~~~~ 
(9) ~~Two W~~ Two wattmeters are connected to measure input to a balanced three phase circuit indicate 2000 W and 500W. Find $\cos\phi$ when.

1. Both readings are +ve
2. latter reading is obtained after reversing CC.

case (1)

$$\tan\phi = \frac{\sqrt{3}(W_1 - W_2)}{W_1 + W_2} = \sqrt{3}\left(\frac{3}{5}\right) \Rightarrow \phi = 46.10^\circ$$

$\cos\phi = 0.693.$

case (2)

$$\tan\phi = \frac{\sqrt{3}(W_1 - (-W_2))}{W_1 + W_2} = \frac{\sqrt{3}(2000 - (-500))}{2500.}$$

$$= \sqrt{3}\frac{5}{3}. \Rightarrow \phi = 70.888^\circ$$

$\cos\phi = 0.327.$

(8) One of the wattmeter's read 10kW when load PF = 0.5. When load pF changes to 0.8. Find new wattmeters readings if power remains unchanged.

~~B~~ $P_t = W_1 + W_2.$ $W_1 = 10kW.$

$\cos\phi = 0.5.$

$P = V_L I_L \cos(0.5)$

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

~~$W2+10$~~ $W1+10 = W1+10$

~~$\phi_2 = \cos^{-1}(0.8) =$~~

~~$W1 =$~~

$W1 = 10KW \quad W2 = 0$ when $\cos\phi = 0.5$

$P = W1 + W2 = 10KW$.

$W1' + W2' = 10KW$

$\cos\phi = \cos\left(\tan^{-1}\left(\frac{W2' - W1'}{W1+W2}\right)\right)$

$W_1' = 2.835\ KW$

$W_2' = 7.165\ KW$

$0.8 = \cos\left(\tan^{-1}\frac{\sqrt{3}(W2' - W1')}{W'1 + W2'}\right)$

$0.74 = \frac{\sqrt{3}(W2' - W1')}{10}$

$7.4 = W2' - W1'$

$10 = W2' + W1'$

$2W2 = (17.4)/\sqrt{3}$

$W2 = (8.7)\sqrt{3}$

$W1' = (1.3)/\sqrt{3}$

(Q) consider 3 impedances $(6+j8)$ are connected across 400V 50Hz, delta supply. Determine

(a) ~~ttt~~ I_L

(b) Readings of watt meters.

(a) $\phi = \tan^{-1}\left(\frac{8}{6}\right) = 53.13^\circ$

$|Z| = \sqrt{36+64} = 10\,\Omega$

$V_L = V_{ph}$ in delta.

$I_{ph} = \frac{V_{ph}}{|Z|} = \frac{400}{10} = 40\,A.$

$I_L = I_{ph}\sqrt{3} = 69.28\,A.$

(b) $W_1 = V_L I_L \cos(30+\phi)$ 83.13°

$= 400(69.28)\cos(83.13)$

$= 3.314\,kW.$

$W_2 = V_L I_L \cos(30 - 53.130°)$
$= 25.48 \text{ KW}$

$|Z|$ value remains same.
$V_L = 200V$
$I_{ph} = \frac{V_{ph}}{|Z|} = \frac{200}{\sqrt{3}(10)} = 11.547 \text{ A}$
$I_L = I_{ph} = 11.54 A$

$W_1 = 200(11.54)\cos(30 + 53.130)$
$= 276.07 W$
$W_2 = 200(11.54)\cos(30 - 53.130)$
$= 2.122 \text{ KW}$

(8) A 400V, 3ϕ motor has full load output of 20 hp. efficiency being 88% and power factor lagging 0.8 lagging. Find readings of 2 wattmeters.

$\phi = \cos^{-1}(0.8) = 36.86°$
$P = 20 \text{ Hp} = 20 \times 0.746 = 14.92 \text{ KW}$
$\eta = \frac{P_{out}}{P_{inp}}$
$P_{in} = \frac{P_{out}}{\eta} = \frac{14.92}{0.88} = 16.95 \text{ KW}$

$P = \sqrt{3} V_L I_L \cos\phi$
$16.95 \times 10^3 = \sqrt{3}(400)(I_L)0.8$
$I_L = 30.58 A$

$W_1 = V_L I_L \cos(30 + \phi)$ [∵ lagging PF]
$W_1 = 400(30.58)\cos(30 + 36.8) = 4.806 \text{ KW}$

$W_2 = V_L I_L \cos \cancel{\cos} (30 - \phi)$

$= \sqrt{}(400)(30.58)\cos(30 - 36.86)$

$= 12.144\,KW.$

~~Q Two watt meters are connected to measure power in 3ϕ circuit. The reading of one watt-meter is 5KW when cos ϕ is 1.~~

Q A balanced 3ϕ star connected load of 100KW takes a leading current of 80A connected to 3ϕ ~~1.1KV~~ 1.1KV 50Hz supply. Find R, XL and capacitance. Also calculate cos ϕ

star ⇒ ~~V_L~~ $I_L = I_{ph} = 80A$.

