Ans-1 (a) $\phi_{max} = 0.0683\,Wb$

$E = 4.44 N f \Phi_{max}$

$a = \dfrac{V_{HS}}{V_{LS}} = \dfrac{\cancel{22000}^{10}}{\cancel{2200}} = 10$

$\dfrac{220000}{4.44 \times 60 \times 0.0683} = N_{HS}$

$\boxed{N_{HS} = 1209}$

$N_{LS} =$

$a = \dfrac{N_{HS}}{N_{LS}}$ $\boxed{N_{LS} = 121}$

$N_{LS} = \dfrac{1209}{10} = 120.9$

(b) $\cancel{\Phi_{max} = \Phi' + 20\%\,\phi}$ $E' = 26400\,V$

$\cancel{= 0.0683 +}$ $f = 57\,Hz$

$\Phi_{max} = \dfrac{26400}{4.44 \times 1209 \times 57} = 0.08628\,Wb$

$\boxed{\Phi_{max} = 0.08628\,Wb}$

Ans-2 $\Phi = 0.113 \sin 188.5t$

$\omega = 188.5 = 2\pi f$

$f = \dfrac{188.5}{2\pi} = 30\,Hz$

$(\Phi_{max} = 0.113)$

$E = 4.44 N \Phi_{max} f$

$N_{HS} = \dfrac{2400}{4.44 \times 0.113 \times 30} = \boxed{160}$

$a = \dfrac{2400}{115} = \dfrac{N_{HS}}{N_{LS}}$

$\boxed{N_{LS} = 8}$

Ans-3 $H_{rms} = 352\ At/m$

$B_{max} = 1.505T$

$H = \frac{NI}{l}$

$E = 4.44 N \phi_{max} f$

$\frac{2400}{4.44 \times \cancel{1.505} \times 60} = N_{HS}$ (0.0142973)

