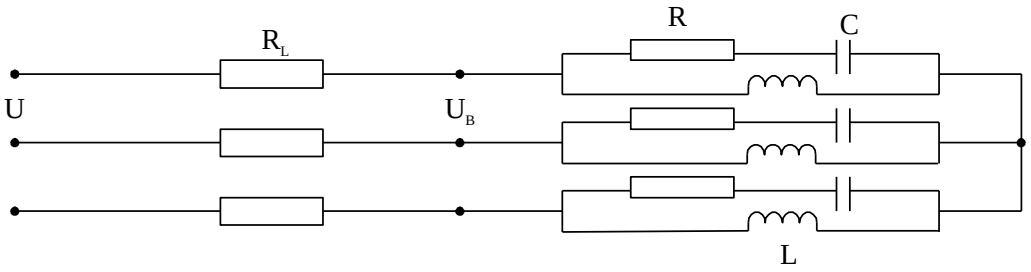
**1.**

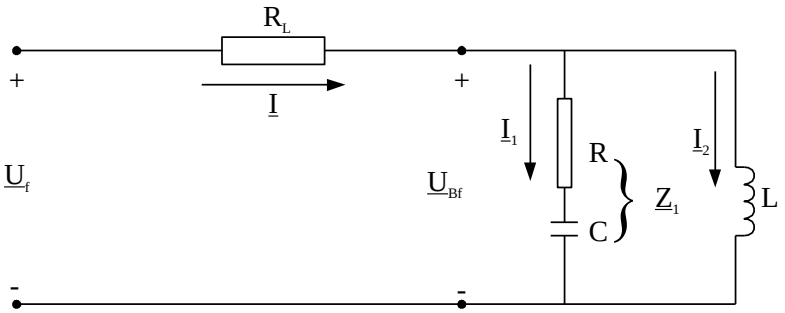
Y-kopplad belastning; U = 400 V; f = 50Hz; $R_L$ = 0,5 Ω/fas

R = 20 Ω; C = 1000 μF; L = 100 mH

**a)** **$U_B$ = ?**




**Ekvivalent Y-fas-krets :**




$U_f$ - riktfas $\qquad U_f = \dfrac{U}{\sqrt{3}} = \dfrac{400}{\sqrt{3}} = 230{,}9\,V$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi 50 \cdot 1000 \cdot 10^{-6}} = 3{,}18\,\Omega/\,fas$$

$$\underline{Z}_1 = 20 - j3{,}18 = 20{,}25\angle -9{,}03^\circ\ \Omega/\text{fas}$$

$$\underline{Z}_2 = j\omega L = j2\pi 50 \cdot 100 \cdot 10^{-3} = j31{,}42 = 31{,}42\angle 90^\circ\ \Omega/\,fas$$

$$\underline{Z}_B = \underline{Z}_1 \,//\, \underline{Z}_2 = \frac{20{,}25\angle -9{,}03^\circ \cdot 31{,}42\angle 90^\circ}{20 - j3{,}18 + j31{,}42} = 18{,}39\angle 26{,}28^\circ\ \Omega/\,fas$$

$$\underline{Z}_{tot} = 0{,}5 + 16{,}49 + j8{,}14 = 18{,}84\angle 25{,}6^\circ\ \Omega/\,fas$$

$$\underline{I} = \frac{\underline{U}_f}{\underline{Z}_{tot}} = \frac{230{,}9\angle 0^\circ}{18{,}84\angle 25{,}6^\circ} = 12{,}26\angle -25{,}6^\circ\ A$$

$$\underline{U}_{Bf} = \underline{Z}_B \underline{I} = 225{,}46\angle 0{,}68^\circ\ V$$

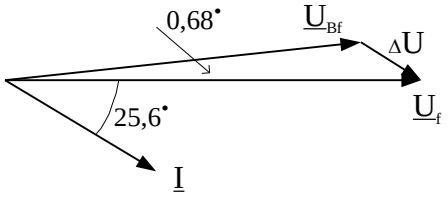
$$U_B = \sqrt{3} U_{Bf} = 390{,}5\,V$$

**b)** $\underline{I}_1 = ?$ $\underline{I}_2 = ?$

$$\underline{I}_1 = \frac{\underline{U}_{Bf}}{\underline{Z}_1} = \frac{225{,}46\angle 0{,}68^\circ}{20{,}25\angle -9{,}03^\circ} = 11{,}13\angle 9{,}71^\circ \; A$$

$$\underline{I}_2 = \frac{\underline{U}_{Bf}}{\underline{Z}_2} = \frac{225{,}46\angle 0{,}68^\circ}{31{,}42\angle 90^\circ} = 7{,}18\angle -89{,}32^\circ \; A$$

