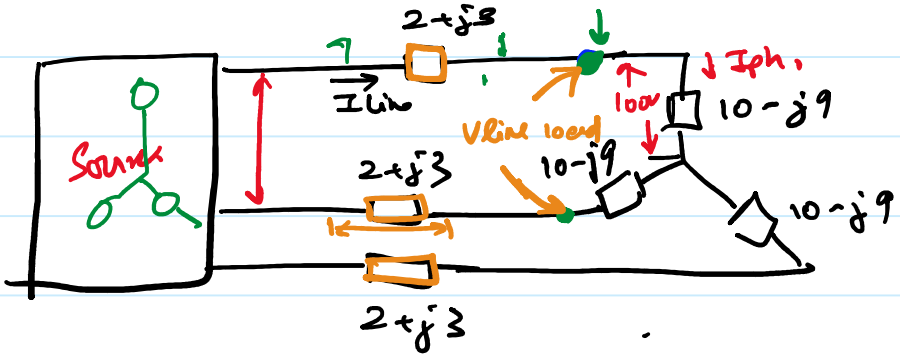
4.2 Three-Phase Power - Tutorial

Tuesday, January 11, 2022 11:21 AM

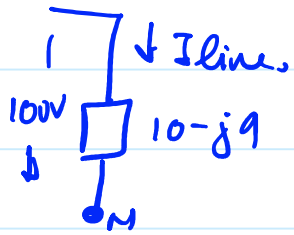
6)

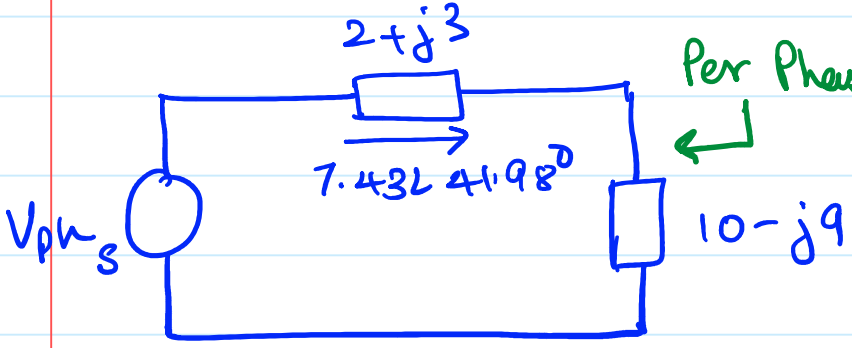


Balanced System? Yes. ✓ $I_{line} = I_{ph}$,

$V_{ph} = 100\angle 0^\circ$

$$I_{line} = \frac{V_{ph}}{10-j9} = \frac{100\angle 0}{10-j9} = 7.432\angle 41.98^\circ \text{ A}$$

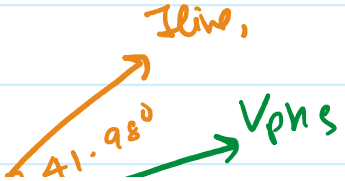


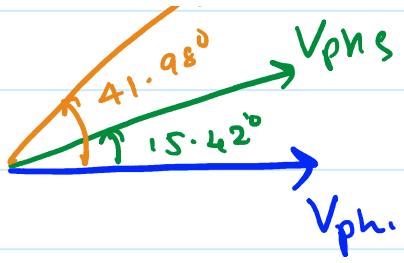


Per Phase equivalent diagram

$$V_{phs} = (2+j3+10-j9)(7.432\angle 41.98^\circ)$$
$$= \underline{99.72\angle 15.42\ V}$$

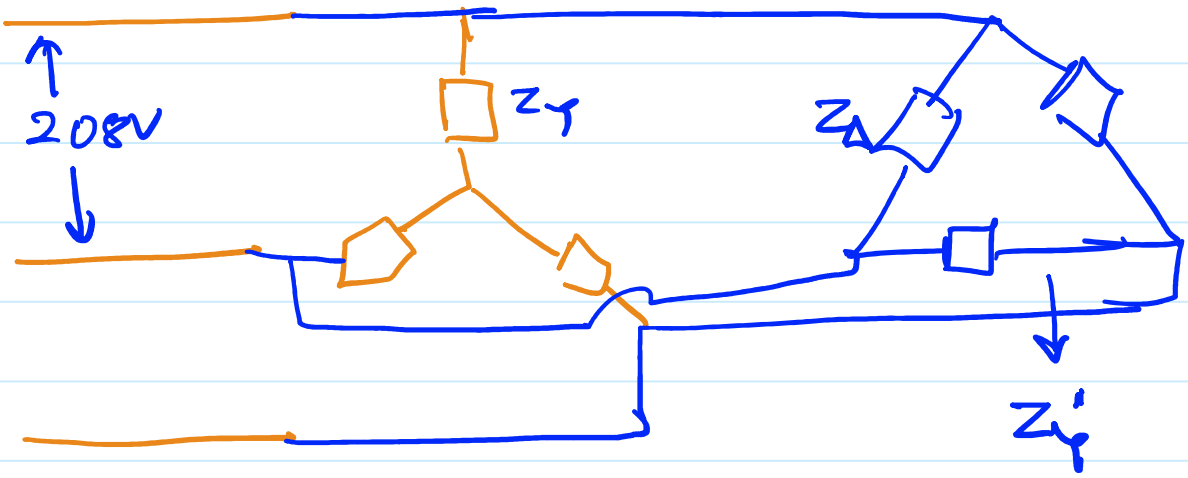
$$|V_{line-line}| = 99.72 \times \sqrt{3} = \sqrt{3}\,|V_{phs}|$$
$$= 172.72\ V$$





