Lösung zu Aufgabe 1:

a) $\underline{Z}_V = \frac{U_{NV}^2}{S_{NV}} \cdot e^{-j\arccos\varphi_V} = \frac{(690\,V)^2}{110\,kVA} \cdot e^{-j\arccos 0,85} = 4,328\,\Omega \cdot e^{-j31,8°}$

$R_{V,Y} = Z_V \cdot \cos\varphi_V = 4,328\,\Omega \cdot 0,85 = 3,679\,\Omega$

$X_{V,Y} = Z_V \cdot \sin\varphi_V = Z_V \cdot \sqrt{1-\cos^2\varphi_V} = 4,328\,\Omega \cdot \sqrt{1-0,85^2} = 2,280\,\Omega$

b) $\ddot{u} = \frac{U_{NT1}}{U_{NT2}} = \frac{220\,kV}{690\,V} = 319$

$X_{2\sigma}' = \ddot{u}^2 \cdot X_{2\sigma} = 319^2 \cdot 0,25\,\Omega = 25,4\,k\Omega$

$\underline{Z}_T' = jX_{1\sigma} + jX_{2\sigma}' = j30\,k\Omega + j25,4\,k\Omega = j55,4\,k\Omega$

c) $\underline{Z}_{V,y}'^* = R_{V,Y}'^* - jX_{V,Y}'^* = \ddot{u}^{*2} \cdot \left(R_{V,Y}^* - jX_{V,Y}^*\right) = 300^2 \cdot (3\,\Omega - j1,8\,\Omega) = (270 - j162)\,k\Omega$

$\underline{I}_{L,1} = \frac{U_{G,Strang}}{\underline{Z}_G + \underline{Z}_T'^* + \underline{Z}_{V,y}'^*} = \frac{\frac{220\,kV}{\sqrt{3}}}{(12 + j20)\,k\Omega + j50\,k\Omega + k\Omega(270 - j162)\,k\Omega} = 0,429\,A \cdot e^{j18,07°}$

$I_{L,2} = \ddot{u} \cdot I_{L,1} = 300 \cdot 0,429\,A = 129\,A$

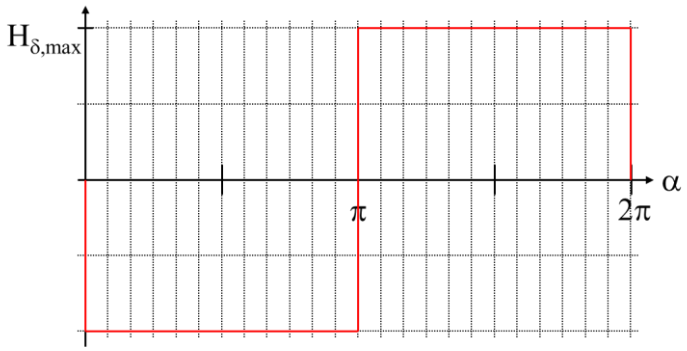
d) $\varphi_{L,2} = \varphi_{L,1} + 5 \cdot 30° = 168,07°$

$U_{V,Strang} = I_{L,2} \cdot \sqrt{R_{V,Y}^2 + X_{V,Y}^2} = 451,31\,V$

Die kapazitive Komponente wirkt spannungserhöhend.

Lösung zu Aufgabe 2:

a) p = 1

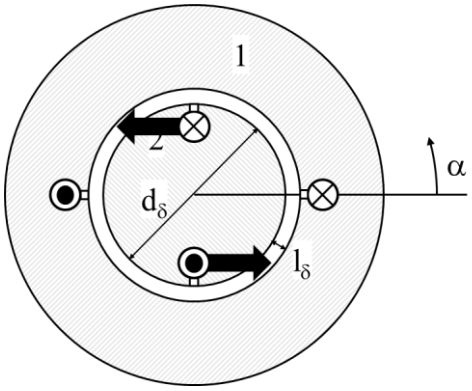


b) $\Theta = w_1 \cdot I_1 = 2 \cdot H_{\delta,max} \cdot l_\delta$

$$H_{\delta,max} = \frac{w_1 \cdot I_1}{2 \cdot l_\delta} = \frac{213 \cdot 12\ A}{2 \cdot 2{,}5\ mm} = 511{,}2\ \frac{kA}{m}$$