**c)**




**d)** S=? P=? Q=?

$$\underline{S} = 3\underline{U}_f \underline{I}^* = 3 \cdot 230{,}9\angle 0^\circ \cdot 12{,}26\angle 25{,}6^\circ = 8{,}49 \cdot 10^3 (0{,}902 + j0{,}432) =$$
$$= 7{,}66 \cdot 10^3 + j3{,}67 \cdot 10^3$$

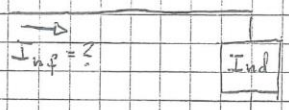
S = 8490 VA P = 7660 W Q = 3670 VAr

**e)** $\cos\varphi_B = ?$

$$\cos\varphi_B = \cos 26{,}28^\circ = 0{,}897$$ - induktiv karaktär

$U = 400\ V$ ; $f = 50\ Hz$

Före:

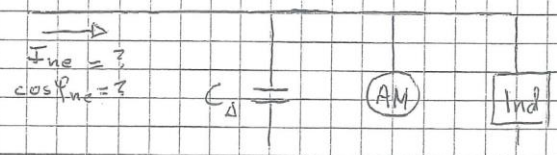



$P_i = 140\ kW$ ; $\cos\varphi_i = 0,707$

$Q_i = P_i \tan\varphi_i = 140\ kVAr$

$S_i = \sqrt{2} \cdot 140\ kVA \Rightarrow I_{nf} = \dfrac{S_i}{\sqrt{3}\,U} = \dfrac{\sqrt{2} \cdot 140 \cdot 10^3}{\sqrt{3} \cdot 400} = 285,5\ A$

Efter:




$C_\Delta = 1\ mF$

$P_m = 15\ kW$ ; $P_i = 140\ kW$

$I_m = 28,5\ A$ ; $Q_i = 140\ kVAr$

AM

$$\begin{cases} S_m = \sqrt{3} \cdot 400 \cdot 28,5 = 19745\ VA \\ Q_m = \sqrt{S_m^2 - P_m^2} = \sqrt{19745^2 - 15000^2} = 12840\ VAr \end{cases}$$

$\Delta$ - kopplad kond

$U_c = 400\ V$ ; $Q_c = 3\omega C_\Delta U_c^2 = 3 \cdot 100\pi \cdot 1 \cdot 10^{-3} \cdot 400^2 = 150,8\ kVAr$

$Q_{ne} = Q_i + Q_m - Q_c = 140 + 12,84 - 150,8 = 2,04\ kVAr$

$P_{ne} = P_i + P_m = 140 + 15 = 155\ kW$

$\tan\varphi_{ne} = \dfrac{2,04}{155} \Rightarrow \cos\varphi_{ne} = 0,99$

$I_{ne} = \dfrac{P_{ne}}{\sqrt{3}\,U\cos\varphi_{ne}} = \dfrac{155 \cdot 10^3}{\sqrt{3} \cdot 400 \cdot 0,99} = 223,7\ A$

(5)

3-fas trafo: $S_n = 40\,kVA$; $1{,}5/0{,}23\,kV$; $D/yn$

a) $z_k = ?$ ; $r_k = ?$

$U_k = 125\,V$ ; $P_k = 550\,W$ ; $I_k = I_{1n}$

$$I_k = I_{1n} = \frac{S_n}{\sqrt{3}\,U_{1n}} = \frac{40\cdot 10^3}{\sqrt{3}\cdot 1{,}5\cdot 10^3} = 15{,}4\,A$$

$$R_k = \frac{P_k}{3\,I_k^2} = \frac{550}{3\cdot 15{,}4^2} = 0{,}77\,\Omega/fas \quad (R_k' = 0{,}018\,\Omega/fas)$$

$$Z_k = \frac{U_{kf}}{I_k} = \frac{125}{\sqrt{3}\cdot 15{,}4} = 4{,}68\,\Omega/fas \Rightarrow X_k = 4{,}62\,\Omega/fas \quad (X_k' = 0{,}11\,\Omega/fas)$$

$$Z_{bas} = \frac{U_{1n}^2}{S_n} = \frac{(1{,}5\cdot 10^3)^2}{40\cdot 10^3} = 56{,}25\,\Omega/fas$$

