Uppgift 1. a)

b)

$$P = \sqrt{3} U I \cos\varphi_2 = \sqrt{3} \cdot 400 \cdot 9 = 5175W$$

c) Alla strömmar ska summeras med riktning

$$\bar{I}_{L1} = \bar{I}_1 + \bar{I}_{S1}$$
$$\bar{I}_{L2} = \bar{I}_2 + \bar{I}_{S1}$$
$$\bar{I}_{L3} = I_{S3}$$
$$\bar{I}_1 = \frac{P_1}{U_1 \cos\varphi} = \frac{1500}{\frac{400}{\sqrt{3}} \cdot 1} = 6.5A$$

Last 1 resistiv, så U_1 och I_1 ligger i fas.

$$\arg U_1 = 0°V, \quad \bar{I}_1 = 6.5e^{j0°}A$$
$$\bar{I}_2 = \frac{36 \cdot 16}{\frac{400}{\sqrt{3}} \cdot 0.55} = 4.53A$$

Induktiv last ger att I_2 ligger vinkeln φ_2 efter spänningen U_2.

$$\varphi_2 = \cos^{-1} 0.55 = 57°$$
$$\arg U_2 = -120°V$$
$$\bar{I}_2 = 4.53e^{-j177°}A$$

Fasvinkeln för sågen är 34°, vilket leder till:

$$\bar{I}_{S,1} = 5e^{-34°}A$$
$$\bar{I}_{S,2} = 5e^{-154°}A$$
$$\bar{I}_{S,3} = 5e^{-274°}A$$

Linjeströmmarna blir nu:

$$\bar{I}_{L1} = 6.5e^{j0°} + 9e^{-j34°} = 13.96 - j5.03 = 14.8e^{-j20°}A$$
$$\bar{I}_{L2} = 4.53e^{-j177°} + 9e^{-j154°} = -12.61 - j4.19 = 13.3e^{-j162°}A$$
$$\bar{I}_{L3} = 9e^{-j274°}A$$

d) Eftersom sågen belastar nätet symmetriskt leder den inte till någon ström i nollan. Därför kan vi räkna ut I_N genom:

$$I_N = \bar{I}_1 + \bar{I}_2 = 6.5e^{j0°} + 4.53e^{-j177°} = 1.97 - j0.24 = 1.99.e^{-j7°}A$$

e)

Uppgift 2.

a)

$$P_{F0} = 7.1 + 1.1 = 8.2kW$$
$$P_{FKM} = 9.8 + 2.4 = 12.2kW$$

b) Märkströmmen fås enligt

$$S_M = \sqrt{3} \cdot U_{1M} \cdot I_{1M} = \sqrt{3} \cdot U_{2M} \cdot I_{2M} \Longrightarrow$$
$$\Longrightarrow \begin{cases} I_{1M} & = & \frac{800 \cdot 10^3}{\sqrt{3} \cdot 10 \cdot 10^3} & = & 46.2A \\ I_{2M} & = & \frac{800 \cdot 10^6}{\sqrt{3} \cdot 400} & = & 1155A \end{cases}$$

$$P_{FKM} = 3R_{2k}I_{2M}^2 \Rightarrow R_{2k} = \frac{P_{FKM}}{3I_{2M}^2} = \frac{12200}{3 \cdot 1155^2} = 3.05m\Omega$$
$$U_{2k} = U_{1k}\frac{U_{2M}}{U_{1M}} = 380 \cdot \frac{400}{10000} = 15.2V$$
$$Z_{2k} = \frac{U_{2k}}{\sqrt{3}I_{2k}} = /I_{2k} = I_{2M}/ = \frac{15.2}{\sqrt{3} \cdot 1155} = 7.6m\Omega$$
$$X_{2k} = \sqrt{Z_{2k}^2 - R_{2k}^2} = \sqrt{0.0076^2 - 0.00305^2} = 6.96m\Omega$$