$\boxed{N_{HS} = 630}$

$a = \frac{2400}{480} = 5$

$\boxed{a = 5}$

$\boxed{N_{LS} = 126}$

$\phi = B \cdot A$

$= 1.505 \times 95 \times 10^{-4}$

$= 0.0142973$

$352 = \frac{(126) I_m}{1.07}$

$\boxed{\cancel{I_m = 62.77A}}$

$I_m = \frac{352 \times 1.07}{126} = 3A$

Ans-4 $a = \frac{4800}{600} = 8$

$f = 60Hz$

$(I_m = 2\% I_r)$

$l = 3.15m$

$B = 1.55T$

$H = 360\ At/m$

$2000 \times 10^3 = \sqrt{3} \, 4800 \, I_{rated}$

$\boxed{I_{rated} = \frac{416.66A}{\sqrt{3}}}$

$\boxed{P = \sqrt{3} VI \cos\phi}$

$\left(H = \frac{NI}{l}\right)$

$\boxed{I_m = \frac{8.333A}{\sqrt{3}}}$

$\boxed{I_m = 4.811A}$

$H = \frac{N I_m}{l}$

$N = \frac{360 \times 3.15}{4.811} = 236$

$\boxed{N_{HS} = 236}$

$\boxed{N_{LS} = 30}$

$E = 4.44 N f \phi_{max}$

$\frac{4800}{4.44 \times 236 \times 60} = \phi_{max}$

$\boxed{\phi_{max} = 0.076Wb}$

$(\phi = B \cdot A)$

$A = \frac{\phi}{B} = \frac{0.076}{1.55} = 0.049m^2$

-5 $I_0 = 2.5\%\ I_r.$

$I_{rated} = \frac{P_{rated}}{V_{rated}} = \frac{50\times10^3}{480} = 104.1$

$\boxed{I_0 = 2.604\,A}$

$\theta = \theta_v - \theta_i$

$79.8 = 0 - \theta_i$

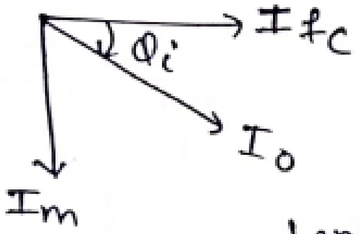
$\boxed{\theta_i = -79.8^\circ}$

$\cos\theta_i = \frac{I_{fc}}{I_0}$

$I_{fc} = I_0 \cos\theta_i$

$I_{fc} = 2.604 \cos(-79.8)$

$\boxed{I_{fc} = 0.4611\,A}$



$\tan\theta_i = \frac{I_m}{I_{fc}}$

$I_m = I_{fc}\tan\theta_i$

$I_m = 0.4611 \tan(79.8)$

$\boxed{I_m = 2.5626\,A}$

Ans-6 $I_{rated} = \frac{240\times10^3}{7200}$

$\boxed{I_{rated} = 27.77\,A}$

$\boxed{I_m = 0.4166\,A}$

$P_{core} = V_T I_{fc}$

$1100 = (7200)\, I_{fc}$

$I_{fc} = \frac{1100}{7200} = 0.152\,A$

$\boxed{I_{fc} = 0.152\,A}$

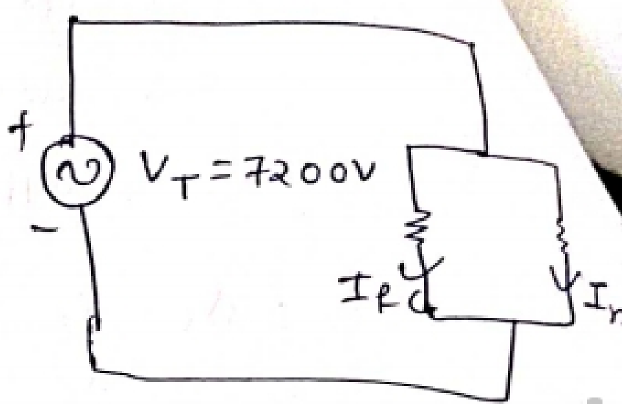
$I_0 = \sqrt{I_{fc}^2 + I_m^2}$

$I_0 = \sqrt{(0.152)^2 + (0.4166)^2}$

$\boxed{I_0 = 0.446\,A}$

$$\cos\theta = \frac{I_{fc}}{I_0}$$

$$\cos\theta = \frac{0.152}{0.446} = 0.34$$

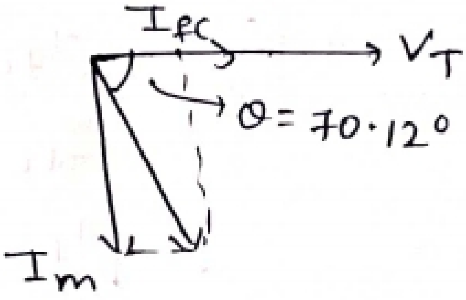


$P_{core} = 74\%$ of $P_{core} + P_e$

$$1100 = \frac{74}{100} \times 1100 + P_e$$

$$P_e = 1100 - 814$$

$$\boxed{P_e = 286\,W}$$



Ans-7 $P_h = 215\,W$

$P_e = 115\,W$

$$I_{rated} = \frac{P_{rated}}{V_{rated}} = \frac{75\,KVA}{120} = \frac{75 \times 10^3}{120} = 625\,A.$$