$$z_k = \frac{4{,}68}{56{,}25} = 0{,}0832 \; ; \; r_k = \frac{0{,}77}{56{,}25} = 0{,}0137$$

$$\underline{z_k = 8{,}32\%} \; ; \; \underline{r_k = 1{,}37\%}$$

b) $R_{Fe} = ?$ ; $X_m = ?$

$P_o = 384\,W$ ; $I_o = 10\,A$ ; $U_o = U_{2n} = 230\,V$

$$P_{of} = \frac{384}{3} = 128\,W \; ; \; R_{Fe} = \frac{U_{of}^2}{P_{of}} = \frac{\left(\frac{230}{\sqrt{3}}\right)^2}{128} = 137{,}8\,\Omega/fas$$

$$Q_{of} = \sqrt{S_{of}^2 - P_{of}^2} = \sqrt{\left(\frac{230}{\sqrt{3}}\cdot 10\right)^2 - 128^2} = 1321{,}7\,VAr$$

$$X_m = \frac{U_{of}^2}{Q_{of}} = \frac{\left(\frac{230}{\sqrt{3}}\right)^2}{1321{,}7} = 13{,}34\,\Omega/fas$$

$R_{Fe} = 137{,}8\,\Omega/fas$ ; $X_m = 13{,}34\,\Omega/fas$ hänfört till nedsp. sidan

c) $U_2 = ?$ ; $I_2 = 100\,A$ ; $\cos\varphi_2 = 0{,}8$

$$\Delta U = \sqrt{3}\,I_2\left(R_k'\cos\varphi_2 + X_k'\sin\varphi_2\right) = \sqrt{3}\cdot 100\left(0{,}018\cdot 0{,}8 + 0{,}11\cdot 0{,}6\right) = 13{,}93\,V$$

$$\underline{U_2 = 230 - 13{,}93 = 216{,}07\,V}$$

d) $$\underline{P_{cu} = 3\,R_k'\,I_2^2 = 3\cdot 0{,}018\cdot 100^2 = 540\,W}$$

**5.** AM : $P_n = 15\,kW$ ; $U_n = 400\,V$ ; $f_n = 50\,Hz$ ;
$I_n = 32\,A$ ; $n_n = 970\,rpm$ ; $\cos\varphi = 0{,}81$

a) Motorns momentkurva approximeras med en rät linje mellan tomgång och märkdrift

$$T_n = \frac{P_n}{\omega_n} = \frac{15 \cdot 10^3}{\frac{2\pi \cdot 970}{60}} = 147{,}7\,Nm \quad ; \quad n_s = 1000\,rpm$$

vid $n_s$ är $T = 0$

$$T_{AM} = T_n \frac{n_s - n}{n_s - n_n} = 147{,}7 \frac{1000 - n}{1000 - 970}$$

Lastens momentkurva :

$$T_L = T_{L1}\left(\frac{n}{n_{L1}}\right)^2 \qquad T_{L1} = 140\,Nm \quad \text{vid} \quad n_{L1} = 1000\,rpm$$

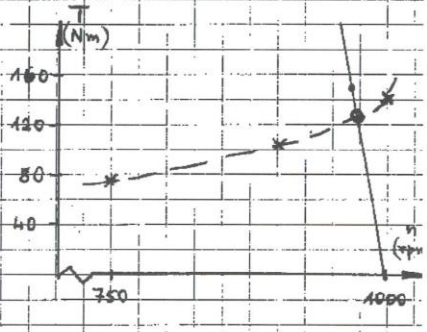
$$T_L = 140\left(\frac{n}{1000}\right)^2$$

Vid drift gäller : $T_{AM} = T_L$

$$147{,}7\,\frac{1000 - n}{30} = 140\left(\frac{n}{1000}\right)^2$$

$$n^2 + 35{,}164 \cdot 10^3\, n + 35{,}164 \cdot 10^6 = 0$$

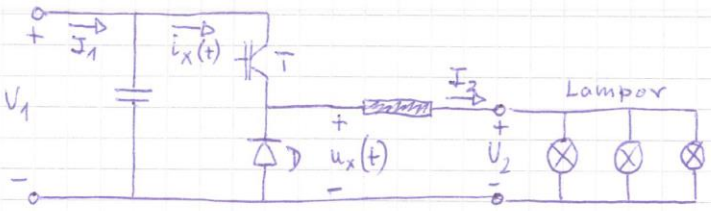
$$n = \begin{cases} -36157\,rpm \\ 973\,rpm \end{cases}$$




b) $$T = 140\left(\frac{973}{1000}\right)^2 = 132{,}5\,Nm$$

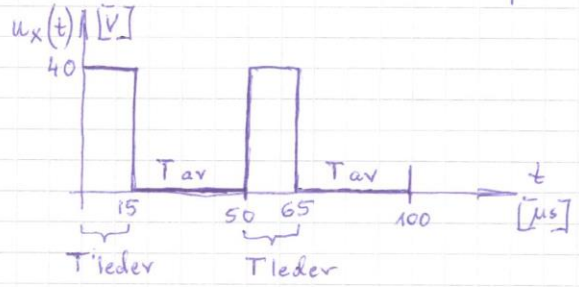
(8)

