Elektroenergiesysteme - Gedächtnisprotokoll (2.)

Aufgabe (1.)

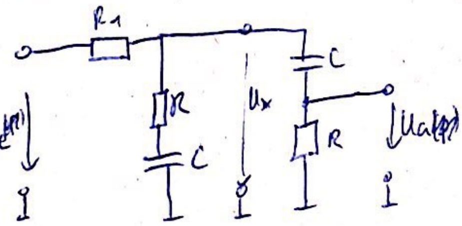
a)

$I_1(p)$	$I_2(p)$	$I_3(p)$	$U_{w1}(p)$	$U_{w2}(p)$	=
$R_1+R_2+pL_1+pL_2$	$-pL_2$	$-R_2$	0	0	$U_e(p)$
$-pL_2$	pL_2	0	1	0	0
$-R_2$	0	$R_2+R_3+pL_3+\frac{1}{pC_1}$	0	-1	0
0	0	0	1	$-\frac{w_1}{wL}$	0
0	w_2	w_3	0	0	0

~~F(p) = det(~~ $\quad \frac{U_a(p)}{U_e(p)} = \frac{I_3(p)\cdot\frac{1}{pC_1}}{U_e(p)} = \frac{\det(I_3)\cdot\frac{1}{pC_1}}{\det I\cdot U_e(p)}$ //

b) ?

c)



$$F(\omega) = \frac{U_a}{U_e} = \frac{U_a}{U_x}\cdot\frac{U_x}{U_e}$$

$$\Rightarrow \frac{U_a}{U_x} = \frac{R}{R+\frac{1}{j\omega C}} = \frac{j\omega CR}{1+j\omega CR}$$

$$\Rightarrow \frac{U_x}{U_e} = \frac{Z}{R_1+Z} \quad \text{mit } Z = \left(R+\frac{1}{j\omega C}\right) \| \left(R+\frac{1}{j\omega C}\right)$$

$$Z = \frac{1}{2}\left(R+\frac{1}{j\omega C}\right)$$

$$\Rightarrow \frac{U_x}{U_e} = \frac{\frac{1}{2}\left(R+\frac{1}{j\omega C}\right)}{R_1+\frac{1}{2}\left(R+\frac{1}{j\omega C}\right)} = \frac{R+\frac{1}{j\omega C}}{2R_1+R+\frac{1}{j\omega C}} = \frac{1+j\omega CR}{1+j\omega C[R+2R_1]}$$

$$\text{somit } F(\omega) = \frac{U_a}{U_x}\cdot\frac{U_x}{U_e} = \frac{j\omega CR}{1+j\omega CR}\cdot\frac{1+j\omega CR}{1+j\omega C[R+2R_1]} = \frac{j\omega CR}{1+j\omega C[R+2R_1]}$$

$$\Rightarrow \alpha = 0 \quad \beta = \omega CR \quad \gamma = 1 \quad \delta = \omega C[R_1+2R_1]$$

d) $$|F(\omega)| = \frac{\omega CR}{\sqrt{1+(\omega C[R+2R_1])^2}}$$

e) $\varphi(\omega) = 90° - \tan^{-1}(\omega C\,[R+2R_1])$

$$\Rightarrow \varphi(\omega_0) = \frac{\pi}{4} \rightarrow 1 \doteq \omega C\,[R+2R_1] \rightarrow \omega_0 = \frac{1}{C\,[R+2R_1]}$$

Aufgabe 2.

a) $I_M = U_Y \cdot e^{j\omega t}\left[G_R + G_S \cdot e^{-j\frac{2\pi}{3}} + G_T \cdot e^{-j\frac{4\pi}{3}}\right] \doteq 0$

$G_R + G_S \cdot e^{-j\frac{4\pi}{3}} + G_T \cdot e^{-j\frac{4\pi}{3}} \doteq 0$ mit $G_S = 0$, da Leerlauf

$G_R + G_T \cdot e^{-j\frac{4\pi}{3}} \doteq 0 \leadsto G_R = \frac{1}{R_1 + j\omega L_1} \quad G_T = \frac{1}{R_2 + \frac{1}{j\omega C_1}} = \frac{j\omega C_1}{1 + j\omega R_2 C_1}$

≙ nicht der Parallelschaltung, also neu rechnen...

$$\rightarrow \frac{1}{R_1 + j\omega L_1} + \frac{j\omega C_1}{1 + j\omega R_2 C_1}\left(-\frac{1}{2} + \frac{\sqrt{3}}{2}\right) = 0$$

$$1 + j\omega R_2 C_1 + j\omega C_1\,[R_1 + j\omega L_1]\left(-\frac{1}{2} + j\frac{\sqrt{3}}{2}\right) = 0$$

$$1 + j\omega R_2 C_1 + (j\omega C_1 R_1 - \omega^2 L_1 C_1)\left(-\frac{1}{2} + j\frac{\sqrt{3}}{2}\right) = 0$$

$$1 + j\omega R_2 C_1 - \frac{1}{2} j\omega C_1 R_1 + \frac{1}{2}\omega^2 L C_1 - \frac{\sqrt{3}}{2}\omega C_1 R_1 - j\omega^2 L_1 C_1 \frac{\sqrt{3}}{2} = 0$$