7) 208V → 3ϕ

$Z_\Delta = 21\angle 30^\circ \Omega$ $Z_Y = 9\angle -60^\circ \Omega$.

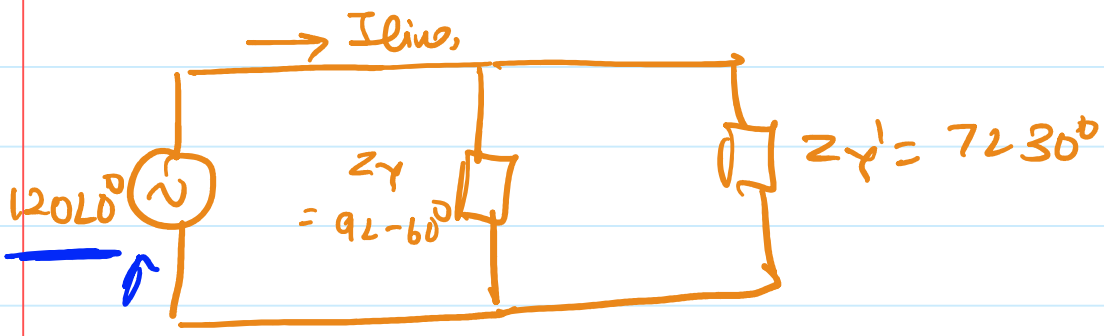


$$Z_Y' = \frac{Z_\Delta}{3} = \frac{21\angle 30^\circ}{3} = 7\angle 30^\circ \Omega.$$

$V_{line} = 208V$

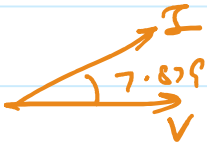
$|V_S|_{ph} = \frac{208}{\sqrt{3}} = 120V$

→ I_{line}



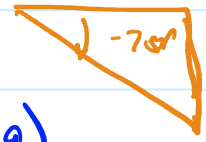
$$I_{line} = \frac{V_{ph}}{Z_y \| Z_y'} = \frac{120\angle 0^\circ}{9\angle -60 \| 7\angle 30^\circ}$$

$$= \frac{120\angle 0^\circ}{5.527\angle -7.879} = 21.7\angle 7.879^\circ \text{ A}$$



$$|I_{line}| = 21.7 \text{ A}$$

$$P_{3\phi} = 3|V_{ph}||I_{ph}|\cos\theta_3$$



$$= 3 \times 120 \times 21.7 \times \cos(-7.879)$$

$$= 7744 \text{ W}$$

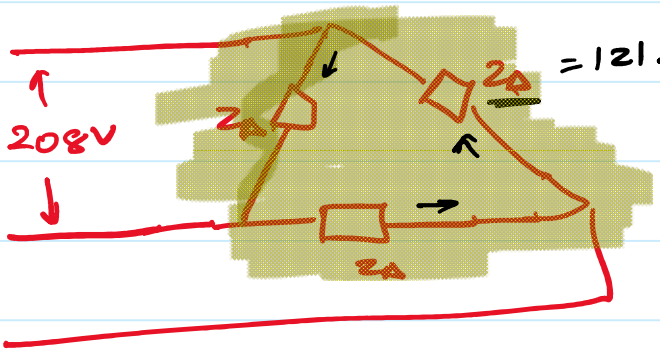
	Voltage	Current
Y	$V_{line} = \sqrt{3}\, V_{ph}$	$I_{line} = I_{ph}$
Δ	$V_{line} = V_{ph}$	$I_{line} = \sqrt{3} I_{ph}$

$$P_{3\phi} = Re(3VI^*)$$

8 208V, 3φ

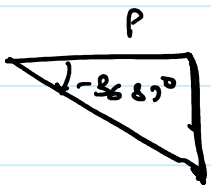
Δ load → 2 kW @ 0.8 leading p.f.

Z_Δ ?