$$\boxed{I_m = 15.625\,A}$$

$P_{core} = P_e + P_h$

$P_{core} = 215 + 115 =$

$$\boxed{P_{core} = 330\,W}$$

$P_{core} = (120)\, I_{fc}$

$$\frac{330}{120} = I_{fc}$$

$$\boxed{I_{fc} = 2.75\,A}$$

$$I_0 = \sqrt{I_m^2 + I_{fc}^2}$$

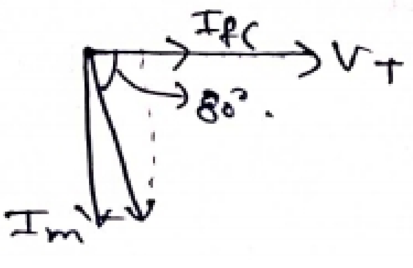
$$I_0 = \sqrt{(15.625)^2 + (2.75)^2}$$

$$\boxed{I_0 = 15.865\,A}$$

$$\cos\theta_i = \frac{I_{fc}}{I_0} = \frac{2.75}{15.865}$$

$\cos\theta_i = 0.1733$

$$\boxed{\theta_i = 80°}$$



-8

$a = \frac{\cancel{480}}{\cancel{120}} = 4$

$a = \frac{E'_{HS}}{E'_{LS}} \rightarrow E'_{LS} = \frac{460}{4}$

$\boxed{E'_{LS} = 115V}$

$I_s = \frac{115}{24\angle 32.8^\circ}$

$\boxed{I_s = 4.791\angle -32.8\ A}$

$\cancel{a=1}$

$I_p = \frac{I_s}{a}$

$I_p = \frac{4.791\angle -32.8}{4}$

$\boxed{I_p = 1.1979\angle -32.8A}$

$Z'_{in} = a^2 Z_{Load}$

$Z'_{in} = 16(24\angle 32.8^\circ)$

$\boxed{Z'_{in} = 384\angle 32.8^\circ\ \Omega}$

Ans-9 $E'_{HS} = 220$

$a = \frac{7200}{240} = 30$

$\boxed{a = 30}$

$Z_L = 144\angle 46$

$V_i = 220$

Step up transforme

$\cancel{I_s = \frac{7.33}{144\angle 46^\circ}}$

$\cancel{\boxed{I_s = 0.0509\angle -46A}}$

$\cancel{\left(a = \frac{E'_{PS}}{E'_S}\right)}$

$\cancel{E'_S = \frac{E'_{HP}}{a} = \frac{220}{30}}$

$\cancel{\boxed{E'_{LS} = 7.33V}}$

$Z_p = \frac{V_p}{I_p}$

$Z_p = \frac{220}{1375\angle -46}$

$(Z_p = 0.16\angle 46^\circ\ \Omega)$

$a = \frac{V_{HS}}{V_{LS}}$

$V_s = aV_{LS} = 30(220)$

$\boxed{V_s = 6600V}$

$I_s = \frac{V_s}{Z_L}$

$\boxed{I_s = 45.83\angle -46^\circ}$

$\left(a = \frac{I_p}{I_s}\right)$ $\boxed{I_p = 1375\angle -46^\circ}$

active power = $P = |V_p||I_p|\cos\phi$

$$P = (220)(1375)\cos 46$$

$$P = 210.1\times10^3$$

$$\boxed{P = 210.1\ \text{kW}}$$

reactive power

$$Q = |V_p||I_p|\sin\phi$$

$$= (220)(1375)\sin 46$$

$$\boxed{Q = 217.6\ \text{kvar}}$$

apparent power:

$$S = |V_p||I_p|$$

$$S = (220)(1375)$$

$$\boxed{S = 302.5\ \text{kVA}}$$

Ans-10

$$a = \frac{\cancel{2300}^{10}}{\cancel{230}} = 10 \qquad f = 60\,\text{Hz}$$

$$\boxed{a = 10}$$

$$a = \frac{E_{HS}}{E_{LS}} = \frac{V_P}{V_S} \qquad I_P = \frac{1}{a} I_S$$

$$S = \frac{150\times10^3}{\cancel{10}}$$

$$(S = 75\,\text{kVA})$$

$$P = VI\cos\phi \qquad I_P = \frac{997.2}{10}$$

$$I = \frac{150\times10^3}{230\times0.654} \qquad \boxed{I_P = 99.72\,A}$$

$$Z = \frac{V_S}{I_S} = \frac{230}{997.2} \qquad \boxed{I = 0.9972\times10^3\,A}$$

$$\boxed{Z = 0.23\,\Omega} \qquad \boxed{I_S = 997.2\,A}$$

$\frac{N_{HS}}{N_{LS}} = \frac{5}{1} = a.$

$I_{LS} = 15.6 \angle -32^\circ A$

$Z_L = 8 \angle 32^\circ \Omega$

$I_p = \frac{I_s}{a}$

$I_p = \frac{15.6 \angle -32}{5}$

$\boxed{I_p = 3.12 \angle -32 A}$

$V = IR.$

$E_{LS} = (15.6 \angle -32)(8 \angle 32)$

$\boxed{E_{LS} = 124.88V}$

$a = \frac{E_{HS}}{E_{LS}}.$

$E_{HS} = 5 \times 124.8$

$\boxed{E_{HS} = 624V}$

active power

$= P = |V_P||I_P| \cos\phi$

$P = (124.8)(3.12) \cos 32$

$\boxed{P = 1651.047W}$

operating at lower side.

