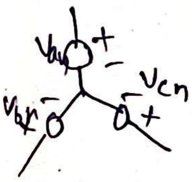
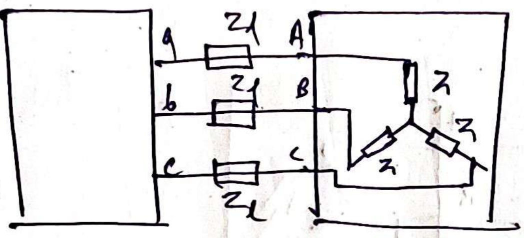
## ET - Tutorial 3

1)



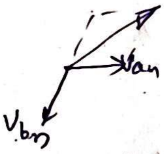

$|V_{ab}| = 45\,kV$

$Z_l = 0.5 + 3j\ \Omega$

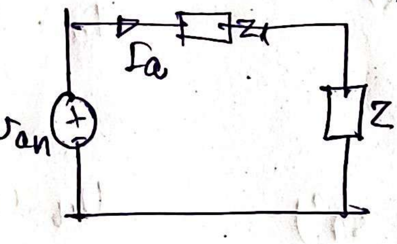
$Z = 4.5 + 9j\ \Omega$

$V_{ab} = V_{an} - V_{bn} = \sqrt{3}\, V_{an} \angle 30^\circ$

$\Rightarrow V_{an} = \frac{45}{\sqrt{3}} \angle \theta - 30^\circ$




$I_a = \frac{V_{an}}{Z_l + Z} = \frac{\frac{45}{\sqrt{3}} \angle(\theta - 30^\circ)}{(0.5 + 3j) + (4.5 + 9j)}$



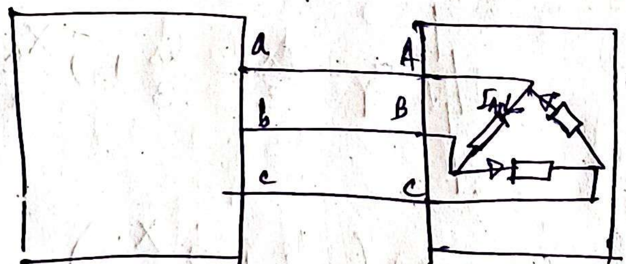

$= 1.999 \angle(\theta - 97.38^\circ)\ kA$

$\theta = 30^\circ$

$$\boxed{\begin{aligned} I_a &= 1.999 \angle -67.38^\circ\ kA \\ I_b &= 1.999 \angle 172.62^\circ\ kA \\ I_c &= 1.999 \angle 52.62^\circ\ kA \end{aligned}}$$

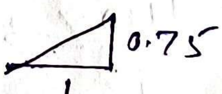
$$\boxed{\begin{aligned} P_{load} &= 3|I_a|^2\, Re(Z) = 53.946\ MW \\ P_{line} &= 3|I_a|^2\, Re(Z_l) = 5.994\ MW \end{aligned}}$$

2)




$\rightarrow$ 3kW, pf = 0.8 lag

$V_{ab} = 208 \angle 0^\circ\ V$




$I_a = I_{AB} - I_{CA}$


$V_{ab} \cdot I_{AB}^* = (1 + 0.75j) \times 10^3$

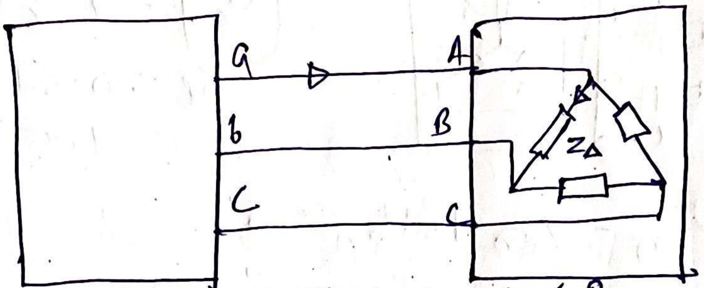
$\Rightarrow I_{AB} = \frac{1000}{208}(1 - 0.75j) = 6.01 \angle -36.87^\circ\ A$

