**Uppgift 1.** a) Se boken

b)

$$P = P_I + P_{II} = 29kW$$
$$Q = \sqrt{3}(P_{II} - P_I = \sqrt{3}(22 - 7) = 26kVAr$$
$$S = \sqrt{P^2 + Q^2} = \sqrt{29000^2 + 25981^2} = 38.9kVA$$
$$I_L = \frac{S}{\sqrt{3}U_H} = \frac{38.9}{\sqrt{3} \cdot 400} = 56.2A$$

c)

$$Q_{kond} = -Q_{ind} = -25981VAr$$
$$Q_{kond} = -3U_h^2 \omega C = /\omega = 2\pi f/ = -3 \cdot 400 \cdot 2\pi \cdot 50C \Rightarrow$$
$$C = \frac{-25981}{-3 \cdot 400^2 \cdot 2\pi \cdot 50} = 1.72 \cdot 10^{-4}F = 172\mu F$$

d)

$$Q = 0 \Rightarrow S = P = 29kVA$$
$$I_L = \frac{29000}{\sqrt{3} \cdot 400} = 41.9A$$

e) Exempel på godtagbara svar är att minskad ström leder till mindre förluster, minskat spänningsfall vid överföring, samt att lägre ström leder till att komponenter inte behöver dimensioneras efter lika stor ström.

**Uppgift 2.** a) Tomgångsvärden:

$$P_{F0} = \frac{U_0^2}{R_0} = 800W$$
$$Q_{F0} = \frac{U_0}{X_0} = 4000VAr$$
$$S_{F0} = \sqrt{P_{F0}^2 + Q_{F0}^2} = 4079VA$$
$$I_0 = \frac{S_{F0}}{\sqrt{3}U_0} = 0.12A$$

Kortslutningsvärden:

$$I_{2M} = \frac{S_M}{\sqrt{3}U_{2M}}$$
$$U_{20K} = \sqrt{3}I_{2M} \cdot |R_{2k} + j \cdot X_{2k}|$$
$$P_{FKM} = 3R_{2k}I_{2M}^2 = 2500W$$
$$U_{1k} = U_{20K}\frac{U_{1M}}{U_{2M}} = 791V$$

b)

$$I_2 = I_{2M} \cdot x$$
$$U_{20} = U_{2M}$$
$$U_2 = U_{20} - \sqrt{3}I_2(R_{2K}\cos(\varphi_2) + X_{2K}\sin(\varphi_2)) = 388,3V$$

c)

**Uppgift 3.** a) Lösning 1:

$$P_{ut} = M\omega = 32.5 \cdot \frac{1050 \cdot 2\pi}{60} = 3573W$$
$$P_{in} = P_a + P_m = U_a I_a + U_m I_m = 180 \cdot 22 + 250 \cdot \frac{250}{275} = 4187W$$
$$\eta = \frac{P_{in}}{P_{ut}} = \frac{3573}{4197} = 0,85$$

Lösning 2:

$$E_a = 180 - 22 \cdot 0.7 - 2 = 162.6V$$
$$P_{ut} = E_a I_a = 162.6 \cdot 22 = 3577W$$
$$P_{in} = P_a + P_m = U_a I_a + U_m I_m = 180 \cdot 22 + 250 \cdot \frac{250}{275} = 4187W$$
$$\eta = \frac{P_{in}}{P_{ut}} = \frac{3577}{4187} = 0.85$$

b)

$$M_{II} = \frac{32.5}{2} = 16.2Nm$$
$$E_{a,I} = U_{a,I} - U_b - R_a I_{a,I} = 162.6V$$
$$E_{a,I} = k_1 \phi n_I \Rightarrow k_1 \phi = \frac{E_{a,I}}{n_I} = \frac{162.6}{1050} = 0.155$$
$$M_I = k_2 \phi I_{a,I} \Rightarrow k_a \phi = \frac{M_I}{I_{a,I}} = \frac{32.5}{22} = 1.48$$
$$I_{a,II} = \frac{M_{II}}{k_a \phi} = \frac{16.2}{1.48} = 11A$$
$$E_{a,II} = k_1 \phi n_{II} = U_{a,II} - U_b - R_a I_{a,II} \Rightarrow n_{II} = \frac{U_{a,II} - U_b - R_a I_{a,II}}{k_1 \phi} = \frac{180 - 2 - 0.7 \cdot 11}{0.155} = 1100rpm$$

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

$$n = \frac{U_a - U_b - R_a I_a}{k_1 \phi} = \frac{180 - 2 - 0,7 \cdot 0}{0.155} = 1150rpm$$

**Uppgift 4.** a) 4 poler (synkront varvtal 1500 rpm).

b)

$$P_2 = M\frac{n_2 \cdot 2\pi}{60} = 21\frac{1410 \cdot 2\pi}{60} = 3101W$$
$$P_1 = \frac{P_2}{\eta} = \frac{3101}{0.85} = 3648W$$
$$I_L = \frac{P_1}{\sqrt{3} U_H \cos\varphi_2} = \frac{3648}{\sqrt{3} \cdot 400 \cdot 0.78} = 6.75A$$

c)

$$
\begin{aligned}
U_I = U_F &= \frac{400}{\sqrt{3}} V \\
s_I &= \frac{1500 - 1410}{1500} = 0.06 \\
M &= k_0 U_I^2 s_I \Rightarrow k_0 = 0.0066 \\
U_{II} &= U_H = 400V \\
M &= k_0 U_{II}^2 s_{II} \Rightarrow s_{II} = 0.020 \\
n_{2,II} &= 1500(1 - s_{II}) = 1470rpm
\end{aligned}
$$

**Uppgift 5.** a) Kort ledning ($< 50km$). Ledningskapacitanser försummas, men ledningsresistans $R_L$ och reaktans $X_L$ beaktas. Vi har att

$$
\begin{aligned}
U_2 &= 20 \text{ kV} \\
R_L &= \frac{17.2}{150} \cdot 20 = 2.29 \ \Omega/\text{fas} \\
X_L &= 20 \cdot 0,4 = 8 \ \Omega/\text{fas}
\end{aligned}
$$

Använd spänningsfallsformeln uttryckt i effekt

$$
\begin{aligned}
P_2 &= 5 + 4 = 9 \text{ MW} \\
Q_2 &= \frac{5}{0.8} \cdot 0.6 = 3.75 \text{ MVAr} \\
U_1 &\approx U_2 \left( 1 + \frac{P_2 \cdot R_L + Q_2 \cdot X_L}{U_2^2} \right) = 21.2 \text{ kV}
\end{aligned}
$$

b)

$$
\begin{aligned}
S_2 &= \sqrt{P_2^2 + Q_2^2} = 9.75MVA \\
I &= \frac{S_2}{\sqrt{3}U_2} = \frac{9.75 \cdot 10^6}{\sqrt{3} \cdot 20000} = 281A
\end{aligned}
$$

c)

$$
\begin{aligned}
P_l &= 3R_L I^2 = 544kW \\
Q_l &= 3X_l I^2 = 1.9MVAr
\end{aligned}
$$

d) Reaktiv effekt begränsas av ledningens reaktans, och aktiv effekt av ledningens resistans.