Reactive power.

$Q = V_L I_2 \sin\phi$

$Q = 124.8 \times 15.6 \sin 32$

$Q = 124.8 \times 15.6 \sin 32$

$\boxed{Q = 1031.68 \text{ VAR}}$

apparent power.

$= V_L I_2$

$= 124.8 \times 15.6$

$\boxed{S = 1946.88VA}$

12 $R_{HS} = 2.98 \Omega$ $\quad X_{HS} = 6.52 \Omega$ $\quad a = \frac{7200}{480}$

$R_{LS} = 0.021 \Omega$ $\quad X_{LS} = 0.031 \Omega$

$Zeq_{HS} = R_{HS} + a^2 R_{LS} + j(X_{HS} + a^2 X_{LS})$

$Zeq_{LS} = R_{HS} + \frac{R_{LS}}{a^2} + j\left(X_{HS} + \frac{X_{LS}}{a^2}\right)$

$Zeq_{HS} = 2.98 + (15)^2(0.021) + j(6.52 + 15^2 \times 0.031)$

$\boxed{Zeq_{HS} = 7.705 + j\,13.495}$

13

$R_{HS} = 1.86$ $\quad x_{HS} = 3.41$ $\quad X_{m\,HS} = 4962$

$R_{LS} = 0.15$ $\quad X_{LS} = 0.28$ $\quad R_{fe,HS} = 19{,}501$

$Z_{eq,HS} = 1.86 + 4^2(0.15) + j\,(3.41 + 4^2(0.28))$

$a = \frac{2400}{600}$

$(a=4)$

$$\boxed{Z_{eq,HS} = 4.26 + j\,7.62}$$

$$Z_{eq,LS} = \frac{4.26 + j\,7.62}{16}$$

$$\boxed{Z_{eq,LS} = 0.26625 + j\,(0.47625)}$$

Q4

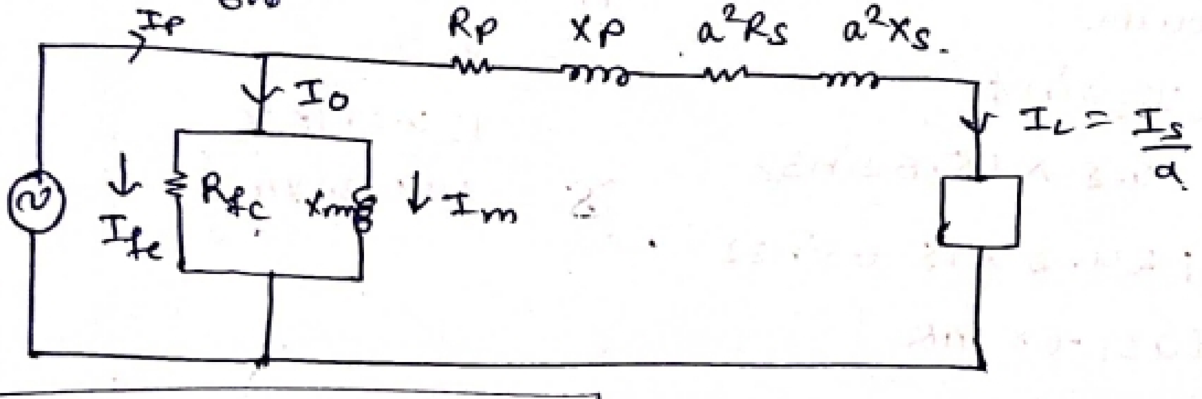
$P = VI\cos\phi$

$I_{LS} = \frac{25\times10^3}{600 \times \angle -36.87} = 41.083\ A$

$I_P = \frac{I_s}{a} = \frac{52.083}{3.666}$

$\boxed{I_P = 14.207\ A}$

$a = \frac{2200}{600} = 3.666$



$$\boxed{I_{LS} = 41.67 \angle -36.87\ A}$$

$Z_{eq\,P} = (1.4 + j\,3.2) + (3.67)^2\,(0.11 + j\,0.25)\,\Omega$

$$\boxed{Z_{eq\,P} = 7.165 \angle 66.31^\circ\,\Omega}$$

$Z_{load} = \frac{V_s}{I_s} = \frac{600}{41.67\angle -36.87} = 14.4\angle 36.87^\circ\,\Omega$

$Z_{load,P} = a^2 Z_{load} = (3.666)^2\,(14.4\angle 36.87$

