal

ii) both meters read equal, but one is negative

iii) one reads twice the other.

iv) one of the meters reads zero.

Soln.

$$\text{power factor} = \cos\phi = \cos\left[\tan^{-1}\left(\frac{\sqrt{3}(\omega_2 - \omega_1)}{\omega_1 + \omega_2}\right)\right]$$

i) Given $W_1 = W_2$

$$\therefore \cos\phi = \cos\left[\tan^{-1}\left(\frac{\sqrt{3}(W_1 - W_1)}{W_1 + W_1}\right)\right] = \cos(0^\circ) = \underline{\underline{1}}$$

ii) Given $W_1 = -W_2$

$$\therefore \cos\phi = \cos\left[\tan^{-1}\left(\frac{\sqrt{3}(W_2 - (-\omega_1))}{-W_2 + W_2}\right)\right] = \cos(90^\circ) = \underline{\underline{0}}$$

(iii) Given $W_2 = 2W_1$.

$$\therefore \cos\phi = \cos\left[\tan^{-1}\left(\frac{\sqrt{3}(2W_1 - W_1)}{2W_1 + W_1}\right)\right] = \cos(30.00^\circ) = \underline{\underline{0.866}}$$

(iv) Let $W_1 = 0$.

$$\therefore \cos\phi = \cos\left[\tan^{-1}\left(\frac{\sqrt{3}(W_2 - 0)}{0 + W_2}\right)\right] = \cos(60^\circ) = \underline{\underline{0.5}}$$

13) Each of the two wattmeters connected to measure the input to a 3ϕ circuit reads 10kW on a blanced load when the power factor is unity. What does each instrumet read when the power factor falls to

(i) 0.866 lagging (ii) 0.5 lagging,

assuming the total 3ϕ power remains unchanged.

Sol^n

Case-1 :- When pf is unity

$$\cos\phi = 1 \Rightarrow \phi = 0^\circ.$$

$$\therefore \tan\phi = \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2} = \tan(0) = 0$$

$$\Rightarrow W_1 = W_2.$$

$$\therefore W_1 = W_2 = 10\,kW \text{ (given)}$$

$$\therefore W_1 + W_2 = 20\,kW$$

Case-2 :- When pf is 0.866 lagging

$$W_1 + W_2 = 20\,kW \longrightarrow (1)$$

$$\cos\phi = 0.866 \Rightarrow \phi = 30^\circ.$$

$$\tan\phi = \tan 30^\circ = 0.577 = \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2}$$

$$0.577 = \frac{\sqrt{3}(W_2 - W_1)}{20}$$

$$\Rightarrow W_2 - W_1 = 6.662 \longrightarrow (2).$$

Solving (1) & (2), we get

$\boxed{W_2 = 13.331\,kW}$ and $\boxed{W_1 = 6.67\,kW}$

Case-3 :- When pf is 0.5 lagging

$$W_1 + W_2 = 20\,kW \longrightarrow (1).$$

$$\cos\phi = 0.5 \Rightarrow \phi = 60^\circ.$$

$$\therefore \tan\phi = \tan 60 = 1.732 = \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2}$$

$$\Rightarrow 1.732 = \frac{\sqrt{3}(W_2 - W_1)}{20}$$

$$\Rightarrow W_2 - W_1 = 20 \longrightarrow (3)$$

Solving (1) and (3), we get

$\boxed{W_1 = 0\,kW}$ and $\boxed{W_2 = 20\,kW}$

14. Two wattmeters connected in a balanced system indicate 4.5kW and −0.5kW. What is the total power and power factor of the circuit.

Solⁿ:

$$W_1 = -0.5\,kW$$

$$W_2 = 4.5\,kW.$$

Total power in the circuit,

$$P = W_1 + W_2$$

$$= -0.5 + 4.5$$

$$\boxed{P = 4\,kW}$$

$$\tan\phi = \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2} = \frac{\sqrt{3}[4.5 - (-0.5)]}{4.5 - 0.5} = 2.165$$

$$\Rightarrow \phi = 65.208^\circ.$$

∴ Power factor is

$$pf = \cos\phi = \cos(65.208)$$

$$\Rightarrow \boxed{pf = 0.4193}$$

15. A 3ϕ, star-connected load draws a line current of 25A. The load kVA and kW are 20 and 16 respectively. Find the readings on each of the two wattmeters used to measure the three-phase power.

