1. Följande belastningar kommer att anslutas till områdets nätstation:

1. En industri som representeras med en impedans $\underline{Z} = 10\angle 30°\ \Omega$/fas.
2. En idrotsanläggning med effekt behovet max 25 kVA vid cos φ = 0,95.
3. En symmetrisk trefas, Δ – kopplad belastning, $\underline{Z} = (18 - j6)\ \Omega$ i varje gren.

a) $\underline{I}_1 = ?$; $\underline{I}_2 = ?$; $\underline{I}_3 = ?$; $\underline{I}_{1+3} = ?$; $\underline{Z}_{ekv} = ?$; visardiagram

U = 400 V $\longrightarrow \underline{U}_{fa} = 230{,}94\angle 0°$ - referens

1. Industri: $\underline{Z} = 10\angle 30° = (8{,}66 + j5{,}00)\ \Omega$/fas

$$\underline{I}_1 = \frac{\underline{U}_f}{\underline{Z}} = \mathbf{23{,}09\angle -30° = (20{,}00 - j11{,}55)}\ \text{A}$$

2. En idrotsanläggning: S = 25 kVA; cos φ = 0,95 $\Rightarrow$ φ = 18,19°

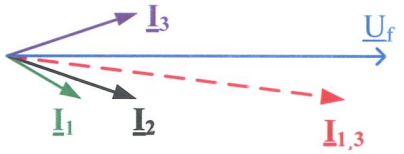
$$\underline{I}_2 = \mathbf{36{,}08\angle -18{,}19° = (34{,}28 - j11{,}26)\ A}$$

3. En belastning: $\underline{Z}_\Delta = \mathbf{18 - j6\ \Omega} \Rightarrow \underline{Z}_y = \mathbf{6 - j2 = 6{,}32\angle -18{,}43°\ \Omega/fas}$

$$\underline{I}_3 = \mathbf{36{,}67\angle 18{,}43° = (34{,}79 + j11{,}59)\ A}$$

$$\underline{I}_{1+3} = \mathbf{89{,}77\angle -7{,}18° = (89{,}07 - j11{,}22)}\ \text{A}$$

$$\underline{Z}_{ekv} = \frac{\underline{U}_f}{\underline{I}} = \mathbf{2{,}58\angle 7{,}18° = (2{,}56 + j0{,}32)}\ \Omega\text{/fas}$$



b) $\underline{S} = ?$; P = ?; Q = ?; cos φ =?; lastens karaktär ?

$$\underline{S} = 3 \cdot \underline{U}_f \underline{I}^* = \mathbf{62463{,}8\angle 7{,}18° = (61974 + j7807)}\ \text{VA}$$

P = **61,97** kW

Q = **7,81** kVAr ind. $\cos\varphi = \mathbf{0{,}992}$

2. Vid kortslutningsprovet kortsluter man transformatorns nedspänningssidan medan uppspänningssidan matas med märkström. Spänningen, som regleras, är mycket lägre än märkspänningen. Med hjälp av uppmäta U_k, I_k och P_k räknar man fram trafos Z_k; R_k och X_k (P_{Fe} och X_m - försummas vid kortsl.-prov).

$S_n = 1250$ kVA 10500/400 V $x_k = 5{,}8\%$ $r_k = 1{,}2\%$

$$Z_{bas} = \frac{U^2}{S_n} = \frac{10500^2}{1250 \cdot 10^3} = 88{,}2\ \Omega/\text{fas}$$

$$Z_k = 0{,}058 \cdot 88{,}2 = 5{,}12\ \Omega/\text{fas}$$

$$R_k = 0{,}012 \cdot 88{,}2 = 1{,}06\ \Omega/\text{fas}$$

$$X_k = \sqrt{Z_k^2 - R_k^2} = 5{,}0\ \Omega/\text{fas}$$

$$\underline{I_k = I_{n1} = \frac{1250 \cdot 10^3}{\sqrt{3} \cdot 10{,}5 \cdot 10^3} = 68{,}73\ \text{A}}$$

$$U_{fk} = Z_k I_k = 351{,}91\ \text{V} \Rightarrow \underline{U_k = 609{,}5\ \text{V}}$$

$$\cos\varphi_k = \frac{R_k}{Z_k} = 0{,}207$$

$$\underline{P_k = 3 \cdot U_{fk} \cdot I_k \cdot \cos\varphi_k = 15{,}02\ \text{kW}}$$