$E_s' = I_s\,(R_s + jX_s + Z_{load})$

$E_s' = 41.67\angle -36.87\,(0.11 + j0.25 + 14.4\angle 66.3)$

$E_s' = 41.67\angle -36.87\,(0.11 + j0.25 + 5.788 + 13.1855j)$

$E_s' = 41.67\angle -36.87\,(0.898 + 18.9735j)$

$E_s' = (18.994\angle 87.29)(41.67\angle -36.87)$

$E_s' =$

×××××

15 $I_{rated} = 4$ $\quad I_s = \dfrac{100\times10^3}{(480)\cos\phi}$ $\quad \cos\phi_1 =$

$V_{rated} = 48V.$

$a = \dfrac{7200}{480}$

$R_{eq\,HS} = R_{HS} + a^2 R_{LS}$

$= 3.06 + 15^2(0.014)$

$\boxed{R_{eq\,HS} = 6.21\Omega}$

$\boxed{Z_{eq\,HS} = (6.21 + j12.125)\Omega}$

$X_{eq\,HS} = X_{HS} + a^2 X_{LS}$

$X_{eq\,HS} = 6.05 + 15^2\,0.027$

$\boxed{X_{eq\,HS} = 12.125\Omega}$

$\theta = \cos^{-1}0.75$

$\boxed{\theta = 41.409^\circ}$

$V_{Load} = 480V$

$I_{LS} = \dfrac{100\times10^3}{480}\angle -41.409$

$Z_{Load,LS} = \dfrac{V_L}{I_{LS}} = \dfrac{480}{208.33\angle -41.409}$

$I_{LS} = 208.33\angle -41.409$

$Z_{Load,LS} = 2.304\angle 41.409\,\Omega$

$\boxed{Z_{in\,HS} = 531.1\angle 41.95\Omega}$

$Z_{Load\,HS} = a^2 Z_{load\,LS}$

$= (15)^2\,(2.304\angle 41.409)$

$\boxed{Z_{Load\,HS} = 518.4\angle 41.409}$

$Z_{in\,HS} = Z_{Load\,HS} + Z_{eq\,HS} = 531.1\angle 41.95$

$$I_P = \frac{I_S}{a} = \frac{208.33 \angle -41.409 + 180}{15}$$

$$\boxed{I_P = 13.88 \angle +38.59}$$

I/P impedance at no load $= \dfrac{1}{\left(\frac{1}{R_{Fe}}\right) + \frac{1}{jX_m}}$

$$= \frac{1}{\frac{1}{71400} + \frac{1}{j(17809)}} = \frac{1}{\left(\frac{1}{71400} - j\frac{1}{17809}\right)}$$