LS-omriktare ; $U_1 = 40\,V$ ; $T = 50\,\mu s$ ; $U_2 = 12\,V$ ; $I_2 = 2A$

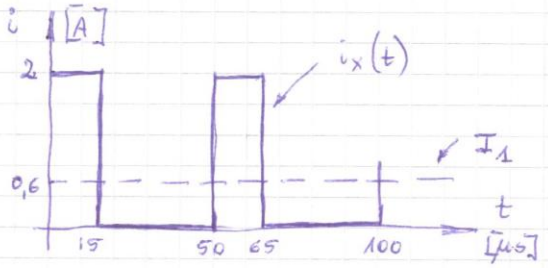



a) $t_p = ?$ $\quad u_x(t) = ?$

b) $U_2 = \frac{t_p}{T} U_1 \Rightarrow t_p = \frac{12}{40} \cdot 50 = 15\,\mu s$



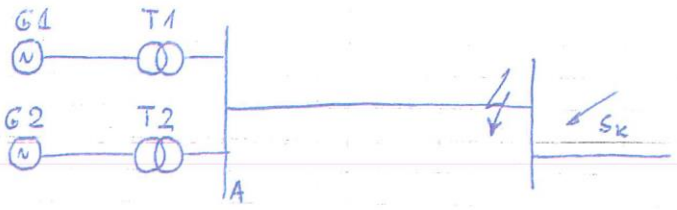

c) $i_x(t) = ?$ $\quad I_1 = ?$




$0 \le t < t_p \quad i_x = I_2 = 2A$

$t_p \le t \le T \quad i_x = 0\,A$

$I_1 U_1 = I_2 U_2 \Rightarrow I_1 = 2 \frac{12}{40} = 0,6\,A$




G1: $\underline{Z}_{G1} = j X_{G1} = j\,0{,}2 \cdot \frac{130^2}{75} = j\,45{,}1\ \Omega/\text{fas}$

G2: $\underline{Z}_{G2} = j X_{G2} = j\,0{,}22\ \frac{130^2}{60} = j\,62{,}0\ \Omega/\text{fas}$

T1: $\underline{Z}_{T1} = j X_{T1} = j\,0{,}1\ \frac{130^2}{75} = j\,22{,}5\ \Omega/\text{fas}$

T2: $\underline{Z}_{T2} = j X_{T2} = j\,0{,}08\ \frac{130^2}{60} = j\,22{,}5\ \Omega/\text{fas}$

Linjen: $\underline{Z}_L = j X_L = j\,0{,}4 \cdot 100 = j\,40{,}0\ \Omega/\text{fas}$

Nätet: $\underline{Z}_N = j X_N = j\,\frac{130^2}{2000} = j\,8{,}45\ \Omega/\text{fas}$

$\underline{Z}_A = (\underline{Z}_{G1} + \underline{Z}_{T1}) /\!/ (\underline{Z}_{G2} + \underline{Z}_{T2})$

$\underline{Z}_A = j X_A = j\,\frac{67{,}6 \cdot 84{,}5}{152{,}1} = j\,37{,}6\ \Omega/\text{fas}$

$\underline{Z}_{vänster} = j X_{vänster} = j\,37{,}6 + j\,40{,}0 = j\,77{,}6\ \Omega/\text{fas}$

$\underline{Z}_{höger} = j X_{höger} = j\,8{,}45\ \Omega/\text{fas}$

$\underline{Z}_K = \underline{Z}_v /\!/ \underline{Z}_h \Rightarrow j\,\frac{77{,}6 \cdot 8{,}45}{86{,}05} = j\,7{,}6\ \Omega/\text{fas}$

$$\underline{I_k} = \frac{U_f}{Z_K} = \frac{130}{\sqrt{3} \cdot 7{,}6} = \underline{9{,}9\ \text{kA}}$$