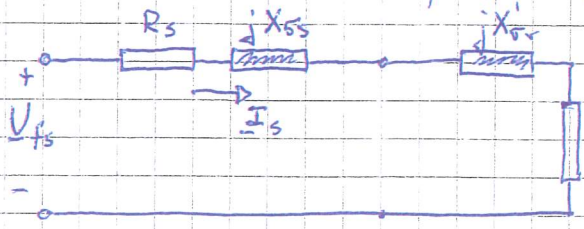
3. En 3-fas AM

400 V; 50 Hz; 10,2 A; 950 rpm; $\cos\varphi = 0{,}63$

$R_s = 1\,\Omega/\text{fas}$; $R_r' = 1{,}5\,\Omega/\text{fas}$; $X_m = 29\,\Omega/\text{fas}$; $X_{\sigma s} = 3\,\Omega/\text{fas}$; $X_{\sigma r}' = 3\,\Omega/\text{fas}$

a) vid start $s = 1 \Rightarrow |Z_r| << |X_m| \Rightarrow X_m$ - försummas

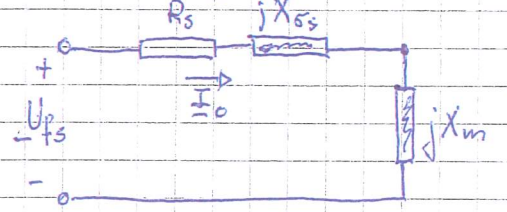
b)



$$\underline{I}_s = \frac{\underline{U}_{fs}}{(R_s + R_r') + j(X_{\sigma s} + X_{\sigma r}')} = \frac{\frac{400}{\sqrt{3}}\angle 0^\circ}{2{,}5 + j\,6{,}0} = 35{,}53\angle -67{,}38^\circ\ \text{A}$$

$\cos\varphi_s = 0{,}385$

vid tomgång $s \approx 0$ ($n_s = 1000$ rpm) $\Rightarrow Z_r$ - försummas



$$\underline{I}_0 = \frac{\underline{U}_{fs}}{R_s + j(X_{\sigma s} + X_m)} = \frac{\frac{400}{\sqrt{3}}\angle 0^\circ}{1 + j\,32} = 7{,}2\angle -88{,}2^\circ\ \text{A}$$

$\cos\varphi_0 = 0{,}031$

Polpartalet: 3

c) 25 Hz $\Rightarrow$ $\underline{U}_{fs} = \frac{200}{\sqrt{3}}\angle 0^\circ$ V; $X_{\sigma s} = 1{,}5\,\Omega/\text{fas}$; $X_m = 14{,}5\,\Omega/\text{fas}$

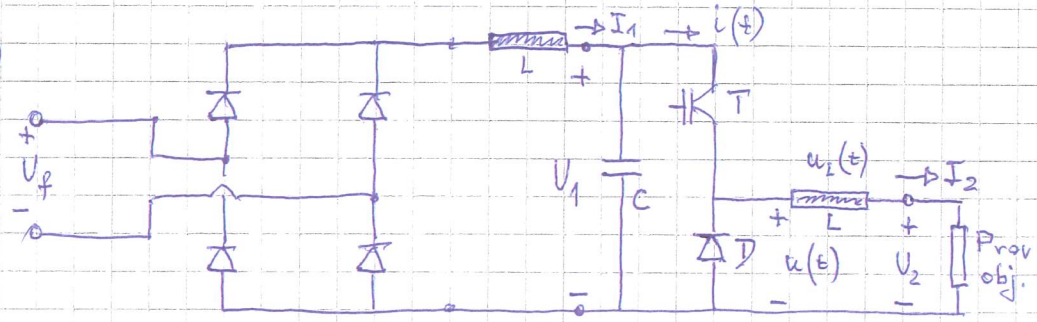
$\underline{I}_{025} = 7{,}2\angle -86{,}42^\circ$ A; $\cos\varphi_{025} = 0{,}062$