$I_a = \sqrt{3}\, I_{AB} \angle -30^\circ$

$-66.87 - 120 + 360 = 173.13$

$$\boxed{\begin{aligned} I_a &= 10.41 \angle -66.87^\circ\ A \\ I_b &= 10.41 \angle 173.13^\circ\ A \\ I_c &= 10.41 \angle 53.13^\circ\ A \end{aligned}}$$

3)




$V_{ab} = 1100\,V$, $I_a = 100\,A \angle \theta$ ~~$I_{AB} = 100\,A\angle\theta$~~ , $\theta > 0$

~~$\frac{160}{3}\times 10^3 = 100^2\,Re(Z_\Delta)$~~

~~$\Rightarrow R_\Delta = 5$~~

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

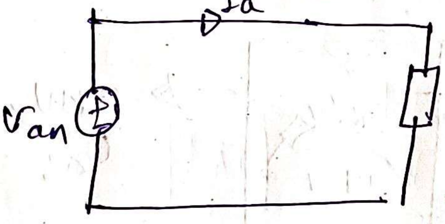
$V_{ab} = V_{an} - V_{bn} = \sqrt{3}\, V_{an} \angle 30^\circ$

$\therefore\; I_{AB} = \frac{100}{\sqrt{3}} \angle(\theta + 30^\circ)$

$\frac{160}{3}\times 10^3 = \left(\frac{100}{\sqrt{3}}\right)^2 Re(Z_\Delta)$

$\Rightarrow \boxed{R_\Delta = 16\,\Omega}$

$V_{an} = \frac{1100}{\sqrt{3}} \angle -30^\circ$




$Z_Y = \frac{Z_\Delta}{3} = \frac{R_\Delta}{3} + j\frac{X_\Delta}{3}$

$\frac{1100}{\sqrt{3}} \angle -30^\circ = (100\angle\theta)\left(\frac{16}{3} + j\frac{X_\Delta}{3}\right)$

$\Rightarrow 11\sqrt{3}\angle(-\theta - 30^\circ) = 16 + j X_\Delta$

$\therefore\; 16^2 + X_\Delta^2 = 11^2 \times 3$

$\Rightarrow X_\Delta = -\sqrt{3\times 121 - 256} = -10.3441\,\Omega$

$\Rightarrow \frac{1}{\omega C} = 10.3441$

$\Rightarrow C = \frac{10^6}{2\times\pi\times 50\times 10.3441}\,\mu F$

$\boxed{C_\Delta = 307.72\,\mu F}$

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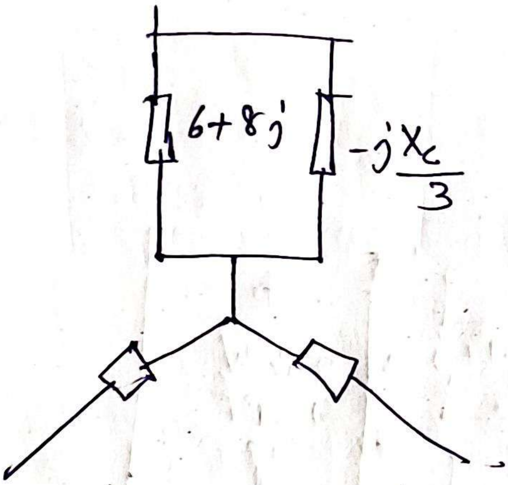


