AP 11.6, 11.8

11.1, 11.8, 11.12, 11.37

AP 11.6 Line voltage $\vec{V}_{AB}$ at term. of bal. 3ϕ Δ load is $4160\angle 0^\circ$ V. $\vec{I}_{aA} = 69.28\angle -10^\circ$ A

a) Per-phase impedance of load (pos phase seq)

b) " (neg. phase seq.)

a) $4160\angle 0^\circ = V_\phi$

$I_{aA} = I_{AB} - I_{CA} = \sqrt{3}\, I_\phi \angle -30^\circ$

$$\frac{69.28\angle -10^\circ}{\sqrt{3}\angle -30^\circ} = I_\phi = 39.999\angle 20^\circ \text{ A}$$

$$\frac{V_\phi}{I_\phi} = Z_\phi = \frac{4160\angle 0^\circ}{39.999\angle 20^\circ} = 104.003\angle -20^\circ\ \Omega$$

b) $I_{aA} = I_{AB} - I_{CA} = \sqrt{3}\, I_\phi \angle 30^\circ$ A

$$\frac{69.28\angle -10^\circ}{\sqrt{3}\angle 30^\circ} = 39.999\angle -40^\circ \text{ A}$$

$$\frac{4160\angle 0^\circ}{39.999\angle -40^\circ} = 104.00\angle 40^\circ\ \Omega$$

AP 11.8 3ϕ avg power of CPU 22659 W

Line voltage 208 V_{rms}, line current 73.8 A_{rms}, magnetizing VARs absorbed

a) Total magnetizing reactive power absorbed

b) power factor

a) $V_\phi = \frac{V_L}{\sqrt{3}} = \frac{208}{\sqrt{3}} V_{rms}$

$I_\phi = I_L = 73.8 \, A_{rms}$

$P_{sum} = 22659 = 3V_\phi I_\phi \cos\theta_\phi$

$\cos^{-1}\left(\frac{22659}{3 \cdot \frac{208}{\sqrt{3}} \cdot 73.8}\right) = 31.54° = \theta_\phi$

$Q_{sum} = 3V_\phi I_\phi \sin(\theta_\phi) = 3 \cdot \frac{208}{\sqrt{3}} \cdot 73.8 \sin(31.54) = 13907.84$ VARs