Solⁿ:

$$kVA = 20$$

$$kW = 16.$$

$$kW = kVA * \cos\phi \Rightarrow \cos\phi = \frac{kW}{kVA} = \frac{16}{20} = 0.8$$

$$\therefore \phi = 36.87^\circ.$$

Since kW i.e. active power is 16,

$$\Rightarrow W_1 + W_2 = 16. \longrightarrow (1)$$

$$\tan\phi = \tan(36.87^\circ) = \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2}$$

$$0.75 = \frac{\sqrt{3}(W_2 - W_1)}{16}$$

$$\Rightarrow W_2 - W_1 = 6.928 \longrightarrow (2)$$

Solving (1) & (2), we get

$$2W_2 = 22.928$$

$$\Rightarrow \boxed{W_2 = 11.464 \text{ kW}}$$

Substituting in (2),

$$W_1 = 11.464 - 6.928$$

$$\Rightarrow \boxed{W_1 = 4.536 \text{kW}}$$

16. If the readings on the two wattmeters in a 3ϕ balanced load are 836W and 224W, the latter reading being obtained after the reversal of the current coil connections, calculate the power & power factor of the load.

Sol^n:

$W_2 = 836\text{W}$

$W_1 = -224\text{W}$ (as it is obtain after current coil connections are reversed)

$$\therefore \tan\phi = \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2} = \frac{\sqrt{3}(836 + 224)}{836 - 224} = 3$$

$$\Rightarrow \phi = 71.56^\circ$$

$\therefore$ Power factor is,

$$pf = \cos\phi$$

$$= \cos(71.56^\circ)$$

$$\boxed{pf = 0.316}$$

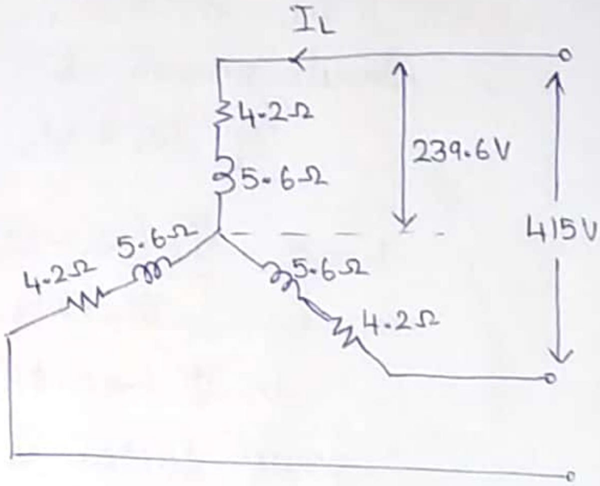
Total power is

$$P = W_1 + W_2 = 836 - 224$$

$$\Rightarrow \boxed{P = 612W}$$

17. Each branch of a 3ϕ, star-connected load consists of a coil with $R = 4.2\Omega$ and $X = 5.6\Omega$. The load is supplied by a line voltage of 415V, 50Hz. The total power supplied by the load is measured using two wattmeters. Find their readings.

Sol^n:



$$Z_{ph} = \sqrt{4.2^2 + 5.6^2} = 7\Omega.$$

$$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{(V_L/\sqrt{3})}{Z_{ph}}$$

$$= \frac{(415/\sqrt{3})}{7}$$

$$I_{ph} = 34.23\,A$$

$$I_L = I_{ph} = 34.23\,A.$$

$$\cos\phi = \frac{R_{ph}}{Z_{ph}} = \frac{4.2}{7} = 0.6 \Rightarrow \phi = 53.13^\circ$$

$\therefore$ Total power is,

$$P = \sqrt{3}\, V_L I_L \cos\phi = \sqrt{3} * 415 * 34.23 * 0.6$$

$$\Rightarrow P = 14762.74W.$$

If two wattmeters are used to measure power, then $W_1 + W_2 = P$

$$\Rightarrow W_1 + W_2 = 14762.74\,W \longrightarrow (1).$$

$$\tan\phi = \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2} \Rightarrow \tan(53.13^\circ) = \frac{\sqrt{3}(W_2 - W_1)}{14762.74}$$

$$\Rightarrow W_2 - W_1 = 11364.36 \longrightarrow (2)$$

Solving (1) & (2), we get

$\boxed{W_1 = 1699.19\,W}$

and $\boxed{W_2 = 13063.55\,W}$

18. The power input to a 2000V, 50Hz, 3ϕ motor running on full-load at an efficiency of 90% is measured by two wattmeters which indicate 300kW and 100kW respectively. Calculate (i) input, (ii) power factor (iii) line current (iv) HP output

Solⁿ

$W_1 = 300kW, \quad W_2 = 100kW.$

∴ Input power is

$P_{in} = W_1 + W_2 \Rightarrow \boxed{P_{in} = 400kW}$

$$\tan\phi = \frac{\sqrt{3}(W_2 - W_1)}{W_1 + W_2} = \frac{\sqrt{3}(100-300)}{100+300} = -0.866$$

$\Rightarrow \phi = -40.89°$

∴ power factor is

$pf = \cos\phi = \cos(-40.89°) \Rightarrow \boxed{pf = 0.7559}$

The three-phase power is

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

$$\Rightarrow I_L = \frac{P}{\sqrt{3}\, V_L \cos\phi} = \frac{400 * 10^3}{\sqrt{3} * 2000 * 0.7559}$$