$$\operatorname{Im}\left(\frac{1}{6+8j}+\frac{3}{-jX_c}\right)=0$$

$$\Rightarrow \operatorname{Im}\left(\frac{6-8j}{100}+j\frac{3}{X_c}\right)=0$$

$$\Rightarrow \boxed{X_c = 37.5\ \Omega}$$

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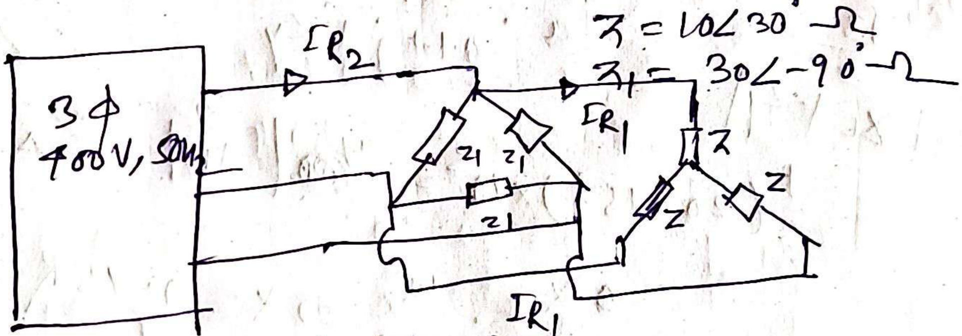
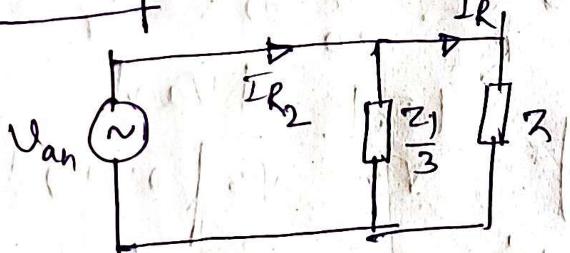
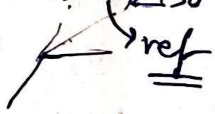


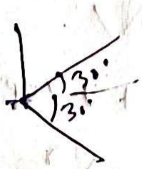




$V_{ab} = V_{an} - V_{bn}$
$= \sqrt{3}V_{an}\angle 30^\circ$




$$I_{R_1} = \frac{V_{an}}{Z} = \frac{\frac{400}{\sqrt{3}}}{10\angle 30^\circ}$$

$$\boxed{I_{R_1} = 23.094\angle -30^\circ}$$

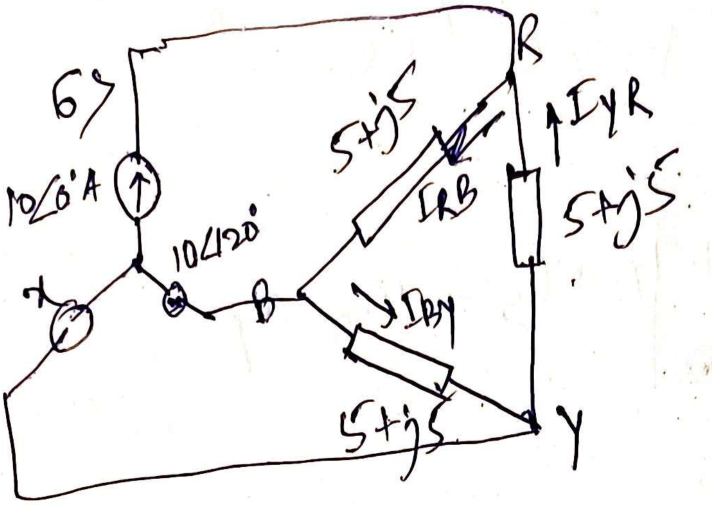



$$I_{R_2} = 23.094\angle -30^\circ + \frac{\frac{400}{\sqrt{3}}}{10\angle -90^\circ}$$

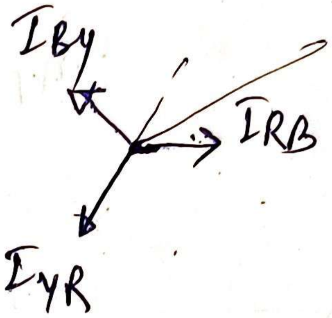
$$= 23.094\angle -30^\circ + 23.094\angle 90^\circ$$

$$\boxed{I_{R_2} = 23.094\angle 30^\circ\ A}$$

6)




