4.1

$U_1 = 220\,V$ $\quad S = 75\,VA$ $\quad f = 50\,Hz$

$U_2 = 15\,V$

$A_{Fe} = (0,02 \cdot 0,03)\,m^2$ $\quad N_1;\ N_2 = ?$

$k_f = 0,9$

$\hat{B} = 1,2\,T$; $S_{Cu} = 2,5\,A/mm^2$; $\Delta U = 5\,\%$

a) Transf. formel

$$U_1 = 4,44\, f\, N_1\, A_{Fen}\, \hat{B} \qquad A_{Fenetto} = k_f\, A_{Fe}$$

$$N_1 = \frac{220}{4,44 \cdot 50 \cdot 0,02\ 0,03 \cdot 0,9 \cdot 1,2} = \underline{1530 \text{ varv}}$$

Vid tomgång är $U_2 = 15 \cdot 1,05 = 15,75\,V$

$$\frac{U_1}{U_2} = \frac{N_1}{N_2} \Rightarrow N_2 = \frac{U_2}{U_1} N_1 = \frac{15,75}{220} \cdot 1530 = \underline{110 \text{ varv}}$$

$$I_2 = \frac{S}{U_2} = \frac{75}{15} = 5A \Rightarrow A_{2Cu} = \frac{I_2}{S_{Cu}} = \frac{5}{2,5} = \underline{2\ mm^2}$$

$$I_1 = I_2 \frac{N_2}{N_1} = 5\,\frac{110}{1530} = 0,359A \Rightarrow A_{1Cu} = \frac{0,359}{2,5} = \underline{0,144 mm^2}$$

laminerad plåt $0,3 - 0,6\,mm$

ev. orienterad magnetiskt - goda magn. egenskaper i valsriktn.

legerad med 5-6 % kisel

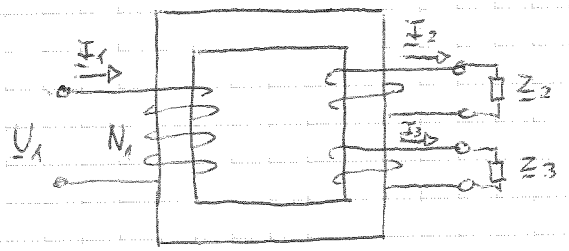
$$E = 4,44\, f N (A) \hat{B}$$

(A) = netto area

$$V = \frac{1}{s} \cdot m^2 \cdot \frac{Vs}{m^2}$$

4.2

en ideal trafo



$N_1 = 500$ $\quad U_1 = 150\ V$ $\quad \underline{I}_1 = ?$

$N_2 = 300$ $\quad \underline{Z}_2 = (30 + j40)\ \Omega$ $\quad \underline{I}_2 = ?$

$N_3 = 200$ $\quad \underline{Z}_3 \rightarrow R_3 // X_3$ $\quad \underline{I}_3 = ?$

$$\frac{U_1}{U_2} = \frac{N_1}{N_2} \Rightarrow U_2 = U_1 \frac{N_2}{N_1} = 150 \cdot \frac{300}{500} = 90\ V$$

$$U_3 = U_1 \frac{N_3}{N_1} = 150\ \frac{200}{500} = 60\ V$$

$$\underline{Z}_2 = 30 + j40 = 50\ \angle 53{,}13^\circ\ \Omega$$

$$\underline{I}_2 = \frac{\underline{U}_2}{\underline{Z}_2} = \frac{90\ \angle 0^\circ}{50\ \angle 53{,}13^\circ} = 1{,}8\ \angle -53{,}13^\circ\ A$$

$$\underline{Z}_3 = \frac{12 \cdot (-j15)}{12 - j15} = \frac{-j180}{12 - j15} = \frac{180\ \angle -90^\circ}{19{,}2\ \angle -51{,}34^\circ} = 9{,}4\ \angle -38{,}66^\circ\ \Omega$$

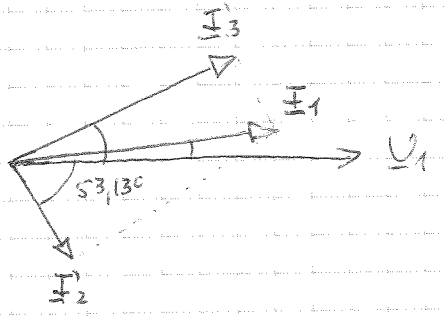
$$\underline{I}_3 = \frac{60\ \angle 0^\circ}{9{,}4\ \angle -38{,}66^\circ} = 6{,}4\ \angle 38{,}66^\circ\ A$$

$$\underline{I}_1 = \underline{I}_2' + \underline{I}_3' = (1{,}8\ \angle -53{,}13^\circ)\ \frac{N_2}{N_1} + \frac{N_3}{N_1}\ 6{,}4\ \angle 38{,}66^\circ =$$

$$= 1{,}08\ \angle -53{,}13^\circ + 2{,}56\ \angle 38{,}66^\circ = 0{,}65 - j0{,}86 + 2 + j1{,}6 =$$

$$= 2{,}65 + j0{,}74 = 2{,}75\ \angle 15{,}6^\circ\ A$$

b)



$\cos 15{,}6^\circ = 0{,}963$ kap

Alt:

Lindning 2: $Z_2 = 30 + j40 \Rightarrow |Z_2| = 50\,\Omega$

$$I_2 = \frac{90}{50} = 1{,}8\,A \Rightarrow P_2 = R_2 I_2^2 = 30 \cdot 1{,}8^2 = 97{,}2\,W$$

$$Q_2 = X_2 I_2^2 = 40 \cdot 1{,}8^2 = 129{,}6\,VAr$$

Lindning 3:

$$P_3 = \frac{U_3^2}{R_3} = \frac{60^2}{12} = 300\,W \; ; \quad Q_3 = \frac{60^2}{15} = 240\,VAr$$

$$S_3 = \sqrt{300^2 + 240^2} = 384{,}2\,VA$$

$$I_3 = \frac{S_3}{U_3} = \frac{384{,}2}{60} = 6{,}4\,A$$

Lindning 1:

$$P_1 = P_2 + P_3 = 97{,}2 + 300 = 397{,}2\,W$$

$$Q_1 = Q_2 - Q_3 = 129{,}6 - 240 = -110{,}4\,VAr$$

$\therefore$ kapacitivt

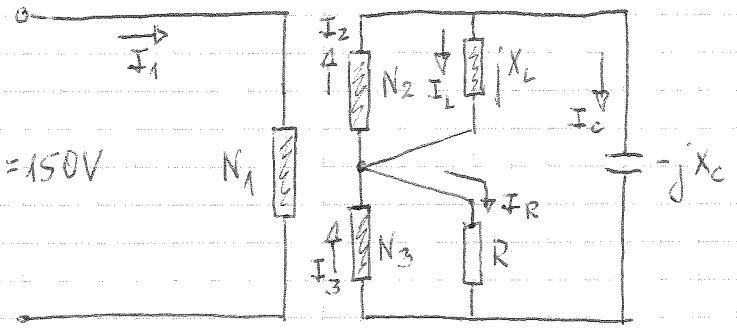
$$S_1 = \sqrt{(397{,}2)^2 + (110{,}4)^2} = 412{,}26\,VA$$

$$\cos\varphi = \frac{P_1}{S_1} = 0{,}963 \quad \text{kap}$$

$$I_1 = \frac{S_1}{U_1} = 2{,}75\,A$$

4.3

4.3



$U_2 = 90\,V$

$U_3 = 60\,V$

$N_2 = 300$

$N_3 = 200$

a) F_m balans $\quad N_1 \underline{I}_1 = N_2 \underline{I}_2 + N_3 \underline{I}_3$

$$\underline{I}_2 = \underline{I}_L + \underline{I}_C = \frac{U_2}{jX_L} + \frac{U_2 + U_3}{-jX_C}$$

$$\underline{I}_3 = \underline{I}_R + \underline{I}_C = \frac{U_3}{R} + \frac{U_2 + U_3}{-jX_C}$$

$$N_1 \underline{I}_1 = \underbrace{j\frac{(U_2+U_3)N_2}{X_C} - j\frac{U_2 N_2}{X_L} + j\frac{(U_2+U_3)N_3}{X_C}}_{I_1 \to min \to = 0} + \underbrace{\frac{U_3 N_3}{R}}_{\text{kan inte göras något åt}}$$

$$\Rightarrow \frac{U_2+U_3}{X_C} N_2 + \frac{U_2+U_3}{X_C} N_3 = \frac{U_2}{X_L} N_2$$

$$\frac{(U_2+U_3)(N_2+N_3)}{X_C} = \frac{U_2}{X_L} N_2 \Rightarrow X_C = \frac{(U_2+U_3)(N_2+N_3)}{U_2 N_2} X_L =$$

$$= \frac{150 \cdot 500}{90 \cdot 300} \cdot 10 = \underline{27{,}78\,\Omega}$$

b) $\underline{I}_2 = -j\frac{90}{10} + j\frac{150}{27{,}8} = -j9 + j5{,}4 = -j3{,}6\ A \quad |I_2| = \underline{3{,}6\,A}$

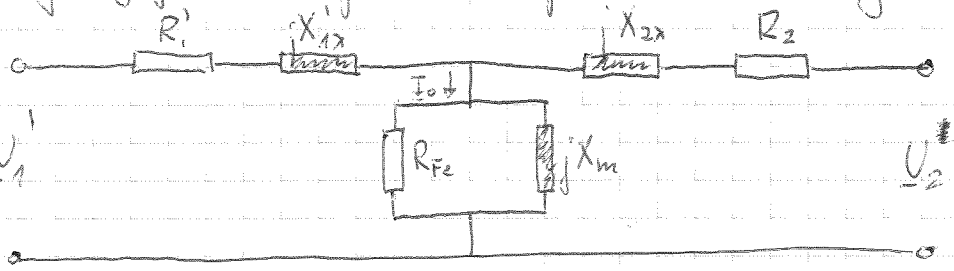
$$\underline{I}_3 = \frac{60}{4{,}5} + j5{,}4 = 13{,}3 + j5{,}4 = 14{,}4\angle 22{,}1^\circ\ A \quad |I_3| = \underline{14{,}4\,A}$$

$$\underline{I}_1 = \underline{I}_2' + \underline{I}_3' = -j3{,}6\,\frac{300}{500} + (13{,}3 + j5{,}4)\frac{200}{500} = -j2{,}16 + 5{,}32 + j2{,}16 =$$

$$= \underline{5{,}32\,A}$$

4.4 $S_n = 25\,kVA$; $400/230\,V$; en enfas trafo 4.4

Tomgångsprovet från nedspänningssida → börja med b)



$$U_2 = U_0 \Rightarrow P_0 = \frac{U_0^2}{R_{Fe}} \Rightarrow R_{Fe} = \frac{U_0^2}{P_0} = \frac{230^2}{275} = 192{,}4\ \Omega$$

$$S_0 = U_0 I_0 = 230 \cdot 7{,}8 = 1794\ VA$$

$$Q_0 = \sqrt{S_0^2 - P_0^2} = \sqrt{1794^2 - 275^2} = 1772{,}8\ VAr$$

$$X_m = \frac{U_0^2}{Q_0} = \frac{230^2}{1772{,}8} = 29{,}84\ \Omega$$

$$R_1' = \left(\frac{U_2}{U_1}\right)^2 \cdot R_1 = \left(\frac{230}{400}\right)^2 \cdot 0{,}031 = 0{,}010\ \Omega$$

$$X_{1\sigma}' = \left(\frac{U_2}{U_1}\right)^2 \cdot X_{1\sigma} = \left(\frac{230}{400}\right)^2 \cdot 0{,}15 = 0{,}05\ \Omega \qquad X_{\sigma 1}$$

$R_1' = 0{,}010\ \Omega$ $\quad R_2 = 0{,}011\ \Omega$ $\quad R_{Fe} = 192{,}4\ \Omega$

$X_{1\sigma}' = 0{,}05\ \Omega$ $\quad X_{2\sigma} = 0{,}05\ \Omega$ $\quad X_m = 29{,}84\ \Omega$

a) 400 V-sidan

$$R_2' = \left(\frac{U_1}{U_2}\right)^2 \cdot R_2 = \left(\frac{400}{230}\right)^2 \cdot 0{,}011 = 0{,}033\ \Omega$$

$$X_{2\sigma}' = \left(\quad\right)^2 \cdot X_{2\sigma} = \left(\quad\right)^2 \cdot 0{,}05 = 0{,}15\ \Omega$$

$$R_{Fe}' = \left(\quad\right)^2 \cdot R_{Fe} = \left(\quad\right)^2 \cdot 192{,}4 = 581{,}9\ \Omega$$

$$X_m' = \left(\quad\right)^2 \cdot X_m = \left(\quad\right)^2 \cdot 29{,}84 = 90{,}25\ \Omega$$