$$= \frac{1}{1.40056 \times 10^{-5} - j\, 5.6151 \times 10^{-5}}$$

$$= \frac{10^5}{1.40056 - j\, 5.6151}$$

$$= \frac{10^5}{525170.94 \angle -74.532}$$

$$\boxed{Z_{in} = 0.190414 \angle 74.532\ \Omega}$$

Q6

$$a = \frac{4160}{240} = 17.33$$

$$I_S = \frac{270}{1.45 \angle -38.74} = 186.2 \angle 38.74$$

$$\boxed{I_S = 186.2 \angle 38.74\,A}$$

$$Z_{eq_{HS}} = 2.16 + (17.33)^2\, 0.0072 + j\,(3.84 + (17.33)^2\, 0.0128)$$

$$\boxed{Z_{eq_{HS}} = 4.32236 + j\,4.2044}$$

$$Z_{load} = a^2 Z_{Load\,LS} = (17.33)^2 (1.45 \angle -38.74)$$

$$= 435.476 \angle -38.74$$

$Z_{in} =$ ~~6e0299~~ $4.32236 + j\,4.2044 + 339.66 - 272.511j$

$$\boxed{Z_{in} = 343.98236 - 268.3066j}$$

~~E_{H}~~

$$E_s = I_s(R_{LS} + jX_{LS} + Z_{Load})$$

$$E_s = (186.2\angle 38.74)(0.0072 + j0.0128 + 1.13099 - 0.9073j)$$

$$= (186.2\angle 38.74)(1.13819 - 0.8945j)$$

$$= (186.2\angle 38.74)(1.447621\angle -38.16)$$

$$\boxed{E_s = 269.546\ V}$$

$$E_P = \frac{E_s}{17.33} = 15.553\ V$$

16

$R_{LS} = 0.0072$ $\quad X_{LS} = 0.0128$

$R_{HS} = 2.16$ $\quad X_{HS} = 3.84$ $\quad a = \frac{4160}{240} = 17.33$

$$V = IR$$

$$I_s = \frac{V}{R} = \frac{270}{1.45\angle -38.74}$$

$$\boxed{I_s = 186.2\angle 38.74\ A}$$

$$Z_{eq} = R_{HS} + a^2 R_{LS} + j(X_{HS} + a^2 X_{LS})$$

$$= 2.16 + 17.33^2(0.0072) + j(3.84 + (17.33)^2(0.0128))$$

$$\boxed{Z_{eq} = 4.3223 + j7.6842}$$

$$Z_{load\,LS} = 1.45\angle -38.74°$$

$$Z_{load\,LS} = 1.1309 - 0.9073j$$

$$Z_{load\,HS} = a^2 Z_{Load\,LS}$$

$$Z_{load\,HS} = 339.66 - 272.515j$$

$$Z_{in} = Z_{eq} + Z_{load\,HS}$$

$$Z_{in} = 4.3223 + 339.66 + 7.6842j - 272.515j$$

$$\boxed{Z_{in} = 343.9823 - 264.8308j}$$

17 $\{ Zeq_{HS} = 0.123 + j\,1.08\,\}$

$$a = \frac{240\cancel{0}}{48\cancel{0}}$$

$$\boxed{a = 5}$$

$$Zeq_{HS} = a^2 Zeq_{LS}$$

$$Zeq_{LS} = \frac{Zeq_{HS}}{a^2} = \frac{0.123 + j\,1.08}{25} = (4.92 + j\,0.0432)\,10^{-3}\,\Omega$$

$P = VI$

$$I_{HS} = \frac{25\cancel{0} \times 10^{2}}{240\cancel{0}}$$

$(I_{HS} = 104.16A)$

phase

$-34.92 + 180$

(145.08)