$x = 10\angle -120^\circ A$



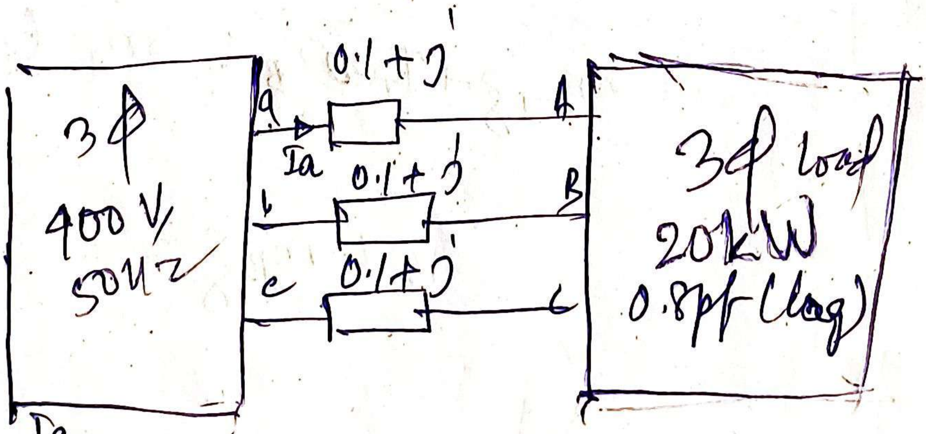

$$10\angle 0^\circ = I_{RB} - I_{YR}$$
$$= \sqrt{3}\, I_{RB} \angle 30^\circ$$

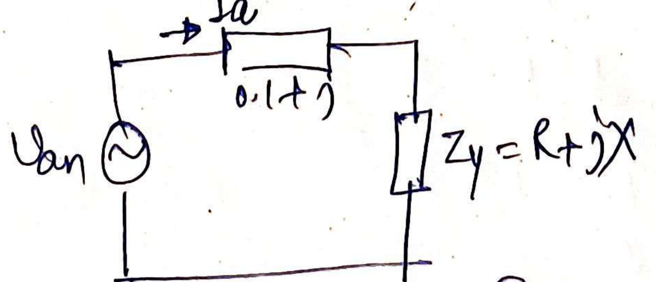
$$P = 3\,|I_{RB}|^2 \times 5 = 499\,W$$
$$Q = 3\,|I_{RB}|^2 \times 5 = 499\,VAR$$

$\Rightarrow$
$$I_{RB} = 5.77\angle -30^\circ$$
$$I_{BY} = 5.77\angle 90^\circ$$
$$I_{YR} = 5.77\angle 210^\circ$$
$$\Rightarrow I_{RY} = 5.77\angle 30^\circ$$

7)

$V_{ab} = V_{an} - V_{bn}$
$= \sqrt{3} V_{an}\angle 30^\circ$




$$\cos\theta = 0.8 \Rightarrow \tan\theta = \frac{6}{8} = 0.75$$
$$= X/R$$
$$\Rightarrow X = 0.75R$$

$$\frac{1}{3}\, 20\times 10^3 = |I_a|^2 \times R$$

$$|V_{an}| = \frac{400}{\sqrt{3}}$$

$$\Rightarrow \frac{1}{3}\times 20\times 10^3 = R\left(\frac{|V_{an}|}{\sqrt{(0.1+R)^2+(1+0.75R)^2}}\right)^2$$

$$\Rightarrow \frac{1}{\cancel{3}}\times \cancel{20}\times 1\cancel{0^3} = R\times\frac{\overset{8}{\cancel{400^2}}/\cancel{3}}{(0.1+R)^2+(1+0.75R)^2}$$

$$\Rightarrow (0.1+R)^2+(1+0.75R)^2 = 8R$$

$$\Rightarrow 1.5625R^2 - 6.3R + 1.01 = 0$$

$$\Rightarrow R = \frac{6.3 \pm 5.777}{2\times 1.5625}$$

$$\Rightarrow R = 3.86\,\Omega \text{ or } \underline{0.16736\,\Omega}$$
$\hookrightarrow$ ignore

$$I_a = \frac{\frac{400}{\sqrt{3}}\angle -30°}{0.1+j+3.86(1+0.75j)}$$

$$I_a = 41.577\angle -74.53°\ A$$

$\theta = 30°$

~~$I_b = 41.577\angle$~~

$$\Rightarrow \boxed{\begin{aligned} I_a &= 41.577\angle -44.53°\ A \\ I_b &= 41.577\angle -164.53°\ A \\ I_c &= 41.577\angle 75.47°\ A \end{aligned}}$$

