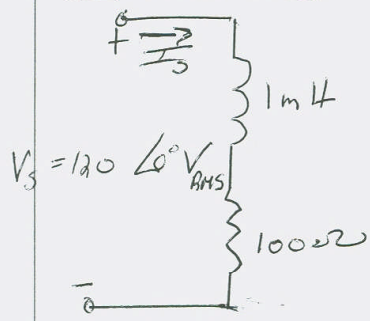
Worksheet Solutions

Short Answers



$f = 5000\,Hz$

$Z_L = j\omega L = j\,(2\pi)(5000)(1\times10^{-3})$
$= 31.42\,\Omega$

$Z_R = 100\,\Omega$

$Z_T = 100 + j\,31.42\ \Omega$
$= 104.8\angle 17.44^\circ\ \Omega$

(1) $I_s = \dfrac{V_s}{Z_T} = \dfrac{120\angle 0^\circ}{104.8\angle 17.44^\circ} = 1.145\angle -17.44^\circ\ A$

$P_T = (120)(1.145)\cos(17.44^\circ)$
$= 131\ W$

(2) $V_R = \left(\dfrac{100}{100 + j31.42}\right)(120\angle 0^\circ) = 114.48\angle -17.44^\circ$

Note: Check out the angles of V_R and I_R (I_s really)!

$P = (114.48)(1.145)\cos(-17.44^\circ - -17.44^\circ)$
$= (114.48)(1.145)\cos 0^\circ$
$= 131\ W$

(3) $V_L = V_s - V_R = 120\angle 0^\circ - 114.48\angle -17.44^\circ$
$= 35.97\angle 72.56^\circ$

Note: Check out the angles of V_L and I_L (I_s)!

$P = (35.97)(1.145)\cos\angle 72.56 - -17.44^\circ$
$= (35.97)(1.145)\cos\angle 90^\circ = 0\ W$

(4)

$$Q_T = VI \sin\theta$$
$$= (120)(1.145) \sin(17.44^\circ)$$
$$= 41.18 \text{ VAR}$$

$$Q_R = VI \sin\theta$$
$$= (114.48)(1.145) \cancel{\sin 0^\circ} \; 0$$
$$= 0 \text{ VAR}$$

$$Q_L = VI \sin\theta$$
$$= (35.97)(1.145) \sin \overbrace{(72.56 - -17.44^\circ)}^{90^\circ !}$$
$$= 41.18 \text{ VAR}$$

(5)

$$S_T = VI$$
$$= (120)(1.145)$$
$$= 137 \text{ VA}$$

Note that

$$S = \sqrt{P_T^2 + Q_T^2}$$
$$= \sqrt{(131)^2 + (41.18)^2}$$
$$= 137 \text{ VA}$$

$$S_R = VI$$
$$= (114.48)(1.145)$$
$$= 131 \text{ VA}$$

Note that $S_R = P_R$ since $Q_R = 0$

$$S_L = VI$$
$$= (35.97)(1.145) = 41.18 \text{ VA}$$

Note that $S_L = Q_L$ since $P_L = 0$

Note that $S_L + S_R \neq S_T$

(1) (a) $Z_{L(400)} = j\omega L$
$= j(800\pi)(0.1) = 251j\ \Omega$

$Z_{LOAD} = (2000 + j251)\ \Omega$

$Z_p = a^2 Z_{LOAD}$
$= \left(\frac{125}{25}\right)^2 (2000 + j251)$
$= (5)^2 (2000 + j251)$
$= 50{,}000 + 6275j$

$Z_{TOTAL} = 1000 + j(2\pi 400)(0.2) + Z_p$
$= 1000 + j502.7 + 50000 + 6275j$
$= 51000 + j6778\ \Omega$

(b) $I_p = \frac{240\angle 0^\circ}{Z_T} = \frac{240\angle 0^\circ}{51000 + j6778} = 4.66\angle -7.57^\circ\ mA$

(c) $I_s = a I_p$
$= (5)(4.66\times10^{-3}\angle -7.57^\circ)$
$= 23.3\angle -7.57^\circ\ mA$

(d)
$E_p = I_p Z_p = (4.66\times10^{-3}\angle -7.57^\circ)(50000 + 6275j)$
$= 235.1\angle -0.416^\circ\ V$

(e) $E_s = \frac{1}{a} E_p = 1/5\,(235.1\angle -0.416^\circ)\ V$
$= 47.01\angle -.417^\circ\ V$

(f)

$$Z_{TH} = 1000 + j\,502.7\ \Omega$$

$$Z_p = 1000 - j\,502.7\ \Omega$$

$$Z_p = a^2\, Z_{LOAD}$$

$$1000 - j\,502.7 = (5)^2\, Z_{LOAD}$$

$$Z_{LOAD} = 40 - j\,20.1\ \Omega$$

$$R = 40\ \Omega$$

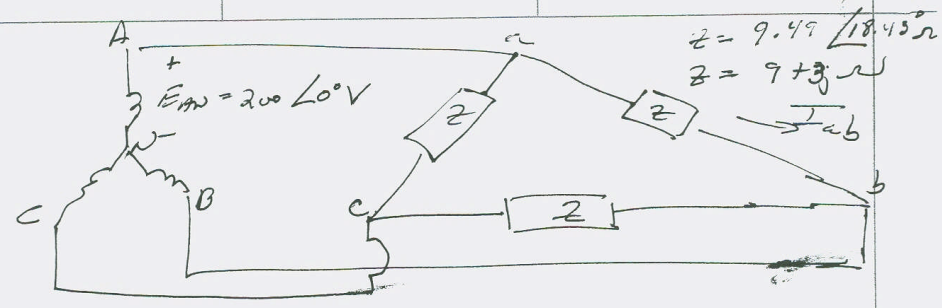
$$Z_C = -j\left(\frac{1}{\omega C}\right) = -j\,20.1$$