Beräkna spänningsfallet:

$$\cos\varphi = 0.87 \Rightarrow \sin\varphi = 0.49$$
$$\frac{U_2}{\sqrt{3}} = \frac{U_{20}}{\sqrt{3}} - I_2(R_{2k}\cos\varphi + X_{2k}\sin\varphi) \Rightarrow$$
$$U_2 = 400 - \sqrt{3} \cdot 1155 \cdot (0.00305 \cdot 0.87 + 0.00696 \cdot 0.49) = 387.9V$$

c)

$$Q_L = 800 \cdot 0.49 = 392kVAr$$
$$Q_{ny} = 800 \cdot \sin(\cos^{-1} 0.95) = 250kVAr$$
$$Q_{kond} = Q_{ny} - Q = - - 142kVAr$$
$$Q_{kond} = -3\left(\frac{U_h}{\sqrt{3}}\right)^2 \omega C = /\omega = 2\pi f/ = -400 \cdot 2\pi \cdot 50C \Rightarrow$$
$$C = \frac{-142000}{-400^2 \cdot 2\pi \cdot 50} = 2.8mF$$

Uppgift 3. a) Shuntmagnetiserad likströmsmotor.

a) Lösning 1:

$$P_{ut} = M\omega = 36 \cdot \frac{900 \cdot 2\pi}{60} = 3393W$$
$$P_{in} = U_aI_a + U_m\frac{U_m}{R_m} = 200 \cdot 18.3 + 200 \cdot \frac{200}{275} = 3805W$$
$$\eta = \frac{P_{in}}{P_{ut}} = \frac{3393}{3805} = 0,89$$

Lösning 2:

$$E_a = 200 - 18.3 \cdot 0.7 - 2 = 185.2V$$
$$P_{ut} = E_a I_a = 185.2 \cdot 18.3 = 3389W$$
$$P_{in} = U_a I_a + U_m \frac{U_m}{R_m} = 200 \cdot 18.3 + 200 \cdot \frac{200}{275} = 3805W$$
$$\eta = \frac{P_{in}}{P_{ut}} = \frac{3393}{3805} = 0,89$$

b)

$$M_{II} = 36 \cdot 0.3 = 10.8Nm$$
$$E_{a,I} = U_{a,I} - U_b - R_a I_{a,I} = 185.2V$$
$$E_{a,I} = k_1 \phi n_I \Rightarrow k_1 \phi = \frac{E_{a,I}}{n_I} = \frac{185.2}{900} = 0.206$$
$$M_I = k_2 \phi I_{a,I} \Rightarrow k_a \phi = \frac{M_I}{I_{a,I}} = \frac{36}{18.3} = 1.97$$
$$I_{a,II} = \frac{M_{II}}{k_a \phi} = \frac{10.8}{1.97} = 5.48A$$
$$E_{a,II} = k_1 \phi n_{II} = U_{a,II} - U_b - R_a I_{a,II} \Rightarrow n_{II} = \frac{U_{a,II} - U_b - R_a I_{a,II}}{k_1 \phi} = \frac{200 - 2 - 0.7 \cdot 5.48}{0.206} = 943rpm$$

c) Tomgång innebär $M = 0$, vilket leder till $I_a = 0$.

$$n = \frac{U_a - U_b - R_a I_a}{k_1 \phi} = \frac{200 - 2 - 0,7 \cdot 0}{0.206} = 961rpm$$

