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Tutorial 3

Date No.

1. $V_{ca} = V_{cn} - V_{an}$

$= \sqrt{3} V_{cn} \angle -30°$

$= 277\sqrt{3} \angle 15°$

$= 480 \angle 15° \text{ V}$ (3 s.f.)

$V_{ab} = V_{an} - V_{bn}$

$= V_{ca} \angle 120°$

$= 480 \angle 135° \text{ V}$

$V_{bc} = V_{bn} - V_{cn}$

$= V_{ca} \angle -120°$

$= 480 \angle -105° \text{ V}$

2. $V_{ba} = \sqrt{3} V_{bn} \angle -30°$

$V_{bn} = \frac{V_{ba}}{\sqrt{3}} \angle 30°$

$= \frac{12\,470}{\sqrt{3}} \angle -35° + 30°$

$= 7200 \angle -5° \text{ V}$ (3 s.f.)

$V_{an} = V_{bn} \angle 120°$

$= 7200 \angle 115° \text{ V}$

$V_{cn} = V_{bn} \angle -120°$

$= 7200 \angle -125°$

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3. $|V_{phase}| = \frac{480}{\sqrt{3}}$

$I_{rms} = \frac{|V|}{R} = \frac{\left(\frac{480}{\sqrt{3}}\right)}{40}$

$= 6.93\ A$ (3 s.f.)

4. $V_{cb} = \sqrt{3}\, V_{cn} \angle 30°$

$V_{cn} = \frac{480}{\sqrt{3}} \angle 95°$

$I_c = \frac{V_{cn}}{Z_y} = \frac{\frac{480}{\sqrt{3}} \angle 95°}{60 \angle -30°}$

$= 4.62 \angle 125°\ A$ (3 s.f.)

$I_a = I_c \angle -120°$

$= 4.62 \angle 5°\ A$

$I_b = I_a \angle -120°$

$= 4.62 \angle -115°\ A$

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5a. $R = 30\angle 0^\circ\ \Omega$

$R^* = 30\angle 0^\circ$

$|V_{an}| = \frac{500}{\sqrt{3}}$

$S_{3\phi} = 3V_{an}I_a^* = \frac{3V_{an}V_{an}^*}{R^*} = \frac{3|V_{an}|}{R^*}$ ——— (i)

$= \frac{3\left(\frac{500}{\sqrt{3}}\right)^2}{30}$

$\approx 8333.33\angle 0^\circ$

$P = 8333.33\cos 0^\circ = 8333.33\,W$

b. $R \approx 78\angle 67.38^\circ\ \Omega$

$R^* = 78\angle -67.38^\circ$

$|V_{an}| = \frac{500}{\sqrt{3}}$

From (i) in part a,

$S_{3\phi} = \frac{3|V_{an}|}{R^*} = \frac{3\left(\frac{500}{\sqrt{3}}\right)^2}{78\angle -67.38^\circ}$

$\approx 3205.128\angle 67.38^\circ$

$P = 3205.128\cos(67.38^\circ)$

$\approx 1232.75\,W$

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c. $R \approx 32.5 \angle -22.6199° \Omega$

$R^* = 32.5 \angle 22.6199°$

From (1) in part a,

$$S_{3\phi} = \frac{3|V_{an}|}{R^*} = \frac{3\left(\frac{500}{\sqrt{3}}\right)^2}{32.5 \angle 22.6199°}$$

$$\approx 7692.308 \angle -22.6199°$$

$P = 7692.308 \cos(-22.6199°)$

$\approx 7100.59 \text{ W}$

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6. Let $R = 10 - j9\ \Omega$, $R_{line} = 2 + j3\ \Omega$

$|R| = \sqrt{181}$ $|R_{line}| = \sqrt{13}$

$R' = R + R_{line}$

$= 10 - j9 + 2 + j3$

$= 12 - j6\ \Omega$

$|R'| = \sqrt{180}$

$|I| = \frac{|V_{phase}|}{R} = \frac{100}{\sqrt{181}}$

$|V'| = |I||R'|$

$= \frac{100}{\sqrt{181}} \sqrt{180} = 100\sqrt{\frac{180}{181}}$

$|V_{line-line}| = |V'|\sqrt{3}$

$= \left(100\sqrt{\frac{180}{181}}\right)\left(\sqrt{3}\right)$

$= 173\ V$ (3 s.f.)