pf = 0.852 lagging

11.1 phase sequence

a) $v_a = 137\cos(\omega t + 63^\circ)$ $V = 137\angle 63^\circ$

$V_b = 137\cos(\omega t - 57^\circ)$ $V = 137\angle -57^\circ$ dbc

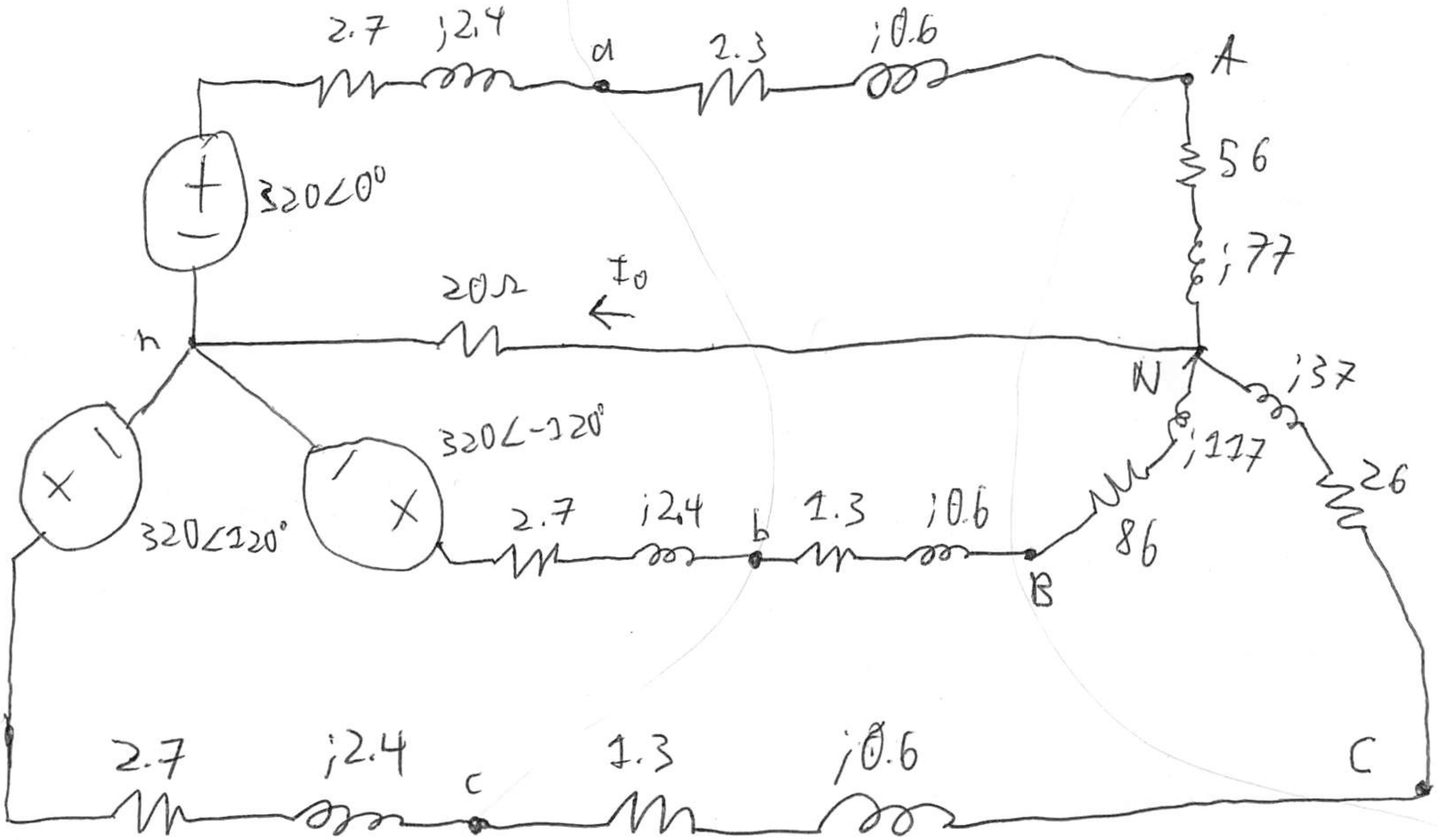
$V_c = 137\cos(\omega t + 283^\circ)$ $V = 137\angle 183^\circ$

b) $v_a = 820\cos(\omega t - 36^\circ)$ $V = 820\angle -36^\circ$

$V_b = 820\cos(\omega t + 84^\circ)$ $V = 820\angle 84^\circ$ acb

$V_c = 820\sin(\omega t - 66^\circ)$ $V = 820\angle -156$

11.8 Find rms value of I_o in unbalanced 3ϕ circuit



$$\vec{I}_o = \vec{I}_{aA} + \vec{I}_{bB} + \vec{I}_{cC} = \frac{V_N}{20}$$

$$Z_{aA} = (2.7 + 1.3 + 56) + j(2.4 + 0.6 + 77) = 60 + j80\ \Omega$$

$$100\angle 53.13°\ \Omega$$

$$Z_{bB} = (2.7 + 1.3 + 86) + j(2.4 + 0.6 + 117) = 90 + j120\ \Omega$$

$$150\angle 53.13°$$

$$Z_{cC} = (2.7 + 1.3 + 26) + j(2.4 + 0.6 + 37) = 30 + j40\ \Omega$$

$$50\angle 53.13°$$

$$I_{aA} = \frac{V_{a'n}}{Z_{aA}} = 1.92 - j2.56\ A$$

$$I_{bB} = -2.12 - j0.26\ A$$

$$I_{cC} = 2.51 + j5.89\ A$$

$$\vec{I}_o = 2.32 + j3.07\ A$$

11.12 Y—Y balanced, acb, ref a — neg. φ seq

mag & phase:

125 v source — a) all line currents

0.1+j0.8 Ω/φ line — b) all line voltages at source

19.9+j14.2Ω/φ load — c) all phase voltages at load

d) all line voltages at load

a) Tutor

$Z_{Line} = 0.8062\angle 82.87^\circ\ \Omega$

$Z_{Load} = 24.45\angle 35.51^\circ\ \Omega$

$$\frac{\overset{a}{125\angle 0^\circ} + \overset{b}{125\angle 120^\circ} + \overset{c}{125\angle -120^\circ}}{20+j15+Z_{src}} = 0$$