(I) $1 + \frac{1}{2}\omega^2 L C_1 - \frac{\sqrt{3}}{2}\omega C_1 R_1 = 0$

(II) $\omega C_1 R_2 - \frac{1}{2}\omega C_1 R_1 - \omega^2 L_1 C_1 \frac{\sqrt{3}}{2} = 0$

aus (I) $R_1 = \frac{2 + \omega^2 L_1 C_1}{\sqrt{3}\,\omega C_1}$ in (II) $\omega C_1 R_2 + \frac{1}{2}\omega C_1 \frac{2 + \omega^2 L_1 C_1}{\sqrt{3}\,\omega C_1} - \omega^2 L_1 C_1 \frac{\sqrt{3}}{2} = 0$

$$\leadsto \omega C_1 R_2 + \frac{\omega C_1}{\sqrt{3}\,\omega C_1} + \frac{1}{2}\frac{\omega^3 L_1 C_1^2}{\sqrt{3}\,\omega C_1} - \omega^2 L_1 C_1 \frac{\sqrt{3}}{2} = 0$$

$$\rightarrow L_1\left[\frac{\omega^2 C_1}{2\sqrt{3}} - \omega^2 C_1 \frac{\sqrt{3}}{2}\right] + \omega C_1 R_2 + \frac{1}{\sqrt{3}} = 0$$

$$\Rightarrow L_1 = -\frac{\omega C_1 R_2 + \frac{1}{\sqrt{3}}}{\frac{\omega^2 C_1}{2\sqrt{3}} - \omega^2 C_1 \frac{\sqrt{3}}{2}} = -\frac{\omega C_1 R_2 + \frac{1}{\sqrt{3}}}{-\frac{\sqrt{3}}{2} C_1} = \frac{2\omega C_1 R_2 + \frac{1}{\sqrt{3}}}{\sqrt{3}\,C_1}$$

$$R_1 = \frac{2 + \omega^2 \frac{2\omega C_1 R_2 + \frac{1}{\sqrt{3}}}{\sqrt{3}\,C_1} C_1}{\sqrt{3}\,\omega C_1} = \frac{2 + \omega^2 \frac{2}{\sqrt{3}}\omega R_2 + \frac{1}{3}}{\sqrt{3}\,\omega C_1}$$

verrechnet ??

Elektroenergiesysteme - Gedächtnisprotokoll (2.)

Aufgabe (2.)

a) $Z_1 = R_1 \| j\omega L_1 = \frac{j\omega L_1 R_1}{R_1 + j\omega L_1} \rightarrow \frac{1}{Z_1} = \frac{R_1 + j\omega L_1}{j\omega L_1 R_1}$ $\quad G_2 = 0$

$Z_2 = R_2 \| \frac{1}{j\omega C_1} = \frac{\frac{R_2}{j\omega C_1}}{R_2 + \frac{1}{j\omega C_1}} = \frac{R_2}{1 + j\omega C_1 R_2} \Rightarrow \frac{1}{Z_2} = \frac{1 + j\omega C_1 R_2}{R_2}$

$I_M \overset{!}{=} 0 \quad I_M = U_Y \cdot e^{j\omega t}\left[G_R + G_S \cdot e^{-j\frac{2\pi}{3}} + G_T \cdot e^{-j\frac{4\pi}{3}}\right] \overset{!}{=} 0$

$\rightarrow 0 = G_R + G_T \cdot e^{-j\frac{4\pi}{3}} = \frac{R_1 + j\omega L_1}{j\omega L_1 R_1} + \frac{1 + j\omega C_1 R_2}{R_2}\left(-\frac{1}{2} + j\frac{\sqrt{3}}{2}\right)$

$\rightarrow 0 = -\frac{jR_1}{\omega L_1 R_1} + \frac{\omega L_1}{\omega L_1 R_1} - \frac{1}{2R_2} - \frac{\sqrt{3}\omega C_1 R_2}{2} + j\frac{\sqrt{3}}{2R_2} - j\frac{\omega C_1 R_2}{2R_2}$

$0 = \frac{1}{R_1} - \frac{1}{2R_2} - \frac{\sqrt{3}\omega C_1 R_2}{2} + j\left(\frac{\sqrt{3}}{2R_2} - \frac{\omega C_1 R_2}{2R_2} - \frac{R_1}{\omega L_1 R_1}\right)$

(I) $\frac{1}{R_1} - \frac{1}{2R_2} - \frac{\sqrt{3}\omega C_1 R_2}{2} \overset{!}{=} 0 \rightarrow \frac{1}{R_1} = \frac{1}{2R_2} + \frac{\sqrt{3}\omega C_1 R_2}{2}$