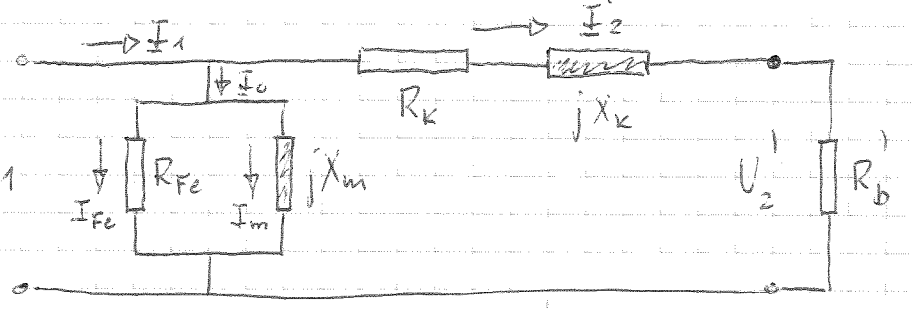
$R_1 = 0{,}031\ \Omega$
$X_{1\sigma} = 0{,}15\ \Omega$
$R_2' = 0{,}033\ \Omega$
$X_{2\sigma}' = 0{,}15\ \Omega$
$R_{Fe}' = 581{,}9\ \Omega$
$X_m' = 90{,}25\ \Omega$

4.5

$U_1 = 400\ V$; $R_b = 2{,}3\ \Omega$

Trafos förenklade ekv. schema:

a)



enl. 4:4:

$R_{Fe} = 581{,}9\ \Omega$

$X_m = 90{,}25\ \Omega$

$R_K = R_1 + R_2' = 0{,}031 + 0{,}033 = 0{,}064\ \Omega$

$X_K = X_{1\sigma} + X_{2\sigma}' = 0{,}15 + 0{,}15 = 0{,}3\ \Omega$

$\underline{Z}_K = 0{,}064 + j\,0{,}3\ \Omega$

$\underline{Z}_b' = R_b' = R_b \left(\frac{400}{230}\right)^2 = 6{,}96\ \Omega$

$$\underline{I}_2' = \frac{\underline{U}_1}{\underline{Z}_K + \underline{Z}_b'} = \frac{400\angle 0^\circ}{0{,}064 + j\,0{,}3 + 6{,}96} = \frac{400\angle 0^\circ}{7{,}02 + j\,0{,}3} = \frac{400\angle 0^\circ}{7{,}03\angle 2{,}45^\circ} =$$

$$= 56{,}9\angle -2{,}45^\circ = (56{,}85 - j\,2{,}43)\ A$$

$$I_2 = I_2' \frac{U_1}{U_2} = 56{,}9 \frac{400}{230} = \underline{98{,}95\ A}$$

$\underline{I}_1 = \underline{I}_2' + \underline{I}_0$

$I_{Fe} = \frac{U_1}{R_{Fe}} = 0{,}69\ A$; $I_m = \frac{U_1}{X_m} = 4{,}43\ A$

$\underline{I}_0 = (0{,}69 - j\,4{,}43)\ A$ 4,48A

$I_1 = 56{,}85 - j\,2{,}43 + 0{,}69 - j\,4{,}43 = 57{,}54 - j\,6{,}86 = 57{,}95\angle -6{,}8^\circ\ A$

$\underline{I_1 = 57{,}95\ A}$

liten I_0 -> försummas ofta

7,7 %

b) $U_2 = I_2 \cdot R_b = 98,95 \cdot 2,3 = \underline{\underline{227,6\ V}}$

c) $P_2 = R_b I_2^2 = 2,3 \left(98,95\right)^2 = 22520\ W$

$P_0 = 275\ W$

$P_{cu} = R_k \left(I_2'\right)^2 = 0,064 \cdot \left(56,9\right)^2 = 207,2\ W$

$P_{förl} = 275 + 207,2 = 482,2\ W$

$$\eta = \frac{P_2}{P_1} = \frac{P_2}{P_2 + P_f} = \frac{22520}{22520 + 482,2} = 0,979$$

$$\underline{\underline{\eta = 97,9\ \%}}$$

4.6 4.6

$I_2 = 99\,A$; $\cos\varphi_2 = 0{,}7$; $U_1 = 400\,V$

a) $R_k = 0{,}064\,\Omega$, $X_k = 0{,}3\,\Omega$ } enl. 4.5

$$I_2' = I_2 \frac{U_2}{U_1} = 99 \frac{230}{400} = 56{,}93\,A$$

$$\Delta U = I_2' (R_k \cos\varphi_2 + X_k \sin\varphi_2) =$$

$$= 56{,}93 (0{,}064 \cdot 0{,}7 + 0{,}3 \cdot 0{,}71) = 14{,}75\,V$$

$$U_2' = 400 - 14{,}75 = 385{,}25\,V$$

$$\underline{U_2} = 385{,}25 \frac{230}{400} = \underline{221{,}5\,V}$$

b) $\underline{P_{förl} = 482{,}2\,W}$ enl. 4.5 (samma U_1 och I_2)

$$P_2 = U_2 I_2 \cos\varphi_2 = 221{,}5 \cdot 99 \cdot 0{,}7 = \underline{15351\,W}$$

$$P_1 = P_2 + P_{förl} = 15351 + 482 = \underline{15833\,W}$$

$$\eta = \frac{P_2}{P_1} = 0{,}969 \triangleq \underline{96{,}9\,\%}$$

Om 3-fas värme med ekv. Y-fas R_k ..... anges ev. Δ kopplade last gör om till Y

Om kod provat →

Enfastrafo

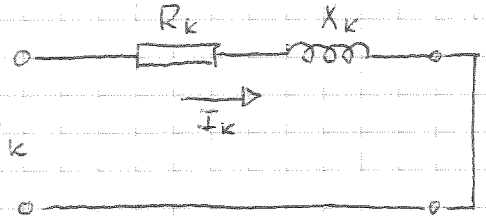
a) Ksl prov utförs med märkström från högsp. sidan med nedsp. sidan kortsluten

$U_{1n} = 3300\ V$; $S_n = 50\ kVA$

$$I_{1n} = \frac{S_n}{U_{1n}} = \frac{50 \cdot 10^3}{3{,}3 \cdot 10^3} = 15{,}15\ A$$

$$I_k = I_{1n}$$

Mha ksl. prov får vi fram R_k och X_k:



$U_k = 155\ V$; $P_k = 587\ W$

$P_k = R_k I_k^2 \Rightarrow$

$$R_k = \frac{P_k}{I_k^2} = \frac{587}{15{,}15^2} = 2{,}56\ \Omega \quad ; \quad Z_k = \frac{U_k}{I_k} = \frac{155}{15{,}15} = 10{,}23\ \Omega$$

$$X_k = \sqrt{Z_k^2 - R_k^2} = 9{,}91\ \Omega \Rightarrow \underline{Z}_k = (2{,}56 + j\,9{,}91)\ \Omega$$

$$I_{2n} = \frac{S_n}{U_{2n}} = \frac{50 \cdot 10^3}{0{,}4 \cdot 10^3} = 125\ A \quad ; \quad I_2 = 0{,}8 \cdot I_{2n} = 100\ A$$

$$I_2' = I_2 \frac{U_{2n}}{U_{1n}} = 100\ \frac{400}{3300} = 12{,}12\ A \qquad \text{se *)} \rightarrow$$

$$\Delta U = I_2' \left(R_k \cos\varphi_2 + X_k \sin\varphi_2\right) = 12{,}12\left(2{,}56 \cdot 0{,}75 + 9{,}91 \cdot 0{,}66\right) =$$
$$= 102{,}7\ V$$

$$U_2' = U_1 - \Delta U = 3300 - 102{,}7 = 3197{,}3\ V$$

$$\underline{U_2} = U_2' \frac{U_{2n}}{U_{1n}} = 3197{,}3\ \frac{0{,}4}{3{,}3} = \underline{387{,}5\ V}$$

4.7

$P_0 = 450\,W$

b) $P_1 = P_2 + P_{förl}$

$P_{förl} = P_0 + P_{cu} = P_0 + R_k (I_2')^2 = 450 + 2{,}56 (12{,}12)^2 =$

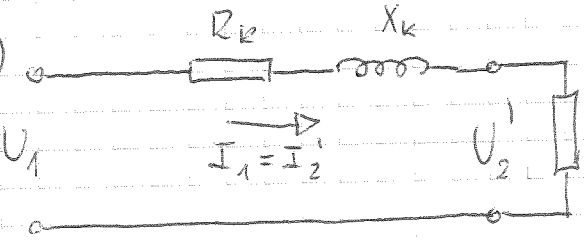
$= 450 + 376 = 826\,W$

$P_2 = U_2 I_2 \cos\varphi_2 = 387{,}5 \cdot 100 \cdot 0{,}75 = 29063\,W$

$P_1 = 29063 + 826 = 29889\,W \approx 29{,}9\,kW$

$\eta = \frac{P_2}{P_1} = \frac{29063}{29889} = 0{,}972 \Rightarrow \eta = 97{,}2\,\%$

*)



Enfastrafo

$S_n = 40\,kVA$; $1,5/0,23\,kV$

$U_k = 125\,V$; $P_k = 550\,W$; $P_0 = 385\,W$

$S_2 = 30\,kVA$; $\cos\varphi_2 = 0,72$

a) Ksl. prov från 1,5 kV sidan:

$$I_{1n} = \frac{S_n}{U_{1n}} = \frac{40\cdot 10^3}{1,5\cdot 10^3} = 26,7\,A \Rightarrow I_k = I_{1n}$$

$$R_k = \frac{P_k}{I_k^2} = \frac{550}{26,7^2} = 0,77\,\Omega$$

$$Z_k = \frac{U_k}{I_k} = \frac{125}{26,7} = 4,68\,\Omega \; ; \; X_k = \sqrt{Z_k^2 - R_k^2} = 4,62\,\Omega$$

$$\underline{Z}_k = (0,77 + j\,4,62)\,\Omega$$

$$P_2 = 30\cdot 0,72 = 21,6\,kW \; ; \; Q_2 = 30\cdot 0,69 = 20,7\,kVAr$$

$$\Delta U = R_k I_2' \cos\varphi_2 + X_k I_2' \sin\varphi_2$$

Vi vet ej I_2' ej inte heller U_2' ; förläng ΔU med U_2'

$$\Delta U \cdot U_2' = R_k U_2' I_2' \cos\varphi_2 + X_k U_2' I_2' \sin\varphi_2$$

$$\Delta U \cdot U_2' = R_k P_2 + X_k Q_2 \Rightarrow \Delta U = \frac{R_k P_2 + X_k Q_2}{U_2'} =$$

$$= \frac{0,77\cdot 21,6 + 4,62\cdot 20,7}{U_2'} \cdot 10^3 = \frac{112,3}{U_2'}\cdot 10^3 \; V$$

om U_2' i kV $\Rightarrow \Delta U = \frac{112,3}{U_2'}\,V \Rightarrow \Delta U = \frac{0,112}{U_2'}\,kV$

$$U_1 = U_2' + \Delta U = U_2' + \frac{0,112}{U_2'} = 1,5$$

$$(U_2')^2 - 1,5\,U_2' + 0,112 = 0$$

$$U_2' = 0,75 \pm \sqrt{0,75^2 - 0,112} = 0,75 \pm 0,67 \Rightarrow 1,42\,kV$$

$$\underline{U_2 = 1,42\,\frac{0,23}{1,5} = 217,9\,V} \; ; \; \underline{I_2 = \frac{S_2}{U_2} = \frac{30}{0,218} = 137,7\,A}$$

b) $P_{Cu} = R_k \left(\vec{I}_2'\right)^2 = 0,77 \left(137,7 \cdot \frac{0,23}{1,5}\right)^2 = 343\ W$

$P_0 = 385\ W$

$P_{fe,k} = P_0 + P_{Cu} = 728\ W$

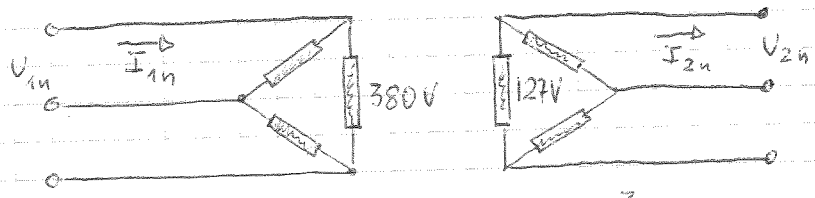
$P_2 = 21600\ W$

$P_1 = 21600 + 728 = 22328\ W$

$\eta = \frac{21600}{22328} = 0,967 \hat{=} 96,7\ \%$

4.9 $S_n = 25\,kVA$

1. Δ/Δ



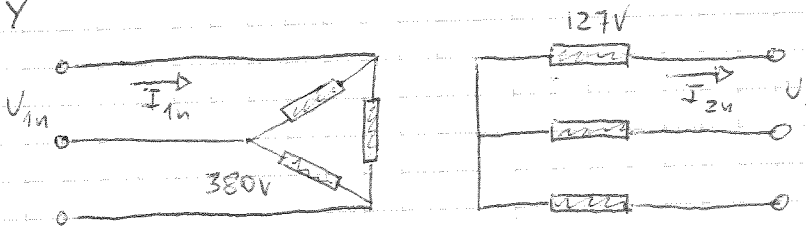
380/127 V

$S_n = \sqrt{3}\, U_{1n} I_{1n} \Rightarrow I_{1n} = \frac{25 \cdot 10^3}{\sqrt{3} \cdot 380} = 38\,A$

