ELECTRICAL ASSIGNMENT 4

Ques 1:- Calculate the active and reactive current components in each phase of a star connected 10,000 V, 3phase alternator supplying 5000 kW at a power factor of 0.8. If the total current remains same when the load power factor is raised to 0.9, find the new output.

Sol^n:- Power supplied $(P) = \sqrt{3} \cdot V_L \cdot I_L \cdot \cos\phi = 5000$ kW

Line current $(I_L) = \dfrac{5000}{\sqrt{3} \cdot V_L \cdot \cos\phi} = \dfrac{5000}{\sqrt{3} \times 10{,}000 \times 0.8}$ $\Rightarrow$ $I_L = I_p = 360.844$

Active component of current in each phase = $I_p \cos\phi = 288.7$ A

Reactive component of current in each phase = $I_p \sin\phi = 216.5$ A

New output when p.f is raised to 0.9 keeping total current remains same. $P' = \sqrt{3} \cdot V_L \cdot I_L \cdot \cos\phi = \sqrt{3} \times 10000 \times 360.8 \times 0.9$

$P' = 5625$ kW

Ques 2:- A 3-phase star connection alternator feeds a 2000hp delta-connected induction motor having a p.f. of 0.95 & efficiency of 0.93. Calculate total current and active & reactive current components in (a) each alternator phase (b) each motor phase

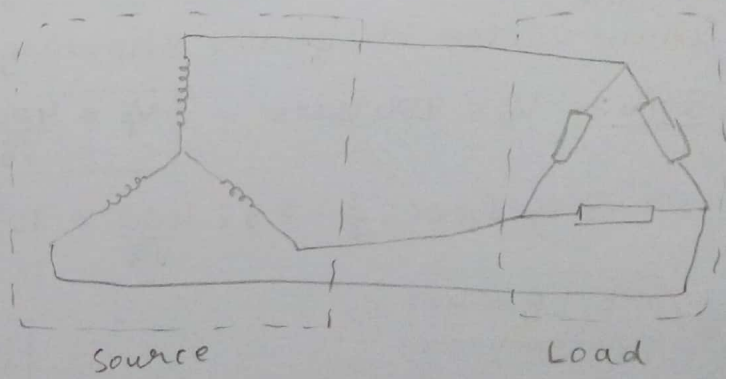
The line voltage is 2200V.

Original power = $\dfrac{2000 \times 746}{0.93}$

$P = 1604.301$ kW

$P = 3 V_p I_p \cos\phi$

$I_p = \dfrac{P}{3 V_p \cos\phi}$



(a) $I_p = \dfrac{P\sqrt{3}}{3 V_L \cos\phi} = 496$ A

Active comp. of current = 421 A

Reactive comp of current = 262 A

(b) $I_p = \dfrac{P}{3 V_L \cos\phi} = 286$ A

Active comp of current = 243 A

Reactive comp of current = 151 A

Ques 3:- A balanced star connected load $(8+j6)\Omega$ per phase is connected to a 3 phase, 230 V supply. Find the line current, power factor, power, reactive power(VA) & total volt ampere.

$\vec{Z} = 8+j6$ $\quad |Z| = 10\Omega$ $\quad V_L = 230$ $\quad V_p = \frac{230}{\sqrt{3}}$ $\quad I_p = \frac{V_p}{Z} = \frac{23}{\sqrt{3}} = 13.3$

p.f $= \cos\phi = \frac{8}{10} = 0.8$ $\quad P = 3 V_p I_p \cos\phi = 3 \times \frac{230}{\sqrt{3}} \times \frac{23}{\sqrt{3}} \times 0.8$

$P = 4232$ W

reactive volt ampere $= 3 V_p I_p \sin\phi = 3174$ VA

Total volt ampere $= 3 V_p I_p = 5290$ VA

Ques 4:- A balanced 3-ϕ Y connected load of 150 KW takes a leading current of 100 A with a line voltage 1100 V, 50 Hz. Find the circuit constants of the load per phase.

$V_L = 1100$ Volts $\quad V_p = \frac{1100}{\sqrt{3}}$ $\quad \omega = 50$ Hz $\quad$ Power in each phase $= 50$ KW

So, $50 \times 10^3 = \frac{1100}{\sqrt{3}} \times 100 \times \cos\phi$ $\quad \cos\phi = \frac{5\sqrt{3}}{11}$

$Z = \frac{V_p}{I_p} = \frac{1100}{\sqrt{3} \times 100} = \frac{11}{\sqrt{3}}$ $\quad R = Z\cos\phi = \frac{11}{\sqrt{3}} \times \frac{5\sqrt{3}}{11}$ $\quad R = 5\Omega$

$X_C = Z\sin\phi = \frac{11}{\sqrt{3}} \sqrt{1 - \frac{75}{121}} = \frac{11}{11} \frac{\sqrt{46}}{\sqrt{3}} = \sqrt{\frac{46}{3}}$

$C = \frac{\sqrt{3}}{100\pi\sqrt{46}}$ $\quad C = 810\,\mu F$

Ques 5: A balanced Y connected load is supplied from a sym. 3 ϕ, 400V system. The current in each phase is 30A and lags 30° behind the phase voltage. Find (a) the phase voltage.
(b) the total power.
Draw vector diagram showing the current and voltages.