$$B_{\delta,max} = \mu_0 \cdot H_{\delta,max} = 4\pi \cdot 10^{-7}\ \frac{V\ s}{A\ m} \cdot 5{,}112 \cdot 10^5\ \frac{A}{m} = 0{,}642\ T$$

c)



$$F = w_2 \cdot I_2 \cdot l_{Fe} \cdot B_{\delta,max} = 5 \cdot 40\ A \cdot 0{,}3\ m \cdot 0{,}642\ T = 38{,}5\ N$$

$$M = 2 \cdot F \cdot \frac{d_\delta}{2} = F \cdot d_\delta = 38{,}5\ N \cdot 0{,}12\ m = 4{,}622\ Nm$$

d) $U_i \sim n$ (Drehzahl)

$I_a \sim M$ (Drehmoment)

in der Spannungsquelle (Produkt aus Spannung und Strom durch die Quelle, motorisch positiv gezählt)

Lösung zu Aufgabe 3:

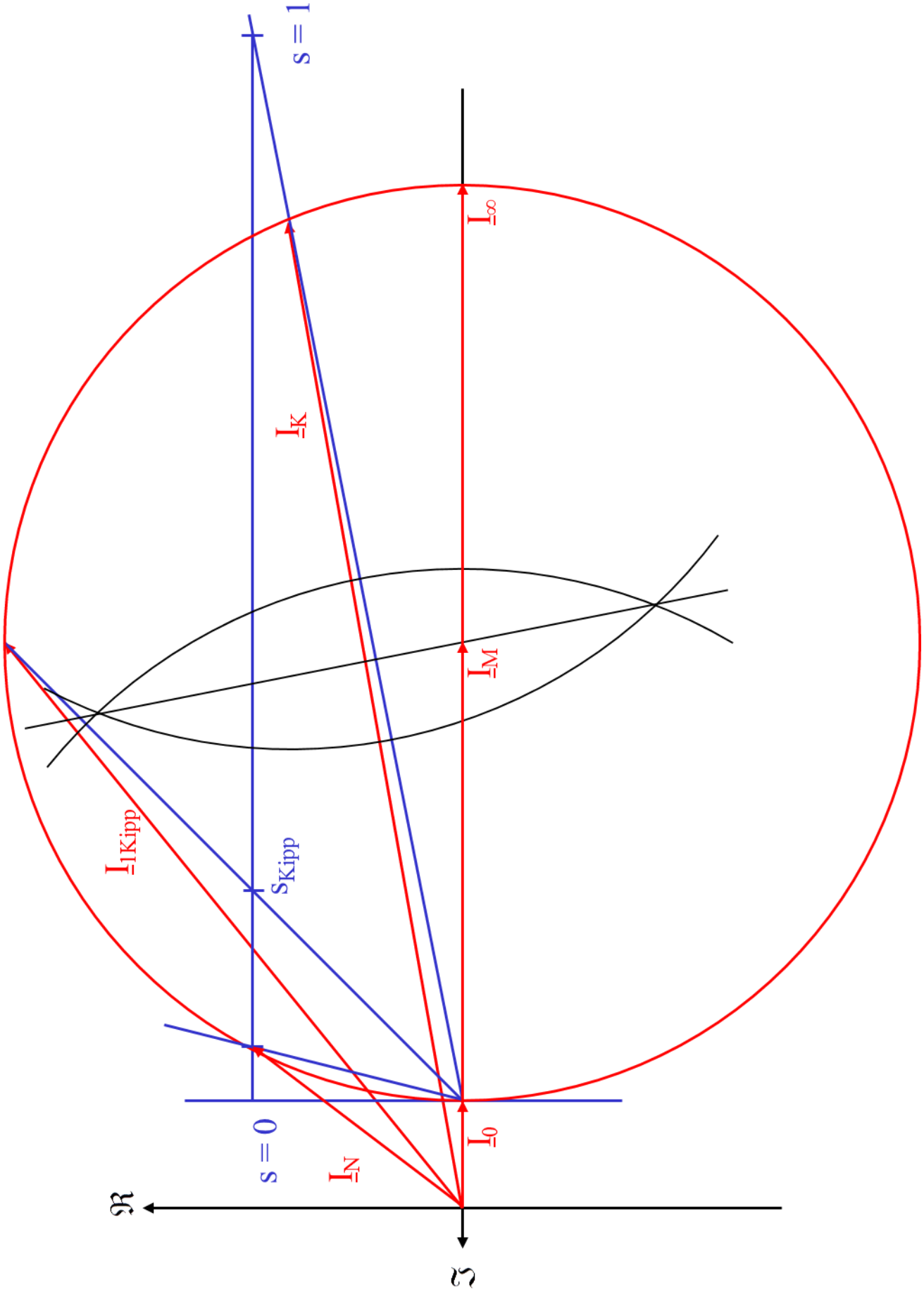
$$n_0 = \frac{f_1}{p} = \frac{400\ \text{Hz}}{3} = 133\,\text{s}^{-1} = 8000\ \text{min}^{-1}$$