Uppgift 4. a)

$$n_1 = \frac{120}{f} p$$

Poltal 6 ger $n_1 = 1000$. Därför har maskinen 6 poler. Eftersläpningen bkir

$$s = \frac{n_1 - n_2}{n_1} = \frac{1000 - 960}{1000} = 0.04$$

b)

$$P_1 = \frac{M\omega}{\eta} = \frac{154 \cdot 960 \cdot 2\pi 60}{0.89} = 17400W$$
$$I_L = \frac{P_1}{\sqrt{3} U \cos\varphi} = \frac{17400}{\sqrt{3} \cdot 400 \cdot 0.82} = 30.7A$$

c)

$$P_{cu2} = s \frac{N\omega_2}{1 - s} = 0.04 \cdot \frac{154 \cdot 1000 \frac{2\pi}{60}}{1 - 0.04} = W$$

d)

$$P_{F1} = P_1 - P_2 - P_{cu2} = 17400 - 154 \cdot 960 \frac{2\pi}{60} - 645 = 1270W$$

e) I ett svagt nät påverkas spänningens nivå av hur hårt nätet lastas. Därför kommer spänningen att sjunka om maskinen lastas och strömmen genom kablarna ökar.

f) Eftersom den matande spänningen minskar kommer motorns varvtal att minskas jämfört med det starka elnätet.

Uppgift 5. b)

$$U_L = \frac{3}{T}\int_{\frac{T}{6}}^{\frac{T}{2}} u(t)dt = \frac{3\omega}{2\pi}\int_{\frac{\pi}{3\omega}}^{\frac{\pi}{\omega}} u(t)dt = \frac{3\omega}{2\pi}\int_{\frac{\pi}{3\omega}}^{\frac{\pi}{\omega}} \hat{u}\sin(\omega t)dt =$$

$$= \frac{3\omega}{2\pi}\hat{u}\left[-\frac{\cos(\omega t)}{\omega}\right]_{\frac{\pi}{3\omega}}^{\frac{\pi}{\omega}} = \frac{3}{2\pi}\hat{u}\left(-\cos(\pi) + \cos\left(\frac{\pi}{3}\right)\right)$$

$$= \frac{3}{2\pi}\cdot\frac{400}{\sqrt{3}}\cdot\sqrt{2}\cdot(1+0.5) = 234V$$

c)

$$U = \sqrt{\frac{1}{T}\int_0^T u(t)^2 dt} = \sqrt{\frac{\hat{3}u^2}{T}\int_{\frac{T}{6}}^{T/2}\sin^2(\omega t)dt} =$$

$$\Big/ \sin^2(\omega t) = \frac{1-\cos(2\omega t)}{2}, \quad T = \frac{2\pi}{\omega} \Big/ =$$

$$= \sqrt{\frac{3\hat{u}^2}{2\pi}\omega\int_{\frac{T}{3}}^{\frac{\pi}{\omega}}\left(\frac{1}{2} - \frac{\cos(2\omega t)}{2}\right)dt} = \hat{u}\sqrt{\frac{3\omega}{2\pi}\left(\int_{\frac{\pi}{3\omega}}^{\frac{\pi}{\omega}}\frac{1}{2}dt - \int_{\frac{\pi}{3\omega}}^{\frac{\pi}{\omega}}\frac{\cos(2\omega t)}{2}dt\right)} =$$

$$= \hat{u}\sqrt{\frac{3\omega}{2\pi}\left(\left[\frac{t}{2}\right]_{\frac{\pi}{3\omega}}^{\frac{\pi}{\omega}} - \left[\frac{\sin(2\omega t)}{4\omega}\right]_{\frac{\pi}{3\omega}}^{\frac{\pi}{\omega}}\right)} = \hat{u}\sqrt{\frac{3\omega}{2\pi}\left(\frac{\pi}{2\omega} - \frac{\pi}{6\omega} - \frac{\sin(2\pi)}{4\omega} + \frac{\sin(\frac{2\pi}{3})}{4\omega}\right)}$$

$$= \hat{u}\sqrt{\frac{3}{2}\left(\frac{1}{2} - \frac{1}{6} - 0 + \frac{\sqrt{3}}{2}\cdot\frac{1}{4\pi}\right)} = \frac{400}{\sqrt{3}}\sqrt{2}\cdot\sqrt{0.603} = 253.6V$$