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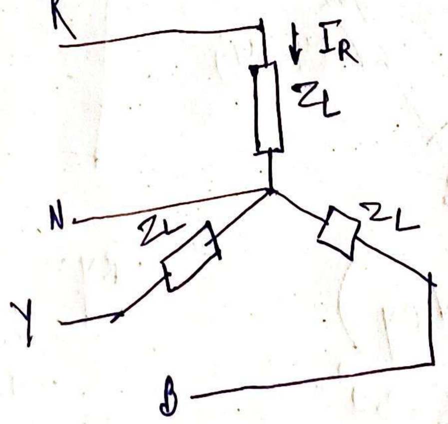



$$5.54\times 10^3 = |I_R|^2\,Re(Z_L)$$

$$|I_R| = 30$$

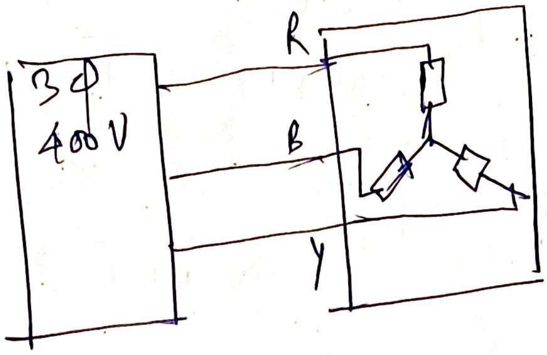
$$\Rightarrow Re(Z_L) = 6.155\,\Omega$$

$$30 = \frac{400/\sqrt{3}}{\sqrt{Re(Z_L)^2 + Im(Z_L)^2}}$$

$$\Rightarrow Im(Z_L) = \pm\left(\frac{400^2/3}{30^2} - 6.155^2\right)^{1/2}$$

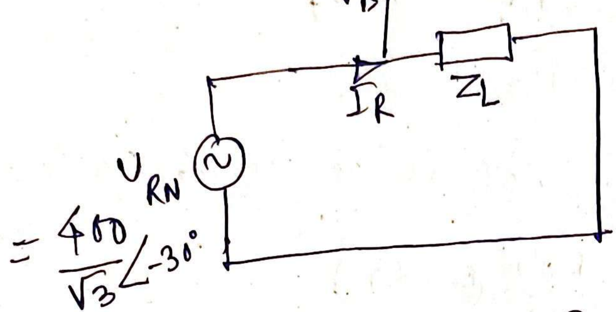
$$= \pm 4.623\,\Omega$$

~~Anal~~
~~Reading~~ =




$V_{RB} = V_{RN} - V_{BN}$
$= \sqrt{3}\, V_{RN} \angle 30$

$V_{RB} = 400\,V \angle 0^\circ$
$V_{BY} = 400\,V \angle -120^\circ\,V.$



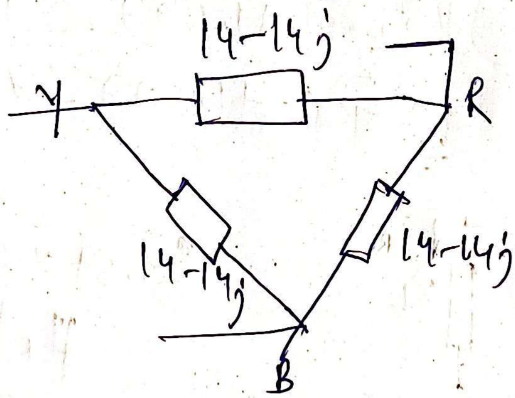

$I_R = \frac{V_{RN}}{Z_L} = \frac{\frac{400}{\sqrt{3}} \angle -30^\circ}{6.155 \pm j\,4.623}$

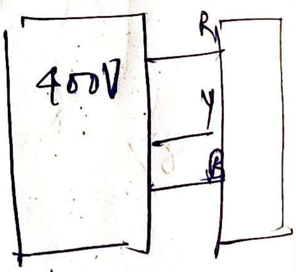
Final reading $= Re\left(V_{BY} \cdot I_R^*\right)$

$= Re\left(\frac{400 \angle -120^\circ \times \frac{400}{\sqrt{3}} \angle 30^\circ}{6.155 \pm j\,4.623}\right)$

$= 12 \times 10^3 \cos(53^\circ)$
$= \boxed{7.2\,kW}$

9)



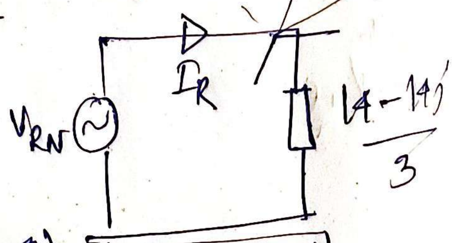




$W_1 = Re\left(I_R^* \, V_{RY}\right)$

$V_{RY} = 400 \angle 0^\circ\,V$
$= V_{RN} - V_{YN}$
$= \sqrt{3}\, V_{RN} \angle 30^\circ$