$I_{2n} = I_{1n} \frac{U_{1n}}{U_{2n}} = 38 \cdot \frac{380}{127} = 113{,}7\,A$

$(S_n = \sqrt{3}\, U_{2n} I_{2n} \Rightarrow I_{2n} = 113{,}7\,A)$

2. Δ/Y



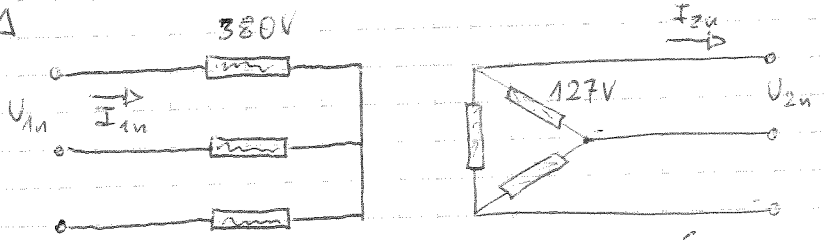
$U_{2n} = \sqrt{3} \cdot 127 = 220\,V$

380/220 V

$I_{2n} = \frac{380}{220} \cdot 38 = \sqrt{3} \cdot 38 = 65{,}6\,A$

$I_{1n} = 38A$

3. Y/Δ

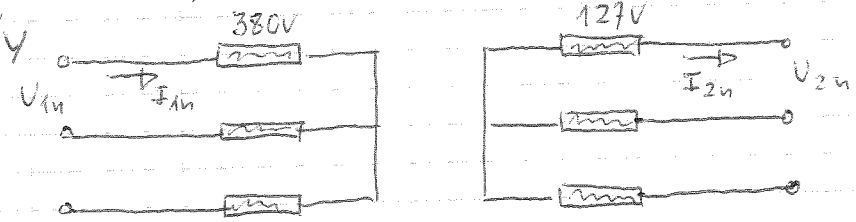


658/127 V

$U_{1n} = 380 \cdot \sqrt{3} = 658\,V$; $I_{1n} = \frac{S_n}{\sqrt{3}\, U_{1n}} = \frac{25 \cdot 10^3}{\sqrt{3}\, 658} = 21{,}9\,A$

$I_{2n} = 113{,}7\,A$ som i 1

4. Y/Y



658/220 V

$I_{1n} = 21{,}9\,A$ som 3 $\quad I_{2n} = 65{,}6\,A$ som 2

L_1	L_2	V_{n1} (V)	I_{1n} (A)	U_{2n} (V)	I_{2n} (A)
Δ	Δ	380	38	127	113,7
Δ	Y	380	38	220	65,6
Y	Δ	658	21,9	127	113,7
Y	Y	658	21,9	220	65,6

4.10

4.10

$S_b = 20\,kVA$ vid 220 V matas från ett nät med 380 V

Alla förluster försummas

Enl. 4.9 → 380/220 V → Δ/Y

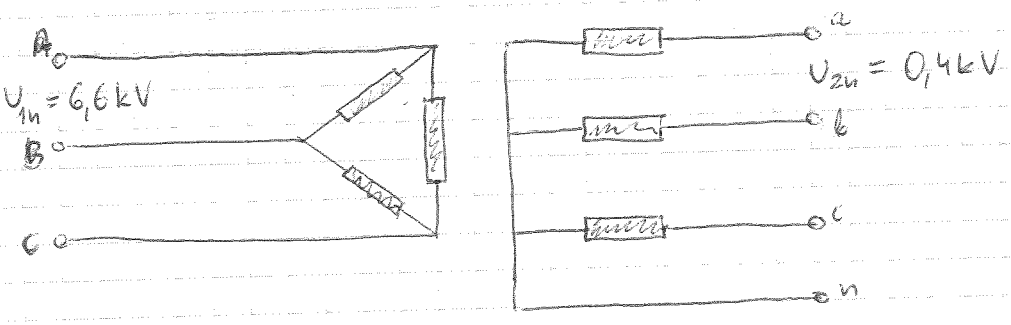
$S_1 = S_2 = S_b = 20\,kVA$

$$I_1 = \frac{20 \cdot 10^3}{\sqrt{3} \cdot 380} = 30{,}4\,A \Rightarrow \underline{I_\Delta = \frac{I_1}{\sqrt{3}} = \frac{30{,}4}{\sqrt{3}} = 17{,}5\,A}$$

$$\underline{I_2 = \frac{20 \cdot 10^3}{\sqrt{3} \cdot 220} = 52{,}5\,A} \qquad \left(I_2 = I_1 \frac{U_{1n}}{U_{2n}} \right)$$

4.11

3-fas trafo $S_n = 125\,kVA$; $6,6/0,4\,kV$ Δ/Y-0



Ksl prov:

från 6,6 kV sidan $I_{1n} = \dfrac{S_n}{\sqrt{3}\,U_{1n}} = \dfrac{125 \cdot 10^3}{\sqrt{3} \cdot 6,6 \cdot 10^3} = 10,93\,A$

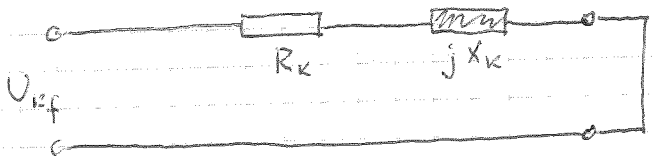
$I_k = I_{1n}$

$U_{kf} = I_k \cdot Z_k \Rightarrow Z_k = \dfrac{U_{kf}}{I_k} = \dfrac{310}{\sqrt{3} \cdot 10,93} = 16,37\ \Omega/fas$

$\cos\varphi_k = \dfrac{P_k}{\sqrt{3}\,U_k\,I_k} = \dfrac{1330}{\sqrt{3} \cdot 310 \cdot 10,93} = 0,23$; $\sin\varphi_k = 0,97$

$\underline{Z}_k = Z_k(\cos\varphi_k + j\sin\varphi_k) = 16,37\,(0,23 + j\,0,97) =$