$$\frac{1}{(800\pi)\,C} = 20.1$$

$$C = 19.8\ \mu F$$

Replace load w/ Resistor 40Ω
Capacitor $19.8\ \mu F$

(2)



$$E_{AB} = \sqrt{3}\, E_{AN} (\angle 30°)$$
$$= \sqrt{3}\,(200 \angle 0°)(\angle 30°)$$
$$= 346.4 \angle 30° \ V$$

$$I_{ab} = \frac{E_{AB}}{Z} = \frac{E_{AB}}{9+3j} = \frac{346.4 \angle 30°}{(9+3j)}$$

$$I_{ab} = 36.5 \angle 11.57° \ A$$

$$I_{\phi LOAD} = 36.5 \ A$$

$$I_{LINE} = \sqrt{3}\, I_\phi = \sqrt{3}\,(36.5) = 63.24 A$$

$$P_T = 3 V_\phi I_\phi \cos\theta$$
$$= 3(346.4)(36.5)\cos(18.43)$$
$$= 35985 \ W$$

$$Q_T = 3 V_\phi I_\phi \sin\theta$$
$$= 3(346.4)(36.5)\sin\underbrace{(30° - 11.57°)}_{\theta_Z}$$
$$= 11992 \ VAR$$

$$S_T = 3 V_\phi I_\phi \quad \text{OR} \quad S_T = \sqrt{P_T^2 + Q_T^2}$$
$$= 37930 \ VA \qquad = 37930 \ VA$$

OR

Careful here!

$$P_T = \sqrt{3}\ V_L I_L \cos\theta$$
$$= \sqrt{3}\ (346.4)(63.22)\cos(30^\circ - 11.57^\circ)$$
$$= 35\ 985\ W$$

$$Q_T = \sqrt{3}\ V_L I_L \sin\theta$$
$$= \sqrt{3}\ (346.4)(63.22)\sin(18.43^\circ)$$
$$= 11\ 992\ VAR$$

$$S_T = \sqrt{3}\ V_L I_L$$
$$= 37\ 930\ VA$$

(3)(a) $Z_C = -j\dfrac{1}{\omega C}$

$= -j\dfrac{1}{2\pi(60)(10\times10^{-6})}$

$= -j\,265\,\Omega$

$Z_{LOAD} = Z_C \,//\, Z_{R2}$

$= \dfrac{1}{\dfrac{1}{-j265} + \dfrac{1}{300}}$

$= 198.6 \angle -48.5^\circ$

$= 131.5 - j148.9\,\Omega$

$V_{LOAD} = \dfrac{Z_{LOAD}}{Z_T} V_{SOURCE}$

$= \left(\dfrac{198.6\angle -48.5^\circ}{133.5 - j148.9}\right)(120\angle 0^\circ)$

$= 119.2 \angle -0.42^\circ\,V$

$I_{LOAD} = \dfrac{V_{LOAD}}{Z_{LOAD}}$

$= \dfrac{119.2\angle -0.42^\circ\,V}{198.6\angle -48.5^\circ\,\Omega}$

$= 0.6 \angle 48.1^\circ\,A$

$S = V_{RMS} I_{RMS}$

$= (119.2)(0.6)$

$= 71.52$ VA

$P = S\cos\theta$

$= 71.52\cos(-48.5^\circ)$

$= 47.4\,W$

$Q = S\sin\theta$

$= 71.52\sin(-48.5^\circ)$

$= -53.6$ VAR

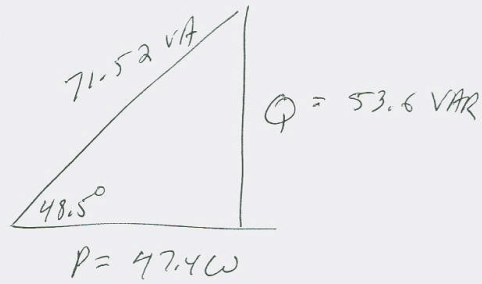
(3) b

$F_p = \cos(-48.5°)$

$= 0.663$ leading

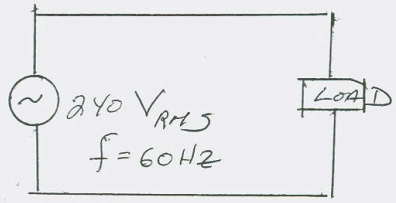
(current leads voltage)

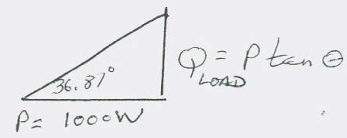
(3) c



(4)

If $P_{LOAD} = 1000\,W$ with $F_p = 0.8$ lagging. Correct the power factor so that $F_p = 1$





$$Q_{LOAD} = P \tan\theta$$
$$= 1000 \tan(36.87°)$$
$$= 750\,VAR$$

$$\cos\theta = 0.8$$
$$\theta = 36.87°$$

Need $Q_c = -750\,VAR$

$$Q_c = V_{RMS} I_{RMS} \sin(-90°)$$
$$Q_c = -V_{RMS} I_{RMS} = -V_{RMS}\left(\frac{V_{RMS}}{|Z|}\right)$$
$$Q_c = -\frac{V_{RMS}^2}{X_c}$$
$$-750 = -\frac{(240)^2}{X_c}$$
$$X_c = 76.8\,\Omega$$
$$X_c = \frac{1}{\omega C}$$
$$76.8 = \frac{1}{2\pi 60\, C}$$
$$C = 34.5\,\mu F$$