$$\boxed{Zeq_{LS} = (4.92 + j\,0.0432)\,10^{-3}\,\Omega}$$

$$\theta = \cos^{-1} 0.82$$

$$\boxed{\theta = 34.92^\circ}$$

$$I_p = \frac{I_s}{a}$$

$$\left(\cancel{V}_s = \frac{V_s}{R}\right)$$

$$I_s = I_p\, a$$

$$\boxed{I_s = 520.83 \angle -34.92}$$

$$Z_{load_{LS}} = \frac{V_s}{I_s}$$

$$Z_{load_{LS}} = \frac{480}{520.83} \angle 34.92$$

$(Z_{load_{LS}} = 0.92 \angle 34.92\,\Omega)$

$$Z_{load_p} = a^2 Z_{load_{LS}}$$

$$= 25\,(0.92) \angle 34.92$$

$$\boxed{Z_{load_p} = 23 \angle 34.92}$$

$$V_p = I_p\,(Z_{in})$$

$$V_p = I_p\,(0.123 + j\,1.08 + 23 \angle 34.92)$$

$$V_p = (104.08 \angle 145.08)\,(0.123 + j\,1.08 + 23 \angle 34.92$$

$$V_p = (104.08 \angle 145.08)\,(0.123 + j\,1.08 + 18.85 + 13.165j)$$

$$= (104.08 \angle 145.08)\,(18.973 + j\,14.245)$$

$$V_p = (104.08 \angle 145.08)\,(25.63 \angle 42.2684)$$

$$E_{ne} = V_2 = E_2 = \frac{E_1}{a} = \frac{2665}{5} = 533$$

$$reg = \frac{E_{ne} - V_{rated}}{V_{rated}} \times 100$$

$\theta = \cos^{-1} 0.7$

$\boxed{\theta = 45.57^\circ}$

$a = \frac{480}{2400} = 0.2$

$\boxed{a = 0.2}$

$= 2400\angle 0^\circ$

$I_s = \frac{250\times10^3 \angle 45.57}{2400}$

$\boxed{I_s = 104.16\angle 45.57 A}$

$I_p = \frac{I_s}{a} = 520.83 \angle -134.43^\circ A$

$\boxed{I_p = 520.83\angle -134.43^\circ A}$

$Z_{eqHS} = a^2 Z_{eqLS}$

$Z_{eqHS} = a^2(0.123 + j\,1.08)$

$= 0.2^2 (0.123 + j\,1.08)$

$Z_{eqHS} = 4.92\times10^{-3} + j\,0.0432$

$\boxed{Z_{eqHS} = 0.04347 \angle 83.50264}$

$Z_{load\,S} = \frac{V_S}{I_S}$

$\boxed{Z_{load\,p} = a^2 Z_{load\,S}}$

19

$a = \frac{4160}{2400} = 1.733$

$\theta = \cos^{-1} 0.95 = 18.194^\circ$

$\boxed{Z_{eqHS} = (0.5196 + j\,2.65)\Omega}$

$I_s = \frac{333\times10^3}{2400} \angle -18.194$

$\{ I_s = 138.75 \angle -18.194 A \}$

$Z_{Load} = \frac{V_s}{I_s} = \frac{2400 \angle 18.194}{138.75}$

$\boxed{Z_{Load} = 17.29 \angle 18.194\,\Omega}$

$I_p = \frac{I_s}{a} = 80.06 \angle -18.194$

$V_p = I_p (Z_{eqHS})$.

$V_p = I_p (Z_{eqHS} + a^2 Z_{loadLS})$

$V_p = 80.06 (49.85 + 18.8634j)$

$V_p = 80.06 (53.2999)$

$\boxed{V_p = 4267.11}$

$V_s = \frac{V_p}{a} =$

$\boxed{V_s = 2461.84\,V}$

20 (c) $a = \frac{\cancel{4800}^{10}}{\cancel{480}} = 10$, $\boxed{a = 10}$ $f = 60Hz$

$I_S = \frac{50 \times 10^3}{480} = 104.16A$

$v_s = 480\angle 0^\circ V$ $\boxed{Z_{eq\,HS} = 8.48\angle 71^\circ}$

$\{I_S = 104.16A\}$

$Z_{load} = \frac{V_S}{I_S} = \frac{480}{104.16} = 4.608\angle 0^\circ \Omega$

$Z_{load\,p} = a^2 Z_{load} = 460.8\angle 0^\circ \Omega$

$V_P = I_P(Z_{eq\,P} + Z_{load\,P})$

$\{V_P = 4831.03\angle -179^\circ V\}$

$\{I_P = \frac{I_S}{a} = 10.42\}$

$V_2 = E_2 = \frac{E_1}{a} = \frac{V_1}{a} = \frac{4831.03}{10} = \{483.103V\}$

$Z_{in\,P} = Z_{eq,P} + Z_{load\,P} = 1341.08\angle 48.82\Omega$

~~$I_m = \frac{V_P}{jX_m}$ = 0.167∠89.6 A~~

~~$\{I_m = 0.167\angle 89.6^\circ A\}$~~