$= (3,77 + j\,15,88)\ \Omega/fas$

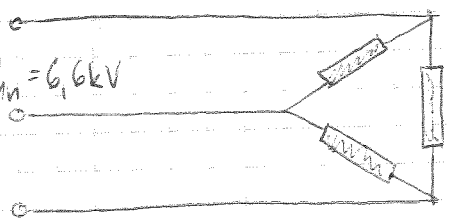


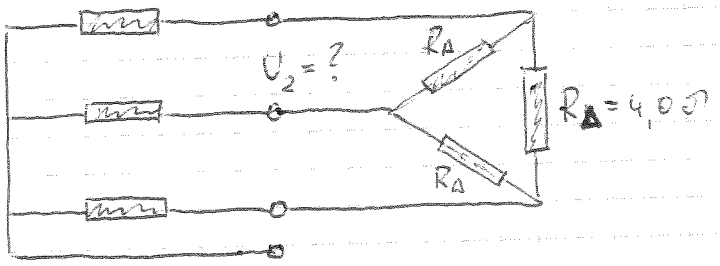
Ekv. Y-fas vid ksl.

alt.: $P_k = 3R_k I_k^2 \Rightarrow R_k$

$Q_k = P_k \tan\varphi_k \Rightarrow X_k = \dfrac{Q_k}{3I_k^2}$ (alt $Q_k = \sqrt{S_k^2 - P_k^2}$)

a)

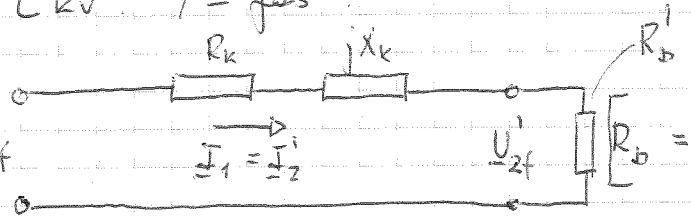




→

4.11

Ekv. Y-fas:



$R_b = \frac{R_\Delta}{3} = \frac{4}{3}\ \Omega/\text{fas}$

$R_b' = \frac{4}{3}\left(\frac{6,6}{0,4}\right)^2 = 363\ \Omega/\text{fas}$

$$\underline{I}_2' = \frac{\underline{U}_{1f}}{\underline{Z}_{tot}} = \frac{6600/\sqrt{3}\,\angle 0^\circ}{3,77 + j15,88 + 363} = \frac{6600/\sqrt{3}\,\angle 0^\circ}{367\,\angle 2,48^\circ} =$$

$$= 10,38\,\angle -2,48^\circ\ \text{A} \qquad |\underline{I}_2'| = 10,38\ \text{A}$$

$$\underline{I}_2 = \underline{I}_2' \frac{U_{1n}}{U_{2n}} = 10,38 \frac{6,6}{0,4} = 171,3\ \text{A}$$

$$U_{2f} = R_b \cdot I_2 = \frac{4}{3} \cdot 171,3 = 228,4\ \text{V}$$

$$U_2 = \sqrt{3} \cdot U_{2f} = 395,6\ \text{V}$$

b) $I_1 = I_2'$ om I_0 försummas

$$I_\Delta = \frac{I_1}{\sqrt{3}} = 5,99\ \text{A}$$

extra Räkna fram z_k; r_k; x_k

$$Z_{bas} = \frac{U_n^2}{S_n} = \frac{6,6^2}{125} = 348,5\ \Omega$$

$$z_k = \frac{16,37}{348,5} = 0,047 \hat{=} 4,7\,\%$$

$$r_k = \frac{3,77}{348,5} = 0,011 \hat{=} 1,1\,\%$$

$$x_k = \sqrt{z_k^2 - r_k^2} = \sqrt{4,7^2 - 1,1^2} = 4,57\,\%$$

4.12 4.12

$P_0 = 1{,}05\ kW \quad ; \quad P_1 = ? \quad ; \quad \eta = ?$

Belastningsförluster:

$$P_{cu} = 3 R_k \left(I_2'\right)^2 = 3 \cdot 3{,}77 \cdot (10{,}38)^2 = 1218{,}6\ W$$

$$P_{förl} = 1218{,}6 + 1050 = 2268{,}6\ W$$

$$P_1 = P_2 + P_{förl} = \sqrt{3}\, U_2 I_2 + P_{förl} = \sqrt{3} \cdot 395{,}6 \cdot 171{,}3 + 2268{,}6 =$$

$$= 119643\ W$$

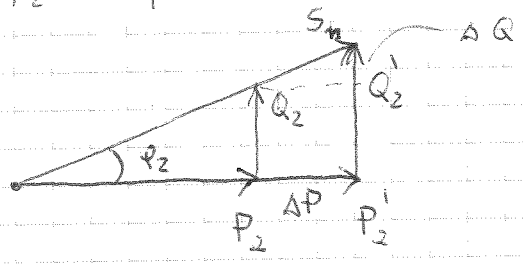
$$\eta = \frac{117375}{119643} = 0{,}981 \triangleq 98{,}1\ \%$$

4.13 4.13

$S_n = 500\ kVA$; $6,0/0,4\ kV$

$P_2 = 300\ kW$; $\cos\varphi_2 = 0,8$ $\quad\quad$ $\Delta P = ?$

a) $\cos\varphi_2 = 0,8$ - konst

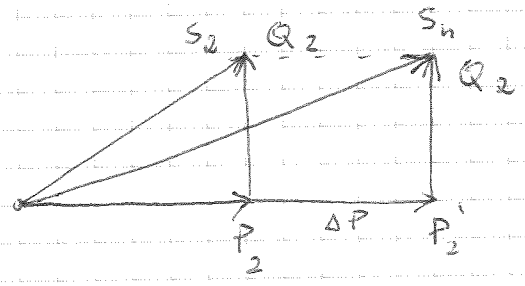


$P_2' = S_n \cos\varphi_2 = 500\ 0,8 = 400\ kW$

$\Delta P = 400 - 300 = \underline{100\ kW}$

b) Q_2 = konst

$Q_2 = P_2 \tan\varphi_2 = 300 \cdot 0,75 = 225\ kVAr$



$S_n^2 = (P_2 + \Delta P)^2 + Q_2^2$

$(300 + \Delta P)^2 = 500^2 - 225^2 = 199375$

$300 + \Delta P = 446,5$

$\Delta P = \underline{146,5\ kW}$

4.14

$S_n = 1\,MVA$; $6,6/0,4\,kV$; $50\,Hz$; $v_k = 3\%$; $z_k = 8\%$

$P_2 = 650\,kW$; $\cos\varphi_2 = 0,8$; $U_2 = 350\,V$

a) Uttagbar aktiv effekt vid $U_{2n} = 400\,V$ och $\cos\varphi_2 = 0,8$

$P_2 = 1000 \cdot 0,8 = 800\,kW$

motsvarar $P_2' = 800 \frac{350}{400} = 700\,kW$

$\Delta P = 700 - 650 = \underline{\underline{50\,kW}}$

alt.