$I_{aA} = \frac{125}{20+j15} = 5\angle -36.87^\circ A$ $\quad I_{bB} = \frac{125\angle 120^\circ}{Z_\phi} = 5\angle 83.13^\circ A$

$I_{cC} = \frac{125\angle -120^\circ}{Z_\phi} = 5\angle -156.87^\circ A$

b) $V_{an} \cdot \sqrt{3} = 125 \cdot \sqrt{3}\angle -30^\circ = 216.51\angle -30^\circ\ V = V_{ab}$

$V_{bn}\sqrt{3} = 125\angle 120^\circ \cdot \sqrt{3}\angle -30^\circ = 216.51\angle 90^\circ = V_{bc}$

$V_{cn}\sqrt{3} = 125\angle -120^\circ \cdot \sqrt{3}\angle -30^\circ = 216.51\angle -150^\circ = V_{ca}$

c) $V_{AN} = 5\angle-36.87^\circ \cdot 24.45\angle 35.51^\circ = 122.25\angle -1.36^\circ\ V = V_\phi$

$V_{BN} = 5\angle 83.13^\circ \cdot 24.45\angle 35.51^\circ = 122.25\angle 118.64^\circ\ V$

$V_{CN} = 5\angle -156.87^\circ \cdot 24.45\angle 35.51^\circ = 122.25\angle -121.36^\circ\ V$

d) (neg ϕ seq)

$V_{AB} = \sqrt{3}\, V_\phi \angle -30^\circ = 211.71\angle -31.36^\circ\ V$

$V_{BC} = \sqrt{3}\, V_\phi \angle +90^\circ = 211.71\angle 208.64^\circ = 211.71\angle 88.64^\circ\ V$

$V_{CA} = \sqrt{3}\, V_\phi \angle -150^\circ = 211.71\angle -151.36^\circ\ V$

120° offset

11.37 Output power 41.6 kVA w/ lagging pf 0.707
Source line voltage 240V

assume neutral

balanced src

3x

balanced load

$0.04+j0.03$

a) magnitude of line voltage at load

b) Find total complex power at terminals of load

a)

$$\sqrt{3}|V_\phi| = |V_{ab}| = |V_{bc}| = |V_{ca}| = 240\text{ V}$$

$$|V_{an}| = 138.56 = |V_{an}|$$

$$V_{an} = 138.56\angle 0^\circ$$

$$V_{bn} = 138.56\angle -120^\circ$$

$$V_{cn} = 138.56\angle 120^\circ$$

$$\angle\cos^{-1}(0.707)$$

$$S_{src\,sum} = 41600\text{ VA} = P_{src\,sum} + Q_{src\,sum}$$

$$= 41600\angle 45^\circ$$

$$\vec{S}_\phi = \frac{S_{src\,sum}}{3} = 13867\angle 45^\circ\text{ VA} = \vec{V}_{an}\vec{I}_\phi^*$$

$$\frac{13867\angle 45^\circ}{138.56\angle 0^\circ} = \vec{I}_\phi^* = 100.08\angle 45^\circ$$

$$= 70.77 + j70.77\text{ A}$$

$$I_\phi = 70.77 - j70.77 = 100.08\angle -45^\circ \qquad |V_{AB}| = 238.92\text{ V}$$

$$V_{aA} = I_\phi \cdot (0.04 + j0.03) = 0.708 + j4.95\text{ V}$$

$$V_{an} - V_{aA} = V_{AN} = 137.85 - j4.95\text{ V} = 137.94\angle -2.06^\circ$$

$$V_{AB} = \sqrt{3}\,V_{AN}\angle 30^\circ = 238.92\angle 27.94^\circ\text{ V}$$

$\cancel{V_{BC} = 238.92 \angle}$

$\cancel{V_{CA} = 238.92 \angle}$

b) $S_{\phi Load} = \vec{V}_{\phi} \vec{I}_{\phi}^{*} = 23911 \angle 72.94^{\circ}$ VA

$3 S_{\phi Load} = 71733 \angle 72.94^{\circ}$ VA