75 Hz $\Rightarrow$ $\underline{U}_{fs} = \frac{400}{\sqrt{3}}\angle 0^\circ$ V; $X_{\sigma s} = 4{,}5\,\Omega/\text{fas}$; $X_m = 43{,}5\,\Omega/\text{fas}$

$\underline{I}_{075} = 4{,}8\angle -88{,}81^\circ$ A; $\cos\varphi_{075} = 0{,}021$

4. En enfasig helvågsdiodlikriktare ; en en-kvadrant LS-omriktare

a)



$U_f = 230\,V$; $U_2 = 120\,V$; $I_2 = 6\,A$; $f_{sw} = 100\,kHz$

b) $t_p = ?$

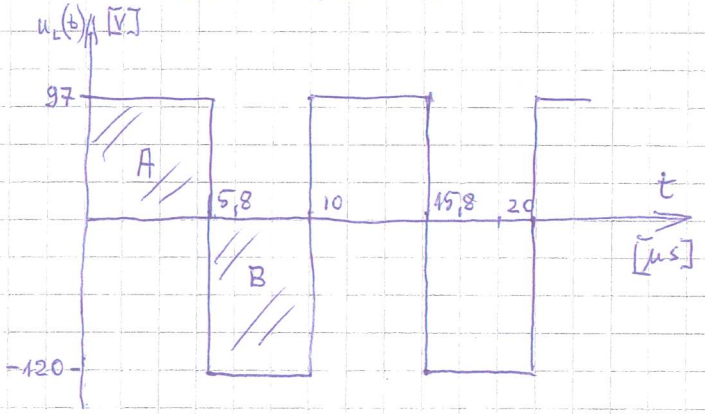
$$U_1 = \frac{1}{\pi}\int \sqrt{2}\,U_f \sin\omega t\, d(\omega t) \approx 0{,}9\,U_f = 207\,V$$

$$\frac{U_2}{U_1} = \frac{t_p}{T} \; ; \; T = \frac{1}{f_{sw}} = 10\,\mu s \; ; \; t_p = 5{,}8\,\mu s$$

c)

$$u_L(t) = u(t) - U_2$$

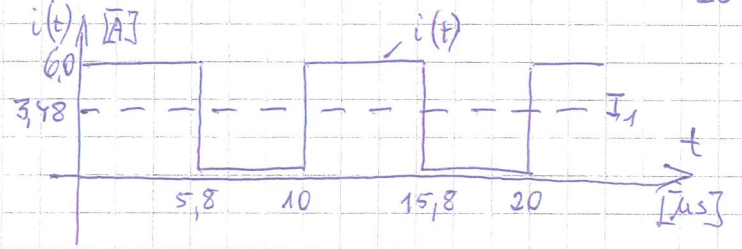
$$u_L(t) = \begin{cases} 87\,V & 0 < t < t_p \\ -120\,V & t_p < t < T \end{cases}$$



Medelvärdet av u_L skall vara noll $\Rightarrow A = B$

d) $i(t) = ?$; $I_1 = ?$

$$I_1 U_1 = I_2 U_2 \Rightarrow I_1 = 6\,\frac{120}{207} = 3{,}48\,A$$

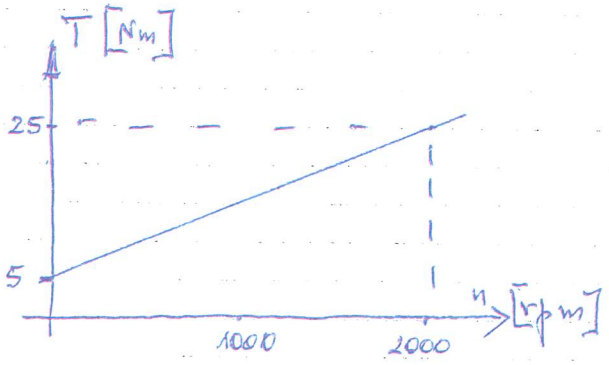


$$i(t) = \begin{cases} 6\,A & 0 < t < t_p \\ 0\,A & t_p < t < T \end{cases}$$

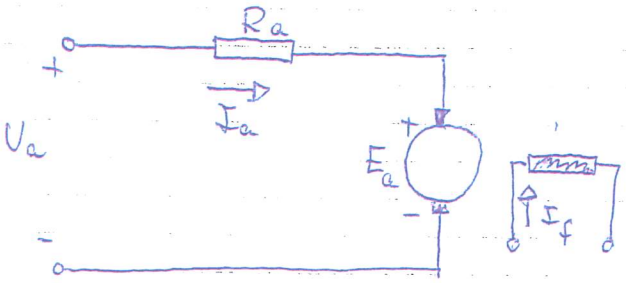
5. LM - separatmotor.