Märkdrift : $S_n = \sqrt{3} U_{n1} I_{n1} = \sqrt{3} U_{n2} I_{n2} \Rightarrow$

$\Rightarrow I_{2n} = \frac{1000}{\sqrt{3}\,0,4} = 1443\,A$

$U_2 = 350\,V$; $I_2 = I_{2n} = 1443\,A$; $\cos\varphi_2 = 0,8$

$P_2 = \sqrt{3} \cdot U_2 I_{2n} \cos\varphi_2 = \sqrt{3} \cdot 350 \cdot 1443 \cdot 0,8 =$

$= 700\,kW$

$\underline{\Delta P = 50\,kW}$

b) $P_{cu} = 3 R_k I_2^2 \Rightarrow$ min om I_2 min $\rightarrow$ om $Q_2 = Q_c$ ($\cos\varphi = 1$)

$Q_2 = P_2 \tan\varphi_2 = 650 \cdot 0,75 = 487,5\,kVAr$

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

$C = \frac{Q_c}{\omega U_2^2} = \frac{487,5 \cdot 10^3}{2\pi \cdot 50 \cdot 350^2} = 12,67\,mF/fas$

$I_{2c} = \frac{P_2}{\sqrt{3} \cdot 350 \cdot 1} = 1072\,A$; $R_k = r_k \frac{U_n^2}{S_n} = 0,03 \frac{0,4^2}{1} = 4,8 \cdot 10^{-3}\,\Omega/fas$

$\underline{P_{cu} = 3 \cdot 4,8 \cdot 10^{-3} \cdot 1072^2 = 16548\,W \approx 16,55\,kW}$

Ingår ej i kursen

4.15

$S_n = 125\,MVA$; $6,6/0,4\,kV$; $\Delta/Y-0$

$U_k = 310\,V$; $P_k = 1,33\,kW$

$P_0 = 1,05\,kW$

η - max ; $\cos\varphi_2 = 0,8$ — $P_2 = ?$

$$\eta = \frac{P_2}{P_2 + P_0 + \alpha^2 P_{cun}}$$

$$\eta = \frac{\alpha S_n \cos\varphi}{\alpha S_n \cos\varphi + P_0 + \alpha^2 P_{cun}} = \frac{\alpha A}{\alpha A + P_0 + \alpha^2 P_{cun}}$$

$$\frac{d\eta}{d\alpha} = 0$$

$$\frac{\left(\alpha A^2 + P_0 + \alpha^2 P_{cun}\right)\cdot A - \left(A + 2\alpha P_{cun}\right)\alpha A}{\left[\quad\right]^2}$$

$$\alpha A^2 + P_0 A + \alpha^2 A P_{cun} - \alpha A^2 - 2\alpha^2 A P_{cun} = 0$$

$$P_0 A = \alpha^2 P_{cun} A \qquad \alpha^2 = \frac{P_0}{P_{cun}} \qquad P_{cun} = P_k$$

$$\alpha = \sqrt{\frac{1,05}{1,33}} = 0,889$$

$$P_2 = \alpha S_n \cos\varphi_2 = 0,889 \cdot 125 \cdot 0,8 = 88,85\,kW$$

$$\eta_{max} = \frac{P_2}{P_2 + P_0 + \alpha^2 P_k} = \frac{88,85}{88,85 + 1,05 + 0,889^2 \cdot 1,33} = 0,977$$

$$\eta_{max} = 97,7\,\%$$

$S_n = 125\,kVA$; $6,6/0,4\,kV$; Δ/Y

$z_k = 4,7\,\%$; $r_k = 1,1\,\%$

$$z_k = \frac{Z_k}{Z_{bas}} \quad ; \quad r_k = \frac{R_k}{Z_{bas}} \quad ; \quad X_k = \sqrt{Z_k^2 - R_k^2}$$

Räkna på 0,4 kV sidan:

$$Z_{bas} = \frac{U_{n2}^2}{S_n} = \frac{400^2}{125 \cdot 10^3} = 1,28\ \Omega/fas$$

$$Z_k = 0,047 \cdot 1,28 = 60,2 \cdot 10^{-3}\ \Omega/fas$$

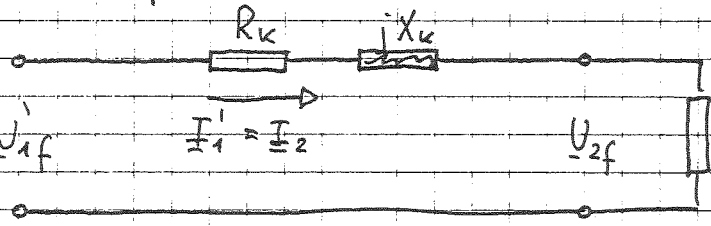
$$R_k = 0,011 \cdot 1,28 = 14,1 \cdot 10^{-3}\ \Omega/fas$$

$$X_k = 58,53 \cdot 10^{-3}\ \Omega/fas$$

a)

Y-kopplad last - $\underline{Z}_L = (0,6 + j\,1,0)\ \Omega/fas = 1,17 \angle 59,04^\circ\ \Omega/fas$

Ekv. Y-fas:



I_2 ; $U_2 = ?$

P_L ; $Q_L = ?$

$$U'_{1f} = \frac{400}{\sqrt{3}}\ V \quad ; \quad \underline{U}'_{1f} = \underline{Z}_{tot}\,\underline{I}_2$$

$$\underline{Z}_{tot} = \underline{Z}_k + \underline{Z}_L = 14,1 \cdot 10^{-3} + j\,58,53 \cdot 10^{-3} + 0,6 + j\,1,0 = 0,614 + j\,1,059 =$$

$$= 1,22 \angle 59,9^\circ\ \Omega/fas$$

$$\underline{I}_2 = \frac{400 \angle 0^\circ}{\sqrt{3} \cdot 1,22 \angle 59,9^\circ} = 189,3 \angle -59,9^\circ\ A \qquad \underline{I_2 = 189,3\ A}$$

$$\underline{U}_{2f} = \underline{Z}_L\,\underline{I}_2 = 189,3 \angle -59,9^\circ \cdot 1,17 \angle 59,04^\circ = 221,5 \angle -0,86^\circ\ V$$

$$\underline{U_2 = \sqrt{3}\,U_{2f} = \sqrt{3} \cdot 221,5 = 383,65\ V}$$

$$\underline{P_L = \sqrt{3}\,U_2 I_2 \cos\varphi_L = \sqrt{3} \cdot 383,65 \cdot 189,3 \cdot \cos 59,04 = 64,7\ kW}$$

$$\underline{Q_L = \sqrt{3}\,U_2 I_2 \sin\varphi_2 = \sqrt{3} \cdot 383,65 \cdot 189,3 \cdot \sin 59,04 = 107,9\ kVAr}$$

b) ej då $I_2 > I_{n2}$ (180,4 A)
eller $S_2 > S_n$
transformatorn är överbelastad

c) $P_{Cu} = 3 R_k I_2^2 = 3 \cdot 14,1 \cdot 10^{-3} \cdot 189,3^2 = \underline{1,52 \text{ kW}}$