Soln:- $V_L = 400$ Volts $\quad V_p = \frac{400}{\sqrt{3}} = 231$ Volts

$P = 3 V_p I_p \cos\phi = 3 \times \frac{400}{\sqrt{3}} \times 30 \times \cos 30° = 3 \times \frac{400}{\sqrt{3}} \times 30 \times \frac{\sqrt{3}}{2}$

$P = 18$ KW

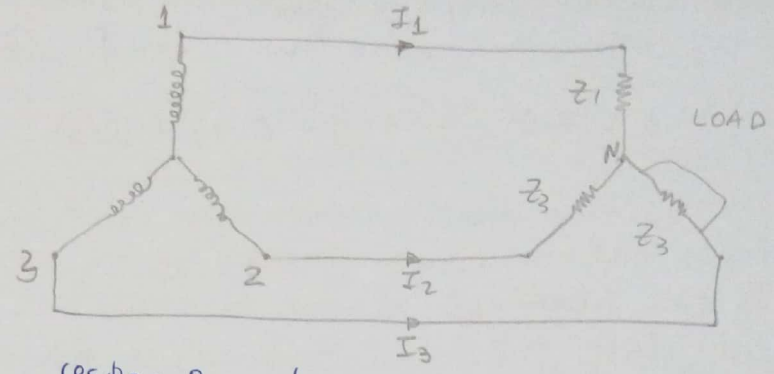
Ques 6:- Three equal star connected inctors take 8 kw at power factor 0.8 when connected to 460V, 3 phase, 3 wire supply. Find the line currents if one inductor is short circuited.

Sol^n:- $P = \sqrt{3}\, V_L I_L \cos\phi$

$$I_L = \frac{P}{\sqrt{3}\, V_L \cos\phi} = \frac{8\times10^3}{\sqrt{3}\times460\times0.8}$$

$$I_L = 12.55\ A$$

$$\text{Phase Impedance} = \frac{V_p}{I_p} = \frac{460}{\sqrt{3}\times12.55} = 21.16\ \Omega$$



$\cos\phi = 0.8 \quad \phi = 37°$

Since Z_3 is short circuit, then 3 & N are at same potential.
The three line voltage as phasor will be

$V_{12} = 460\angle0° \qquad V_{23} = 460\angle-120° \qquad V_{31} = 460\angle120°$

Since 3 & N are at same potential

$$\vec{I_1} = \frac{\vec{V_{13}}}{\vec{Z}} = \frac{-460\angle120°}{21.16\angle37°} \Rightarrow \vec{I_1} = -21.7\angle83°\ A = -2.64 - j(21.5)\ A$$

$$\vec{I_2} = \frac{\vec{V_{23}}}{\vec{Z}} = \frac{460\angle-120°}{21.16\angle37°} \Rightarrow 21.7\angle-157° = \vec{I_2} = -19.97 - j(8.48)\ A$$

$$\vec{I_3} = -(\vec{I_1} + \vec{I_2}) \qquad (\text{As at N } \vec{I_1} + \vec{I_2} + \vec{I_3} = 0)$$

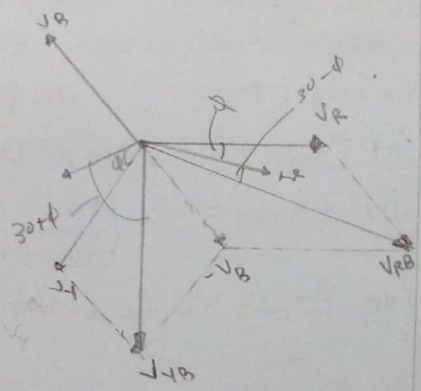
$$\vec{I_3} = (19.97 + 2.64) + j(8.48 + 21.5)\ A$$

$$I_3 = 22.61 + j(29.98) = 37.6\angle53°\ A$$

Ques 7:- $\vec{V_{RB}} = \vec{V_R} - \vec{V_B}$ & $\vec{V_{YB}} = \vec{V_Y} - \vec{V_B}$