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7. $Z_\Delta = 21\angle 30^\circ\ \Omega$

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

$Z_y = 9\angle -60^\circ\ \Omega$

$V_{line} = 208V$

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

$Z_y' \| Z_y = \left(\frac{1}{7\angle 30^\circ} + \frac{1}{9\angle -60^\circ}\right)^{-1}$

$\approx 5.527\angle -7.879\ \Omega$

$I_{line} = \frac{V_{ph}}{Z_y \| Z_y'} = \frac{120\angle 0^\circ}{5.527\angle -7.879}$

$\approx 21.7\angle 7.879^\circ\ A$

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

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

$= 7744W$

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8. $\cos\theta = 0.8$ leading

$\theta \approx 36.87°$

$V_{ph} = 208\angle 0°$

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

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

$= \dfrac{2000}{3(208)(0.8)} = 4A$

$I_{ph} = 4\angle 36.87° A$

$Z_\Delta = \dfrac{208\angle 0°}{4\angle 36.87°} = 52\angle -36.87° \Omega$

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9a. IM

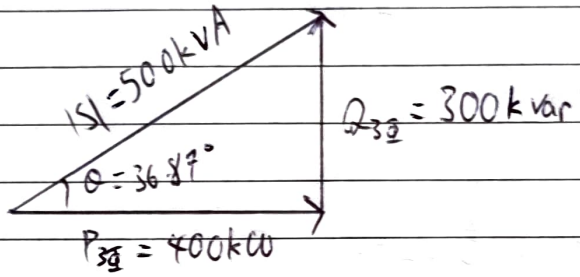
$P_{3\phi} = 400\,kW$

$\theta = \cos^{-1}(0.8) \approx 36.87°$

$Q_{3\phi} = P_{3\phi} \tan\theta = 400 \tan(36.87°)$

$\approx 300\,kvar$

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



SM

$|S| = 150\,kVA$

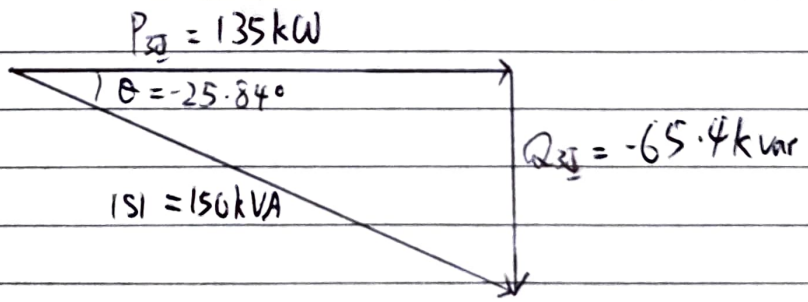
$\theta = -\cos^{-1}(0.9) \approx -25.84°$

$Q_{3\phi} = |S| \sin\theta = 150 \sin(-25.84°)$

$\approx -65.4\,kvar$

$P_{3\phi} = |S| \cos\theta = 150 \cos(-25.84°)$

$\approx 135\,kW$



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$P_{Total} = P_{IM} + P_{SM}$

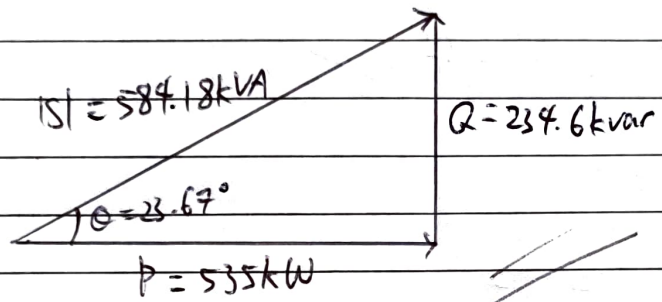
$= 400 + 135 = 535\,kW$

$Q_{Total} = Q_{IM} + Q_{SM}$

$= 300 - 65.4 = 234.6\,kvar$

$S_{Total} = 535 + j234.6$

$= 584.18 \angle 23.67^\circ\ kVA$



b. $p.f._{combined} = \frac{P_T}{|S_T|} = \frac{535}{584.18}$

≈ 0.9158 lagging

c. $|S_{3\phi}| = \sqrt{3}\,|V_{line\text{-}To\text{-}line}|\,|I_{line}|$

$|I_{line}| = \frac{|S_{3\phi}|}{\sqrt{3}\,|V_{line\text{-}To\text{-}line}|} = \frac{584.18 \times 10^3}{\sqrt{3}\,(4160)} \approx 81.08\,A$

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d. $Q_{3\phi c} = -Q_{total} = -234.6 \text{ kvar}$

$$Q_{1\phi c} = \frac{-234.6}{3} = -78.2 \text{ kvar}$$

$$Q_{1\phi c} = -\frac{|V_c|^2}{|Z_c|}$$

$$|Z_c| = -\frac{|V_c|^2}{Q_{1\phi c}} = -\frac{(4160)^2}{-78.2 \times 10^3}$$

$$\approx 221.3\ \Omega$$

$$Z_c = \frac{1}{j}|Z_c| = -j221.3\ \Omega$$

e. p.f. new $= \cos 0^\circ = 1$

$$|V_{ph}| = \frac{|V_{line\text{-}to\text{-}line}|}{\sqrt{3}} = \frac{4160}{\sqrt{3}}$$

$$|I_{line}| = |I_{ph}| = \frac{|P_{3\phi}|}{3|V_{ph}|\cos\theta}$$

$$= \frac{535 \times 10^3}{(3)\left(\frac{4160}{\sqrt{3}}\right)(1)}$$

$$\approx 74.25 \text{ A}$$