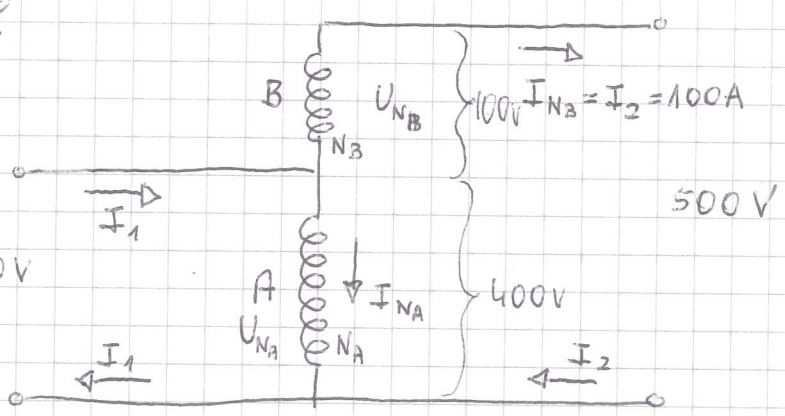
d) $I_1 = I_2 \frac{U_{n2}}{U_{n1}} = 189,3 \cdot \frac{0,4}{6,6} = 11,47 \text{ A}$

$I_\Delta = \frac{I_1}{\sqrt{3}} = \underline{6,6 \text{ A}}$

4.16

4.17

a)



$$I_2 + I_{NA} = I_1 \Rightarrow I_{NA} = I_1 - I_2$$

b) $\dfrac{U_{NA} = 400\,V}{U_{NB} = 100\,V}$ $\qquad \dfrac{U_{NB}}{U_{NA}} = \dfrac{N_B}{N_A} = \dfrac{100}{400}$

c)

$I_{NB} = I_2 = 100\,A$ $\qquad$ mmk like $\rightarrow$

$I_{NB} \cdot N_B = I_{NA} \cdot N_A$; $I_{NA} = I_{NB} \cdot \dfrac{N_B}{N_A} = 100 \cdot \dfrac{1}{4} = 25A$

$\underline{I_{NA} = 25\,A}$; $\underline{I_{NB} = 100\,A}$ $\qquad (I_1 = I_{NA} + I_2 = 125\,A)$

d) $\underline{S_{NA} = U_{NA} \cdot I_{NA} = 400 \cdot 25 = 10\,kVA}$

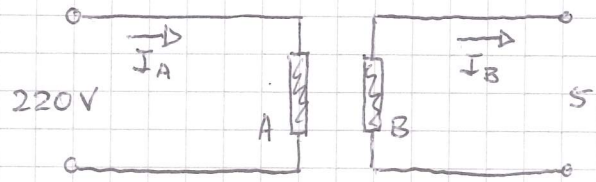
$\underline{S_{NB} = U_{NB} \cdot I_{NB} = 100 \cdot 100 = 10\,kVA}$

Diskutere viklingsdimensjonering

4.17

4.18

1. Fulltransformator (förlustfri; enfas)



$S = 200\,VA$

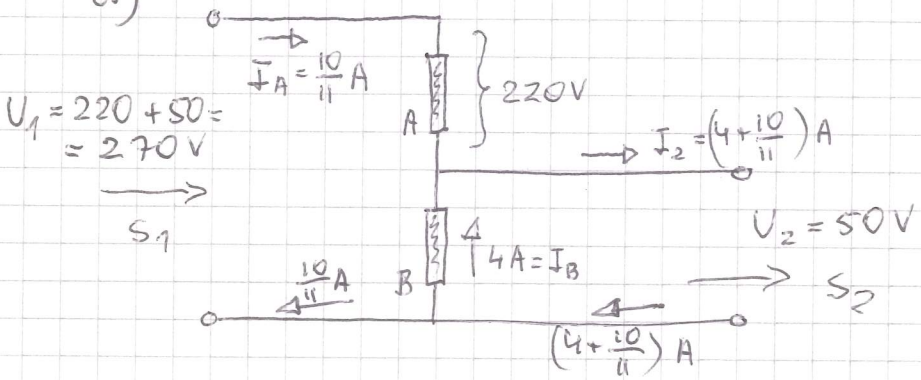
$\therefore\ S = U_1 I_A = U_2 I_B$

$I_A = \frac{200}{220} = \frac{10}{11}\,A$; Lindning A klarar $\frac{10}{11}\,A$

$I_B = \frac{200}{50} = 4\,A$; — " — B — " — $4\,A$

2. Spartransformator

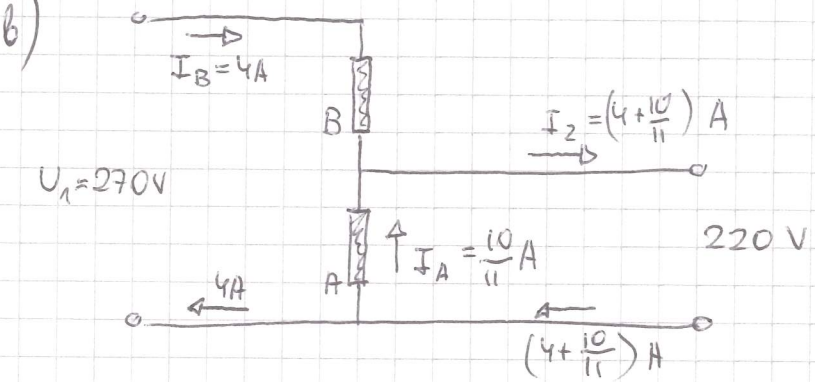
a)



270/50 V

$S_1 = 270 \cdot \frac{10}{11} = 245\,VA$ eller $S_2 = 50(4 + \frac{10}{11}) = 245\,VA$

b)



270/220 V

$S_1 = 270 \cdot 4 = 1080\,VA$ eller $S_2 = 220(4 + \frac{10}{11}) = 1080\,VA$

Jämför!