$\angle$ b/w $\vec{V_{RB}}$ & $\vec{I_R} = 30 - \phi$

$\angle$ b/w $\vec{V_{YB}}$ & $\vec{I_Y} = 30 + \phi$



$W_1 = V_{RB} I_R \cos(30-\phi) = \sqrt{3} V_p I_p \cos(30-\phi)$

$W_2 = V_{YB} I_Y \cos(30+\phi) = \sqrt{3} V_p I_p \cos(30+\phi)$

$$W_1 + W_2 = \sqrt{3} V_p I_p \left[\cos(30-\phi) + \cos(30+\phi)\right]$$

$$= \sqrt{3} V_p I_p \left[2\cos30\cos\phi\right]$$

$$= 3 V_p I_p \cos\phi$$

$$W_1 + W_2 = \sqrt{3} V_L I_L \cos\phi$$

Also $\frac{W_1}{W_2} = \frac{\cos(30-\phi)}{\cos(30+\phi)}$

$$\Rightarrow \frac{W_1 - W_2}{W_1 + W_2} = \frac{\cos(30-\phi) - \cos(30+\phi)}{\cos(30-\phi) + \cos(30+\phi)}$$

$$\frac{W_1 - W_2}{W_1 + W_2} = \frac{2\sin30\sin\phi}{2\cos30\cos\phi} = \tan30°\tan\phi$$

$$\tan\phi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$$

$$\tan\phi = \sqrt{3}\left(\frac{1200-300}{1200+300}\right) = \sqrt{3}\times\frac{900}{1500} = 1.04$$

$\phi = 46.102$

$\cos\phi = 0.6934$ Lag

Ques 8:- A 3-ϕ balanced load power was measured by two wattmeter. If readings of the two wattmeters so connected are 5 and 0.5 kW, the latter reading being obtained after reversal of current coil connections, calculate the power factor of the load.

$W_1 = 5\,kW \quad W_2 = -0.5\,kW \quad \tan\phi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2} = \sqrt{3}\left(\frac{5.5}{4.5}\right) = \sqrt{3} \times \frac{11}{9}$

$\phi = 64.715^\circ$ $\cos\phi = 0.427$ (lag)

Ques 9:- Two wattmeters are used for measuring the power input and the power factor of an overexcited synchronous motor. If the readings of the meters are -2 & $+7$ kW respectively, calculate the input and power factor of motor.

Input power $= W_1 + W_2 = -2 + 7 = 5\,kW$

$\tan\phi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2} = \sqrt{3}\left(\frac{-2-7}{5}\right) = -\frac{9\sqrt{3}}{5} \qquad \phi = 72.216$

P.f $= \cos\phi = 0.3054$ (lead)

Ques 10:- A 3-phase delta connected balanced load consist of a resistance of 10 Ω in series with an inductive reactance of 17.32 Ω. If the circuit is connected to a 440V, 50 Hz supply and the total power consumed is 14,520 W, what is the reading read by each wattmeter if the power is measured by 2 wattmeter method?

$R = 10\,\Omega \quad X = 17.32 = 10\sqrt{3} \quad Z = 20 \quad \cos\phi = \frac{1}{2} \quad \phi = 60^\circ$

$\tan\phi = \sqrt{3} \quad \sqrt{3} = \tan\phi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2} \qquad W_1 - W_2 = W_1 + W_2$

$2W_2 = 0 \quad \boxed{W_2 = 0}$

$W_1 = 14{,}520\,W \quad W_2 = 0$

Ques 11:- The power input to a 2000V, 50 hz, 3-ϕ motor running on full load at efficiency of 90% is measured by two wattmeter which indicates 300 kW & 100 kW respectively. Calculate
(i) input ; (ii) power factor ; (iii) line current (iv) hp output.

(i) Input power $= W_1 + W_2 = 400\,kW$

(ii) $\tan\phi = \sqrt{3}\left(\frac{300-100}{300+100}\right) = \frac{\sqrt{3}}{2} \qquad \phi = 40.893 \qquad \cos\phi = 0.756$

(iii) $P = \sqrt{3}\,V_L I_L \cos\phi \qquad I_L = \frac{400 \times 10^3}{\sqrt{3} \times 2 \times 10^3 \times 0.756} \qquad I_L = 152\,A$

(iv) Output power $= 400 \times 0.9 = 360\,kW = \frac{360 \times 10^3}{735} = 490$ metric hp

Ques 12:- A 3-ϕ motor draws a line current of 50A from 220V source while starting. The p.f. is 0.4. Find the reading of the two wattmeters connected to measure power.

Power $= \sqrt{3}\, V_L I_L \cos\phi = \sqrt{3} \times 220 \times 50 \times 0.4 =$ 7.62 KW

Let the readings of two wattmeters be x & y.

$x + y = 7.62$ —— (i) $\quad \cos\phi = 0.4 \quad \phi = 66.422 \quad \tan\phi = 89.1374$

$\tan\phi = \sqrt{3}\left(\frac{x-y}{x+y}\right)$ $\quad x - y = 10.08$ —— (ii)

On solving (i) & (ii), we get $x = 8.85$ & $y = -1.23$

Reading of wattmeter are 8.85 KW & -1.23 KW