$I_R = \frac{\frac{400}{\sqrt{3}} \angle -30^\circ}{\frac{14 - 14j}{3}}$

$= 34.993 \angle 15^\circ$




$W_1 = 400 \times 34.993 \times \cos(15^\circ) = \boxed{13.52\,kW}$

$$W_2 = Re\left(I_B^{*} V_{BY}\right)$$

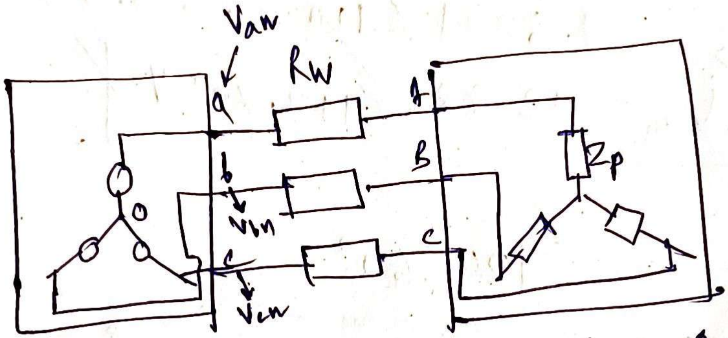
$$I_B = 34.993 \angle 135^\circ$$

$$V_{BY} = 400 \angle 60^\circ$$

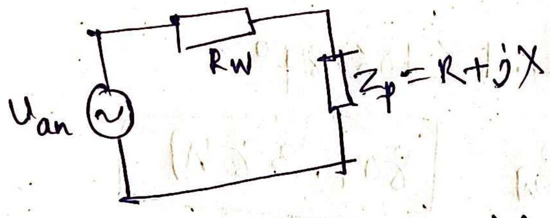
$$\therefore W_2 = 400 \times 34.993 \times \cos(75^\circ)$$

$$= \boxed{3.623\,kW}$$

10)




$$V_{BC} = 120\angle 60^\circ V, \quad R_W = 0.6\,\Omega$$




$\cos\theta = 0.8$

$\Rightarrow \tan\theta = 6/8 = 0.75$

$$0.75 = \frac{X}{R+R_W} \quad \text{---(i)}$$

$$\frac{1}{3}\left(5 \times 0.8 \times 10^3\right) = |I_a|^2 (R + R_W)$$

$$\cancel{I_a = \frac{V_{an}}{R_W + R + jX}} =$$

$$V_{bn} = V_{an}\,\omega^2$$

$$V_{cn} = V_{an}\,\omega$$

$$V_{an} - I_a R_W = V_A, \quad V_{bn} - I_b R_W = V_B$$

$$V_{BC} = V_{bn} - I_b R_w - V_{cn} + I_c R_w$$

$$= V_{an}(\omega^2 - \omega) - R_w I_a(\omega^2 - \omega)$$

$$= (V_{an} - I_a R_W)(\omega^2 - \omega)$$

$$V_{BC}$$

$$I_a = \frac{V_{an}}{R_w + R + jX} \Rightarrow V_{an} - I_a R_W = I_a(R + jX)$$

$$\Rightarrow \frac{V_{BC}}{\omega^2 - \omega} = I_a(R + jX)$$

$$\frac{4}{3} \times 10^3 = \frac{(120^2/3)(R + 0.6)}{R^2 + [0.75(R + 0.6)]^2} \Rightarrow R = 2.395\,\Omega$$

$$\Rightarrow X = 2.246\,\Omega$$

$$I_a = \frac{120\angle 60^\circ}{\sqrt{3}\angle -90^\circ (2.3957 + j\,2.246)}$$

$$= 21.1\angle 106.84^\circ$$

$$3\,|I_a|^2 R_W = \boxed{801.38\,W}$$

$$V_{an} = 21.1\angle 106.84\,(0.6 + 2.3957 + j\,2.246)$$

$$= \boxed{78.99\angle 143.71^\circ\,V}$$