$= 121 \angle \theta$

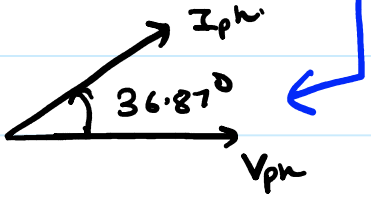
$\downarrow -36.87^\circ$



$P_{3\phi} = 2000\,W$ $\cos\theta = 0.8$ leading.

$\Rightarrow \theta = 36.87^\circ$

↘ I_{ph} and V_{ph}



$$Z_\Delta = \frac{V_{ph}}{I_{ph}}$$

$V_{ph} = 208 \angle 0^\circ$

$P_{3\phi} = 3 V_{ph} I_{ph} \cos\theta = 2 P_{1\phi}$

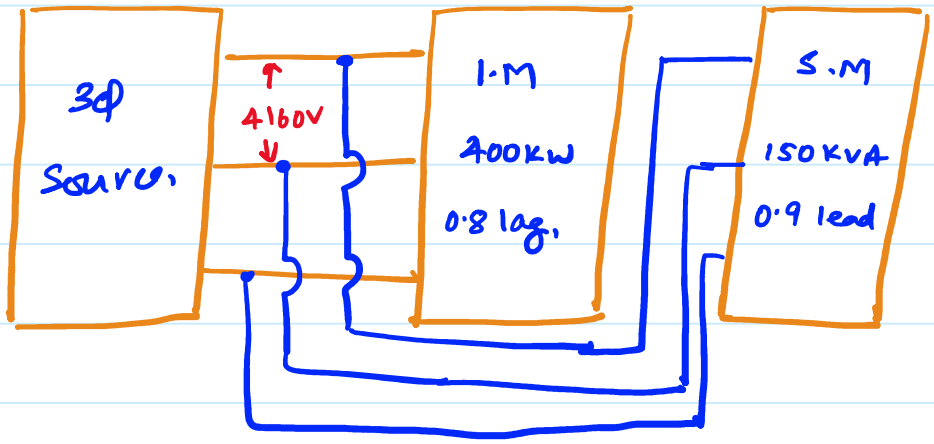
$$|I_{ph}| = \frac{2000}{3 \times 208 \times 0.8} = 4\,A$$

$I_{ph} = 4 \angle 36.87^\circ$

$$Z_\Delta = \frac{208 \angle 0^\circ}{4 \angle 36.87^\circ} = 52 \angle -36.87^\circ$$

[RC Load]

q)



a)

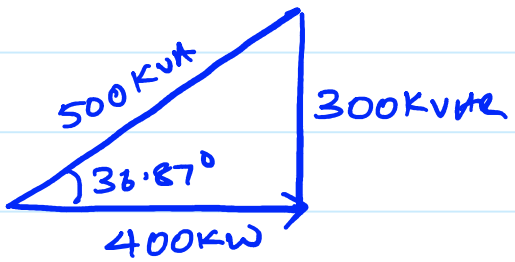
	$P_{3\phi}$	P.F.	$\lvert S \rvert$	$Q_{3\phi}$	θ
1 M	400KW	0·8 lag.	500KVA	300 KVAR	36·87°
S.M	135KW	0·9 lead.	150KVA	-65·4 KVAR	-25·84°

1M → $Q_{3\phi}$ → $P_{3\phi} \tan\theta$

$= 400 \times \tan 36{\cdot}87^\circ$

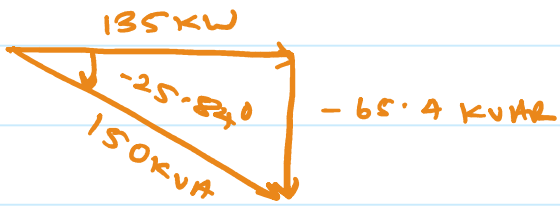
$= 300$ KVAR.

$|S| = \sqrt{400^2 + 300^2} = 500$KVA



S.M → $P_{3\phi} = |S| \cos\theta = 150 \times 0{\cdot}9 = 135$KW

$Q_{3\phi} = |S| \sin\theta = 150 \times \sin(-25{\cdot}84) = -65{\cdot}4$ KVAR.