$\Rightarrow \boxed{I_L = 152.758\,A}$

The HP output is

$$P_{out}(HP) = \eta * P_{in}(HP) = [P_{in}(kW)/0.7457] * \eta$$

$$= \frac{(400/0.7457) * 0.9}{0.9}$$

$\boxed{P_{out} = 482.767\,HP}$

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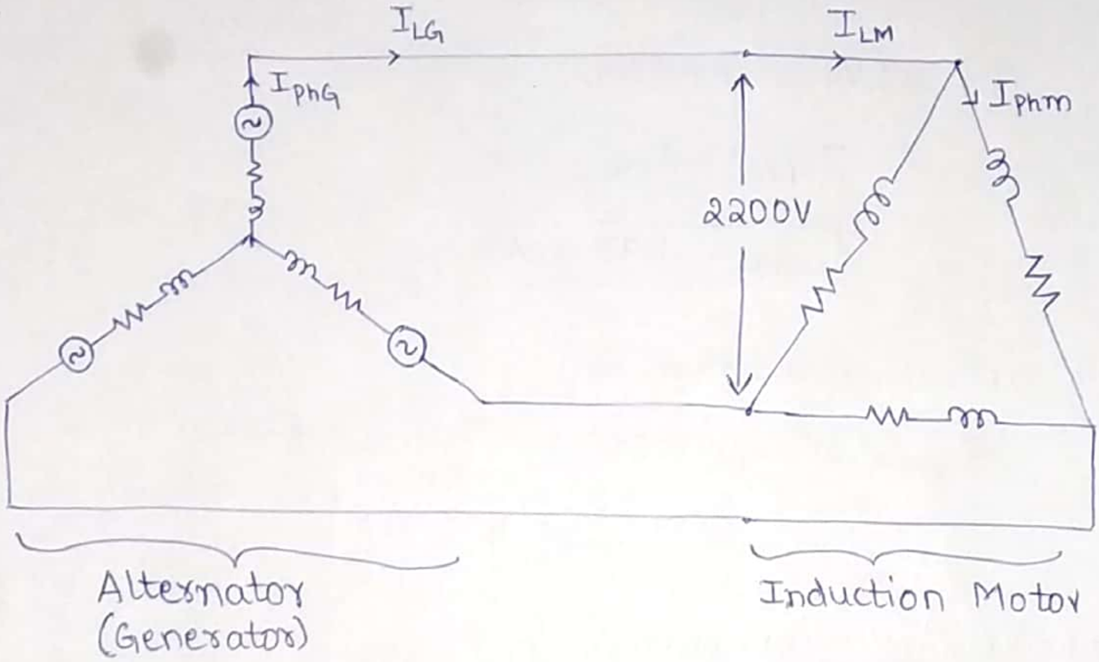
19. A 3ϕ, star-connected alternator feeds a 2000 HP, delta connected induction motor having a pf of 0.85 and an efficiency of 0.93. Calculate the current and the active & reactive components of the currents in

a) each alternator phase

b) each motor phase.

The line voltage is 2200V.

Sol^n:



Given, motor output $P_{out} = 2000 HP = 1491.4 kW$.

Motor input is, $P_{in} = \frac{P_{out}}{\eta} = \frac{1491.4}{0.93} = 1603.65 kW$.

This power input is,

$$P_{in} = \sqrt{3} V_L I_L \cos\phi$$

$$\Rightarrow I_L = \frac{P_{in}}{\sqrt{3} V_L \cos\phi} = \frac{1603.65 * 10^3}{\sqrt{3} * 2200 * 0.85}$$

$$\Rightarrow \boxed{I_{L(motor)} = 495.11 A}$$

Active component of current, $I_{phma} = (I_{LM} \cos\phi)/\sqrt{3}$

$= (495.11 * 0.85)/\sqrt{3}$

$$\boxed{I_{phma} = 242.978 A}$$

Reactive component is

$$I_{phmr} = I_{phm} \sin\phi$$
$$= (495.11/\sqrt{3}) \sin[\cos^{-1}(0.85)]$$

$$\boxed{I_{phmr} = 150.58\,A}$$

For the generator, the line current is

$$I_{LG} = I_{LM}$$

$$\therefore I_{LG} = 495.11\,A.$$

For star connection,

$$I_{phG} = I_{LG}$$

$$\therefore \boxed{I_{phG} = 495.11\,A}$$

The active component is,

$$I_{phGA} = I_{phG} \cos\phi = 495.11 * 0.85$$

$$\Rightarrow \boxed{I_{phGA} = 420.84\,A}$$

The reactive component is,

$$I_{phGR} = I_{phG} \sin\phi = 495.11 * \sin[\cos^{-1} 0.85]$$

$$\Rightarrow \boxed{I_{phGR} = 260.81\,A}$$