$V_{ph} = \frac{1.1}{\sqrt{3}} \times 1000 = 635.085\,V$

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

$100 \times 10^3 = \sqrt{3}(1.1)(10)^3 \cancel{(635.085)} (80)(\cos\phi)$

$0.656 = \cos\phi$

$\cancel{\phi =}\ \phi = \cos^{-1}(0.656) = 49°.$

$|Z| = \frac{V_{ph}}{I_{ph}} = \frac{635.085}{80} = 7.9\angle 49°)$

$= 7.9(\cos(49)) - \sin(49) j$

$= [5.182 - 5.96j]\,\Omega$

$R = 5.182\,\Omega.$

$X_C = 5.96\,\Omega$

$\frac{1}{\omega C} = 5.96.$

$C = \frac{1}{100\pi(5.96)} = 534.07 \times 10^{-6} F.$

⑤ ~~One of W~~

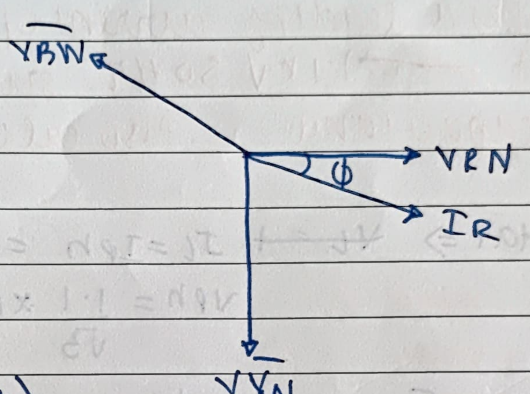
• ⑤ When three identical star connected coils are supplied with 440V 50Hz · 3ϕ supply. A wattmeter is connected in R line (CC) and Neutral (pressure coil) reads 6 KW. Ammeter connected in phase reads 30A. Assuming RYB Find.

(a) R and X_L (b) $\cos\phi$ of Load and

(c) Reactive power.

$V_L = 440V$

$V_{RN} = \frac{440}{\sqrt{3}}$



$W_1 = V_{RN} I_R \cos(\phi)$

$6KW = \frac{440}{\sqrt{3}} \cdot 30 \cos(\phi)$

$6\times10^3 = \frac{440}{\sqrt{3}}(30)\cos(\phi)$

(b) $\cos\phi = 0.787$

$\phi = 38.093$.

(a) $|Z| = \frac{V_{ph}}{I_{ph}} = \frac{440}{\sqrt{3}(30)} = 8.467 \angle 38.093)$

$Z = 6.66 + j5.223$.

$R = 6.66\,\Omega$

$X_L = 5.223\,\Omega$.

~~tot~~ =

(c) Reactive power $= \sqrt{3} V_L I_L \sin\phi$

$= \sqrt{3}(440)(.30)\sin(38.093)$

$= 14.105$ KVAR.

(8) Two wattmeter are connected to measure the power input of a 15HP, 50Hz, 3 phase induction motor at full load. The full load efficiency pf are 0.9 and 0.8 lag resp. Find the readings of 2 wattmeters.

$15HP = 15 \times 0.746 = 11.19 kW$.

~~power~~ $\eta = \frac{P_{out}}{P_{in}}$

$0.9 = \frac{11.19}{P_{in}} \Rightarrow P_{in} = 12.43 kW$

$\cos\phi = 0.8$ lag (Inductive load).

$\phi = \cos^{-1}(0.8) = 36.86°$

~~$W_1 = V_L$~~

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

$V_L I_L = \frac{12.43 \times 10^3}{\sqrt{3}(0.8)} = 8970.57$

$W_1 = V_L I_L \cos(30+\phi)$

$= 8970.57 \cos(66.86)$

$= 3.525 kW$

$W_2 = V_L I_L \cos(30-\phi)$

$= 8970.57 \cos(30-36.86)$

$= 8.906 kW$.

(8) A balanced 3ϕ star connected load is supplied from a symmetrical 3ϕ 400V, 50Hz. The current in each phase load 10A and lags by 60° behind phase voltage.

