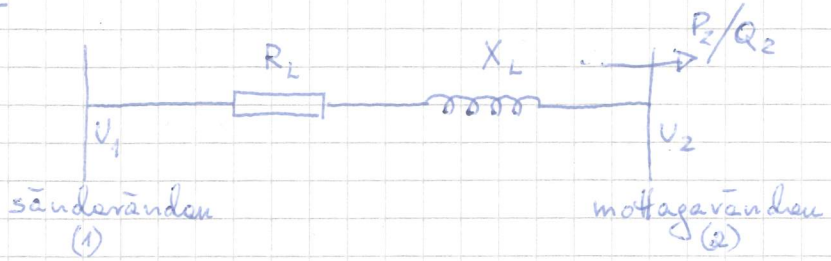
3.1 *

3.1



$l = 40\,km$; $r = 0{,}25\ \Omega/km$, fas ; $x = 0{,}4\ \Omega/km$, fas

$P_2 = 4{,}15\ MW$; $\cos\varphi_2 = 0{,}8$; $U_2 = 30\,kV$

$U_{längsf} = a = R_L I \cos\varphi_2 + X_L I \sin\varphi_2$ $\quad / \cdot \sqrt{3}\,U_2$

$U_{tvärf} = b = X_L I \cos\varphi_2 - R_L I \sin\varphi_2$ $\quad / \sqrt{3}\,U_2$

$$U_{längs} = \frac{R_L P_2 + X_L Q_2}{U_2} \quad \text{(som huvudsp)}$$

$$U_{tvär} = \frac{X_L P_2 - R_L Q_2}{U_2} \quad \text{"}$$

a) med tvärspänningsfallet: $X_L = 0{,}4 \cdot 40 = 16\ \Omega/fas$

$Q_2 = P_2 \tan\varphi_2 = 3{,}11\ MVAr$; $R_L = 0{,}25 \cdot 40 = 10\ \Omega/fas$

$$U_{längs} = \frac{10 \cdot 4{,}15 + 16 \cdot 3{,}11}{30} \approx 3{,}04\ kV$$

$$U_{tvär} = \frac{16 \cdot 4{,}15 - 10 \cdot 3{,}11}{30} \approx 1{,}18\ kV$$

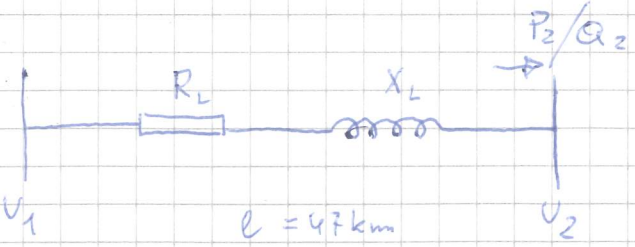
$$U_1 = \sqrt{(U_2 + U_{längs})^2 + U_{tvär}^2} = 33{,}06\ kV$$

vita visardiagr.

b) Utan tvärspänningsfallet:

$U_1 = U_2 + U_{längs} = 33{,}04\ kV$

3.2 *



3.2

$U_2 = ?$ om $U_1 = 51\,kV$

Linjen:

försumma tvärsp.f.

$R_L = r \cdot \ell = 0{,}18 \cdot 47 = 8{,}46$ Ω/fas

$X_L = x \cdot \ell = 0{,}30 \cdot 47 = 14{,}10$ Ω/fas

Belastningen:

P MW	cos φ	Q MVAr
2,2	0,9	1,07
1,7	0,8	1,28
0,6	0,6 kap	-0,8

$P_2 = 4{,}5\,MW$ $\quad Q_2 = 1{,}55\,MVAr$

$$U_1 = U_2 + \frac{R_L P_2 + X_L Q_2}{U_2} \; ; \quad U_2^2 - U_1 U_2 + R_L P_2 + X_L Q_2 = 0$$