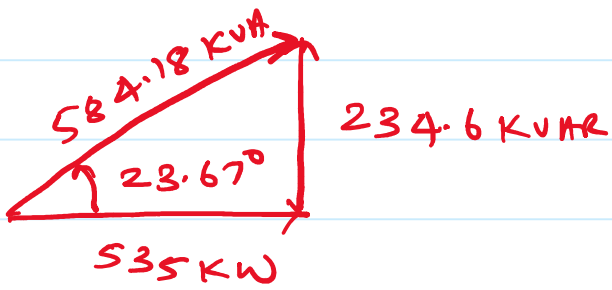


SM + 1M →

$$P_{TOTAL} = P_{IM} + P_{SM}$$
$$= 400 + 135 = 535 \text{ KW}$$

$$Q_{TOTAL} = 300 + (-65.4)$$
$$= 234.6 \text{ KVAR}.$$

$$S_{TOTAL} = 535 + j234.6 \text{ KVA}$$
$$= 584.18 \angle 23.67^\circ \text{ KVA}$$



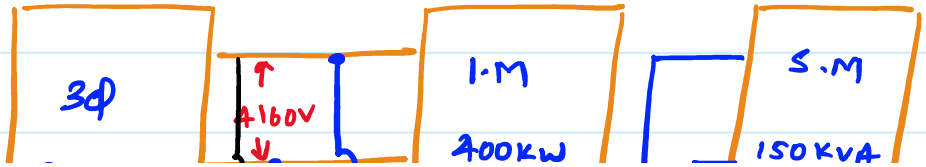
b) Combined motor load p.f = ① $\cos(23.67)$ lag.
$= 0.9159$ lagging.

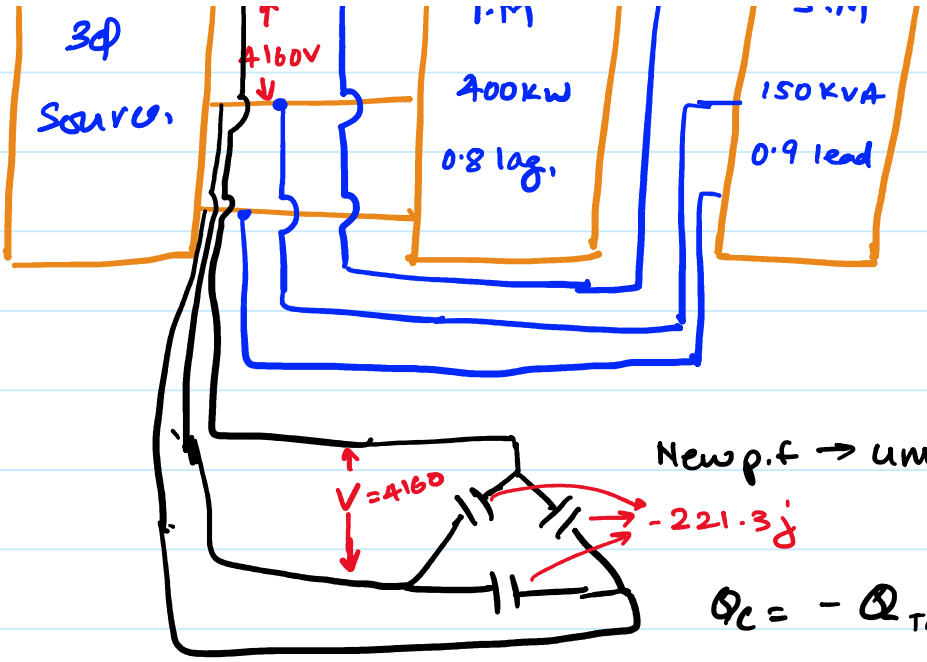
② $\cos\theta_T \rightarrow \quad \frac{P_T}{S_T} = \frac{535}{584.18} = 0.9159$ lagging.

c) $|S_{3\phi}| = 584.18 \text{ KVA} = \sqrt{3}|V_{line}||I_{line}|$
$= 3|V_{ph}||I_{ph}|$

$$|I_{line}| = \frac{584.18 \times 10^3}{\sqrt{3} \times 4160} = 81.08 \text{A}.$$

d)





New p.f → unity,

$Q_c = -Q_{TOTAL}$

$Q_{c3\phi} = -234.6\ KVAR. = 3\,Q_{1\phi}$

$Q_{1\phi} = \dfrac{-234.6\ KVAR}{3}$

$= -78.2\ KVAR.$

$Q_{c1\phi} = -78.2\ KVAR.$

$= \dfrac{-|V_c|^2}{|Z_c|} = -\omega C V^2$

$-78.2\times10^3 = -\dfrac{|4160|^2}{|Z_c|}$

$|Z_c| = \dfrac{4160\times4160}{78.2\times10^3} = 221.3\,\Omega$

$Z_c = \dfrac{1}{j\omega C} = \dfrac{1}{j}\,.|Z_c|$

$Z_c = -j221.3\,\Omega = 221.3\angle -90^\circ\,\Omega$

e) p.f = unity = $\cos 0° = 1$

$|P_{3\phi}| = 535\ kW = \sqrt{3}|V_{ph}||I_{ph}|\cos\theta$.

$$|I_{ph}| = \frac{535 \times 10^3}{3 \times \frac{4160}{\sqrt{3}} \times 1} = 74.25\ A$$

$I_{ph} = I_{line} = 74.25\ A$

PollEv.com/sangitsasidhar