$$n_N = n_0 \cdot (1 - s_N) = 8000\ \text{min}^{-1} \cdot (1 - 0{,}05) = 7600\ \text{min}^{-1}$$

$$M_K = \frac{3 \cdot p \cdot U_{Strang} \cdot I_{K,Strang} \cdot \cos\varphi_K}{2 \cdot \pi \cdot f_1} = \frac{3 \cdot 3 \cdot 115\ \text{V} \cdot 375\ \text{A} \cdot \cos(-80°))}{2 \cdot \pi \cdot 400\ \text{Hz}} = 26{,}82\ \text{Nm}$$

$$\frac{M_N}{M_{Kipp}} = \frac{4{,}1\,\text{cm}}{8{,}6\,\text{cm}} = 0{,}48$$

Skizze s. nächstes Blatt


s = 1
$\underline{I}_\infty$
$\underline{I}_K$
$\underline{I}_M$
$\underline{I}_{1Kipp}$
s_{Kipp}
s = 0
$\underline{I}_N$
$\underline{I}_0$
ℜ
ℑ

Lösung zu Aufgabe 4:

a) $S_{el,max} = U_N \cdot I_{max} = 230\,V \cdot 6{,}35\,A \cdot 0{,}87 = 1462\,VA$

$$\eta_{max} = \frac{P_{max}}{P_{el,max}} = \frac{P_{max}}{S_{el,max} \cdot \cos\varphi_{max}} = \frac{1100\,W}{1462 \cdot 0{,}87} = 86{,}6\,\%$$

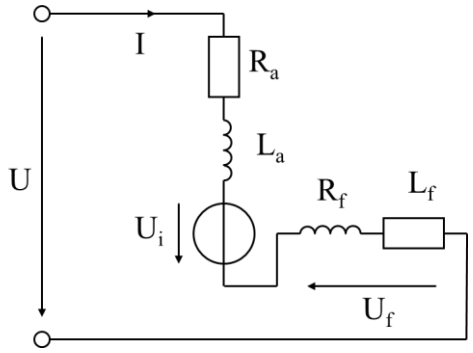
$$M_{max} = \frac{P_{max}}{2\pi \cdot n_{max}} = 5{,}8\,Nm$$

b) $Q_{el,max} = S_{el,max} \cdot \sin\varphi_{max} = S_{el,max} \cdot \sqrt{1 - \cos^2\varphi_{max}} = 721\,var$

$$(L_a + L_f) = \frac{Q_{el,max}}{\omega_N \cdot I_{max}^2} = 56{,}8mH$$

$$(R_a + R_f) = \frac{P_{el,max} - P_{max}}{I_{max}^2} = 4{,}21\,\Omega$$

c)



$$U_{i,max} = \frac{P_{max}}{I_{max}} = 173{,}22\,V$$

$$k \cdot k' = \frac{k \cdot \Phi_{max}}{I_{max}} = \frac{U_{i,max}}{I_{max} \cdot n_{max}} = 0{,}9\Omega$$

d) $$M_N = \frac{k\Phi}{2\pi} \cdot I_N = \frac{k \cdot k'}{2\pi} \cdot I_N^2 \Rightarrow$$

$$I_N = \sqrt{\frac{2\pi M_N}{k \cdot k'}} = 2{,}64\,A$$

$$U_N = \sqrt{\left(k \cdot k' \cdot I_N \cdot n_N + (R_a + R_f) \cdot I_N\right)^2 + \left(\omega \cdot (L_a + L_f) \cdot I_N\right)^2} = 49{,}46\,V (41{,}75V)$$

Normalwaschgang