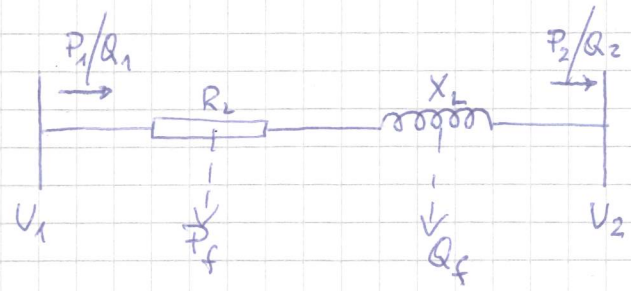
$$R_L P_2 + X_L Q_2 = 8{,}46 \cdot 4{,}5 + 14{,}1 \cdot 1{,}55 = 59{,}9$$

$$U_2^2 - 51 U_2 + 59{,}9 = 0$$

$$U_2 = 25{,}5 \pm \sqrt{25{,}5^2 - 59{,}9} = 25{,}5 \pm 24{,}3$$

$U_2 = 49{,}8\,kV$ $\quad (\Delta U = 25{,}5 - 24{,}3 = 1{,}2\,kV)$

3.3 *



3.3

$(1\,\Omega m = 10^6\,\Omega mm^2/m)$

$\rho = 17{,}5\ \Omega mm^2/km$

Linjen: $R_L = \rho \frac{l}{A} = 17{,}5 \cdot \frac{40}{120} = 5{,}8\ \Omega/fas$

$X_L = 0{,}4 \cdot 40 = 16\ \Omega/fas$

Lasten:

$P_2 = 12\,MW$; $\cos\varphi_2 = 0{,}8 \Rightarrow Q_2 = 9\,MVAr \Rightarrow S_2 = 15\,MVA$

$U_2 = 54\,kV$

a) Visardiagram:

Försumma tvärsp.fallet

$$U_{längs} = \frac{R_L P_2 + X_L Q_2}{U_2} = \frac{5{,}8 \cdot 12 + 16 \cdot 9}{54} = 3{,}96\ kV$$

$$U_1 = U_2 + U_{längs} \approx 58\ kV$$

$P_f = 3 R_L I^2$; $Q_f = 3 X_L I^2$

$$I = \frac{S_2}{\sqrt{3}\,U_2} = \frac{15}{\sqrt{3} \cdot 54} = 0{,}16\ kA$$

$P_f = 3 \cdot 5{,}8 \cdot 0{,}16^2 = 0{,}45\ MW$

$Q_f = 3 \cdot 16 \cdot 0{,}16^2 = 1{,}23\ MVAr$

b) Förlustsummeringsmetoden:

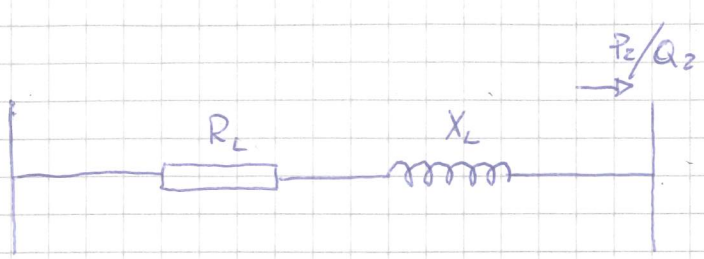
$P_1 = P_2 + P_f = 12 + 0{,}45 = 12{,}45\ MW$

$Q_2 = Q_2 + Q_f = 9 + 1{,}23 = 10{,}23\ MVAr$

$S_1 = \sqrt{12{,}45^2 + 10{,}23^2} = 16{,}1\ MVA$; $S_1 = \sqrt{3}\,U_1 I$ där $I = 0{,}16\ kA$

$$U_1 = \frac{16{,}1}{\sqrt{3} \cdot 0{,}16} = 58{,}1\ kV$$

3.4



3.4

$R_L = 5\ \Omega/\text{fas}$

$X_L = 8\ \Omega/\text{fas}$

Före:

$U_1 = 21\,kV$ $\qquad$ $U_2 = ?$

$S_2 = 5\,MVA$; $\cos\varphi_2 = 0{,}8 \Rightarrow$

$P_2 = 0{,}8 \cdot 5 = 4\,MW$

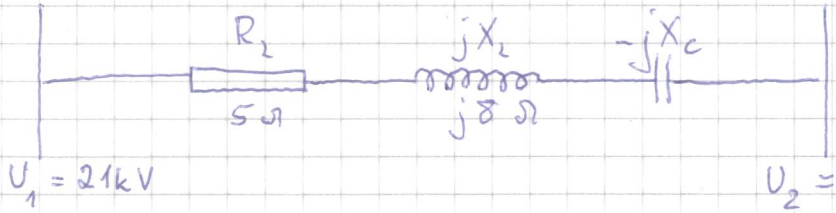
$Q_2 = 0{,}6 \cdot 5 = 3\,MVAr$

$$U_{längs} = \frac{R_L P_2 + X_L Q_2}{U_2} = \frac{5 \cdot 4 + 8 \cdot 3}{U_2} = \frac{44}{U_2}\ kV$$

$$U_1 \approx U_2 + U_{längs} \Rightarrow 21 = U_2 + \frac{44}{U_2} \Rightarrow U_2^2 - 21U_2 + 44 = 0$$

$U_2 = 10{,}5 \pm 8{,}1 \Rightarrow U_2 = 18{,}6\,kV$ $\qquad$ $(U_{längs} = 2{,}4\,kV)$

Efter:

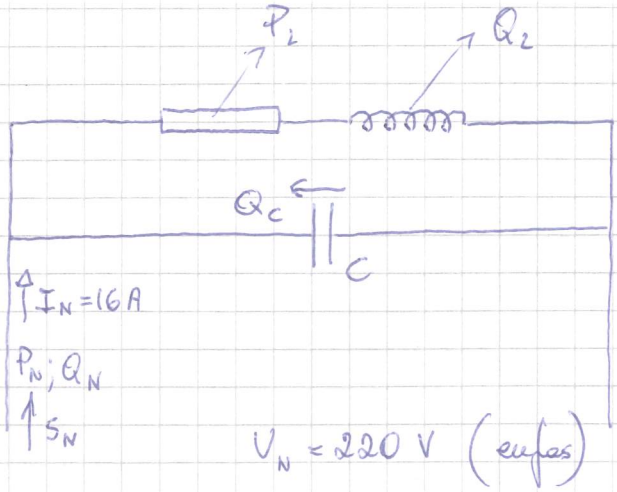


$U_{längs} = 21 - 20{,}5 = 0{,}5\,kV$

$$0{,}5 = \frac{R_L P_2 + (X_L - X_C) Q_2}{U_2} \Rightarrow 10{,}25 = 20 + 24 - 3X_C$$

$3X_C = 33{,}75 \Rightarrow \underline{X_C = 11{,}25\ \Omega/\text{fas}}$

3.5



3.5

$f = 50\,Hz$

$I = 22{,}73\,A$

1. Lysrören: $P_L = 3\,kW$; $\cos\varphi_L = 0{,}6 \Rightarrow Q_L = 4\,kVAr$

$\Rightarrow$ Behov: $P_L = 3\,kW$; $Q_L = 4\,kVAr$

2. Nätet:

$$S_N = U_N I_N = 220 \cdot 16 = 3{,}52\,kVA$$

$$P_N = P_L = 3\,kW$$

$$Q_N = \sqrt{S_N^2 - P_N^2} = \sqrt{3{,}52^2 - 3^2} = 1{,}84\,kVAr$$

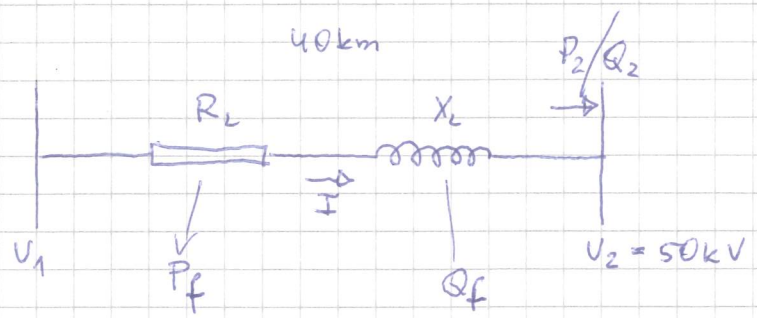
Från nätet: $\begin{cases} P_N = 3\,kW \\ Q_N = 1{,}84\,kVAr \end{cases}$