(a) Impedance per phase.
(b) Resistance and Inductance per phase.
(c) Active and reactive powers.

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

$I_{ph} = 10A = I_L$.

$|Z| = \frac{V_{ph}}{I_{ph}} = \frac{400}{\sqrt{3}(10)} = 23.094 \angle 60°) \Omega$

$\cancel{\phi = \tan^{-1}\left(\frac{X_L}{R}\right)}$.

$\cancel{60° = \tan^{-1}(}$

$Z = [11.54 + j\,19.99]\,\Omega$

(a) $X_L = 19.99 \approx 20$.

$\omega L = 20$.

$L = \frac{20}{\omega} = \frac{20}{100\pi} = \frac{1}{5\pi}$

Impedance per phase $= 23.094\,\Omega$

$= 0.063\,H$

$= 63.66\,mH$.

(b) Resistance $11.54\,\Omega$.

Inductance $= 63.66\,mH$.

(3) $P_{active} = \sqrt{3} V_L I_L \cos\phi$

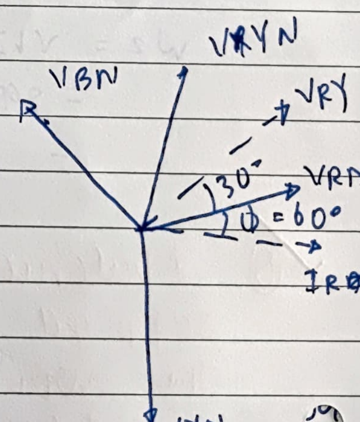
$= \sqrt{3}(400)(10)\cos(60°)$

$P_{3\phi} = 3.464\,kW$.

$P_{reactive} = \sqrt{3} V_L I_L \sin\phi$

$Q_{3\phi}$ $= \sqrt{3}(400)(10)\sin(60°)$

$= 6\,kW$



Q Two wattmeters connected to measure 3φ power for a balanced star connected 3φ load. measure 10kW and 5kW. If I_L = 20A at lagging power factor. Determine

(a) V_L
(b) V_{ph}
(c) Resistance
(d) Inductance.

$\phi = +ve.$

$P = W_1 + W_2 = 15kW.$

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

$$\cos\phi = \cos\left(\tan^{-1}\left(\frac{\sqrt{3}\times 5}{15}\right)\right)$$

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

$\cos\phi = 0.866$ $\phi = 30°.$

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

$15kW = \sqrt{3}\, V_L (20)(0.866)$

$$\frac{15\times 10^3}{\sqrt{3}(20)(0.866)} = V_L$$

$V_L = 500.01\ V.$

(b) $$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{500.01}{\sqrt{3}} = 288.68V.$$

(c) ~~Res~~ $$Z = \frac{V_{ph}}{I_{ph}} = \frac{288.68}{20} = 14.43\angle 30°\ \Omega$$

$\boxed{\because I_L = 30A}$ $Z = [12.5 + j\, 6.25]\ \Omega$

(c) $R = 12.5\,\Omega$

(d) $\omega L = 6.25$

$L = \frac{6.25}{100\pi} = 0.0198\ H$

$= 19.89\ mH.$

(8) A balanced star connected load consumes 3kw. of power at lagging 0.8 power factor when connected to a 3ϕ supply. If $I_L = 12.5A$ a calculated R and X_L in each branch. What will be V I_L and P if same load is connected in delta.

$P = 3KW \quad \cos\phi = 0.8$

$P = \sqrt{3} V_L I_L \cos\phi \qquad I_L = I_{ph} = 12.5A.$

$3(10)^3 = \sqrt{3}(V_L)(12.5)(0.8)$

$V_L = \frac{3000}{\sqrt{3}(12.5)0.8} = 173.20V.$

star $V_L =$

$Z_{ph} = \frac{V_{ph}}{I_{ph}} = \frac{173.20}{\sqrt{3}(12.5)} = 8$

$\phi = \cos^{-1}(0.8) = 36.86$

$Z = 8(0.8) + j(0.599)(8) = 6.4 + j4.792$

$R = 6.4\,\Omega$

$X_L = 4.792\,\Omega.$

For delta

$I_L = \sqrt{3} I_{ph} = \qquad V_L = V_{ph} = 173.20.$

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{173.20}{8} = 21.65A$

$I_L = \sqrt{3} I_{ph} = 37.5\ A \qquad P = \sqrt{3} V_L I_L \cos\phi = 8.9\ KW.$