$P_n = 4{,}5\ kW$; $n_n = 1445\ rpm$; $U_{an} = 260\ V$; $I_{an} = 23{,}4\ A$; $I_{fn} = 1{,}89\ A$

Last



$$T = 5 + \frac{20}{2000} n = 5 + 0{,}01 \cdot n$$



a) $U_a = ?$ vid $n = 1300$ rpm

$$U_a = E_a + R_a I_a = k I_f \omega + R_a \frac{T}{k I_f}$$

k kan räknas fram med hjälp av villkor vid märkdrift:

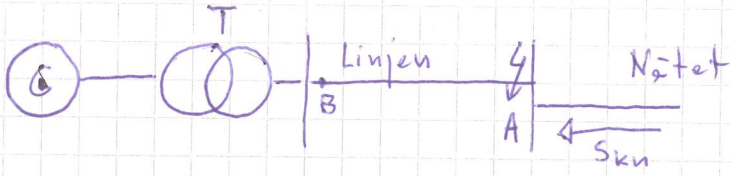
$$E_{an} = U_{an} - R_a I_{an} = 260 - 2{,}89 \cdot 23{,}4 = 192{,}37\ V$$

$$k = \frac{E_{an}}{I_{fn} \omega_n} = \frac{192{,}37}{1{,}89 \frac{2\pi}{60} \cdot 1445} = 0{,}673$$

$$T = 5 + 0{,}01 \cdot 1300 = 18\ Nm$$

$$\underline{U_a = 0{,}673 \cdot 1{,}89 \cdot \frac{2\pi}{60} \cdot 1300 + 2{,}89 \frac{18}{0{,}673 \cdot 1{,}89} = 214{,}06\ V}$$

6.



$I_k = ?$ $I_s = ?$

Beräkning enl. metoden delkortslutningseffekter:

Generator: $S_n = 20$ MVA; $U_n = 10$ kV; $x_d = 22\%$

$$S_{kG} = \frac{S_n}{x_d} = \frac{20}{0{,}22} = 90{,}9 \text{ MVA}$$

Trafo: $S_n = 25$ MVA · 10/220 kV; $x_k = 10\%$

$$S_{kT} = \frac{S_n}{x_k} = \frac{25}{0{,}10} = 250 \text{ MVA}$$

Linjen: 200 km; $x_l = 0{,}4\ \Omega/\text{fas, km}$; $U_n = 220$ kV

för 200 km: $X_l = 200 \cdot 0{,}4 = 80\ \Omega/\text{fas}$

$$S_{kl} = \frac{U^2}{X_l} = \frac{(220 \cdot 10^3)^2}{80} = 605 \text{ MVA}$$

Nätet: $S_{kn} = 2000$ MVA $= S_{k\text{höger}}$

$$S_{kB} = \frac{S_{kG} \cdot S_{kT}}{S_{kG} + S_{kT}} = \frac{90{,}9 \cdot 250}{90{,}9 + 250} = 66{,}66 \text{ MVA}$$

S_{kA} från vänster:

$$S_{kAV} = \frac{66{,}66 \cdot 605}{66{,}66 + 605} = 60{,}04 \text{ MVA}$$

$$S_{kA} = S_{kAV} + S_{kAH} = 2000 + 60{,}04 = 2060{,}04 \text{ MVA}$$

$$\underline{\underline{I_k}} = \frac{S_k}{\sqrt{3} \cdot U_A} = \frac{2060{,}04 \cdot 10^6}{\sqrt{3} \cdot 220 \cdot 10^3} = \underline{\underline{5406 \text{ A}}}$$

$$\underline{\underline{I_s}} = 2{,}55 \cdot I_k = \underline{\underline{13{,}79 \text{ kA}}}$$