$$Q_N + Q_C = Q_L \Rightarrow Q_C = Q_L - Q_N = 4 - 1{,}84 = 2{,}16\,kVAr$$

$Q_C = \omega C U_C^2$ där $U_C = 220\,V$

$$C = \frac{2160}{100\pi \cdot 220^2} \approx 142\,\mu F$$

3.6 3.6



a)

$$R_L = \rho \frac{\ell}{A} = 17,5 \cdot \frac{40}{70} = 10\ \Omega/fas$$

$$X_L = x\ell = 0,4 \cdot 40 = 16\ \Omega/fas$$

$P_2 = 8\,MW$; $\cos\varphi_2 = 0,8 \Rightarrow Q_2 = 6\,MVAr \Rightarrow S_2 = 10\,MVA$

$$U_{lángs} = \frac{R_L P_2 + X_L Q_2}{U_2} = \frac{10 \cdot 8 + 16 \cdot 6}{50} = 3,52\,kV$$

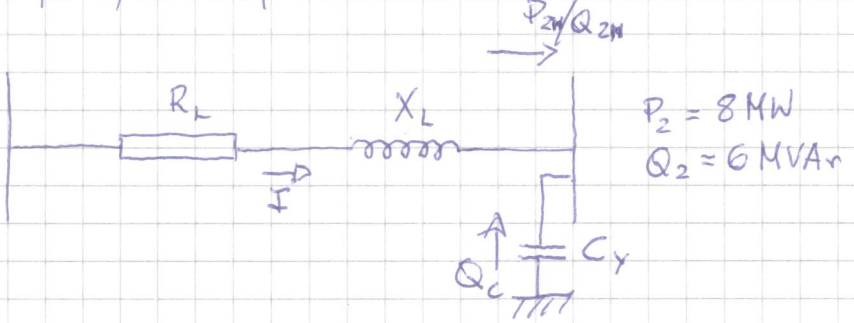
$$U_1 = 50 + 3,52 = 53,52\,kV$$

$$P_f = 3 R_L I^2 \quad ; \quad Q_f = 3 X_L I^2 \quad ; \quad I = \frac{S_2}{\sqrt{3}\,U_2} = \frac{10}{\sqrt{3} \cdot 50} = \frac{1}{5\sqrt{3}}\ kA \quad (115,5\,A)$$

$$P_f = 3 \cdot 10 \cdot \frac{1}{25 \cdot 3} = 0,4\,MW$$

$$Q_f = 1,6 \cdot 0,4 = 0,64\,MVAr$$

b)



$$P_{fard} = 3 R_L I^2 = 0,3\,MW \Rightarrow I = 0,1\,kA$$

$$S_2 = \sqrt{3}\,U_2 \cdot I \Rightarrow S_{2N} = \sqrt{3} \cdot 50 \cdot 0,1 = 5\sqrt{3}\ MVA$$

$$P_{2N} = P_2 = 8\,MW$$

$$Q_{2N} = \sqrt{S_{2N}^2 - P_{2N}^2} = \sqrt{(5\sqrt{3})^2 - 8^2} = 3,32\,MVAr$$

$$Q_{2N} + Q_c = Q_2 \Rightarrow Q_c = 6 - 3,32 = 2,68\,MVAr$$

$$Q_c = 3\omega C_Y U_c^2 = 3\omega C_Y \left(\frac{U_2}{\sqrt{3}}\right)^2 = \omega C_Y U_2^2 \Rightarrow C_Y = \frac{Q_c}{\omega U_2^2}$$

$$C_Y = \frac{2,68 \cdot 10^6}{100\pi \cdot (50 \cdot 10^3)^2} = 3,41\,\mu F/fas$$