$\rightarrow \frac{1}{R_1} = \frac{1 + \sqrt{3}\omega C_1 R_2^2}{2R_2} \rightarrow R_1 = \frac{2R_2}{1 + \sqrt{3}\omega C_1 R_2^2} > 0 \checkmark$

(II) $\frac{\sqrt{3}}{2R_2} - \frac{\omega C_1}{2} - \frac{1}{\omega L_1} \overset{!}{=} 0 \rightarrow \frac{1}{\omega L_1} = \frac{\omega C_1}{2} - \frac{\sqrt{3}}{2R_2} = \frac{R_2\omega C_1 - \sqrt{3}}{2R_2}$

$\rightarrow \omega L_1 = \frac{2R_2}{R_2\omega C_1 - \sqrt{3}} \rightarrow L_1 = \frac{2R_2}{R_2\omega^2 C_2 - \sqrt{3}\omega}$

die Lösung für L_1 ist nicht plausibel, da wenn $\sqrt{3}\omega > R_2\omega^2 C_2$ also $\sqrt{3} > R_2\omega C_2$ die Induktivität negativ wäre, dies ist physikalisch nicht möglich.

b) $S_Y = (G_R^* + G_S^* + G_T^*)U_Y^2 = \left[\left(\frac{R_1 + j\omega L_1}{j\omega L_1 R_1}\right)^* + \left(\frac{1 + j\omega C_1 R_2}{R_2}\right)^*\right]U_Y^2$

$S_Y = \left[\frac{-\omega L_1 + R_1}{\omega L_1 R_1} + \frac{1 - j\omega C_1 R_2}{R_2}\right]U_Y$

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c) $$I_R = \frac{U_R}{Z_Y} \cdot e^{j\omega t} = \frac{U_R}{R+j\omega L} \cdot e^{j\omega t}$$

$$I_S = \frac{U_S}{Z_Y} e^{j\omega t} = \frac{U_S}{R+j\omega L} \cdot e^{j(\omega t - \frac{2\pi}{3})}$$

$$I_T = \frac{U_T}{Z_Y} \cdot e^{j\omega t} = \frac{U_T}{R+j\omega L} e^{j(\omega t - \frac{4\pi}{3})}$$

$U_R = U_S = U_T$:

$$= \frac{U_Y}{R+j\omega L} e^{j\omega t}$$

$$= \frac{U_Y}{R+j\omega L} e^{j(\omega t - \frac{2\pi}{3})}$$

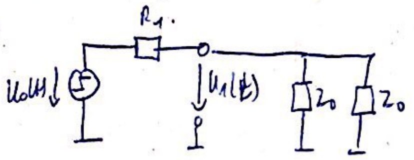
$$= \frac{U_Y}{R+j\omega L} e^{j(\omega t - \frac{4\pi}{3})}$$

$$U_{NM} = \frac{U_Y \frac{1}{R+j\omega L} \overbrace{\left(1 + e^{-j\frac{2\pi}{3}} + e^{-j\frac{4\pi}{3}}\right)}^{=0} e^{j\omega t}}{3 \cdot \left(\frac{1}{R+j\omega L}\right)} = 0 \; //$$

(da symmetrische Last.

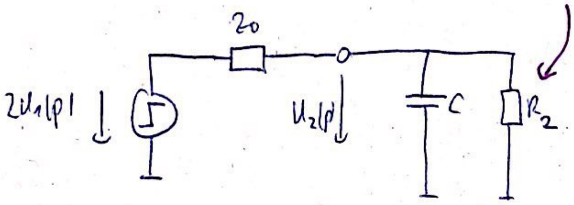
Aufgabe ③

a)



$$X_1(p) = \frac{U_1(p)}{U_0(p)} = \frac{\frac{1}{2} Z_0}{\frac{1}{2} Z_0 + R_1} = \frac{Z_0}{Z_0 + 2R_1}$$

b)



warum hier unten 2x parallele Z_0?

$$Z_A = \frac{1}{pC} \| R_2 = \frac{\frac{R_2}{pC}}{R_2 + \frac{1}{pC}} = \frac{R_2}{1 + pCR_2}$$

$$\frac{U_2(p)}{2U_1(p)} = \frac{Z_A}{Z_0 + Z_A} \Rightarrow U_2(p) = \frac{Z_A}{Z_0 + Z_A} \cdot 2U_1(p)$$

$\Rightarrow$ mit $U_1(p) = \frac{Z_0}{Z_0 + 2R_1} U_0(p) = \frac{Z_0 U_0}{p(Z_0 + 2R_1)}$ folgt

$$U_2(p) = \frac{\frac{R_2}{1+pCR_2}}{Z_0 + \frac{R_2}{1+pCR_2}} \cdot 2 \cdot \frac{Z_0 U_0}{p(Z_0 + R_1 \cdot 2)} = \frac{2R_2}{Z_0 + R_2 + pCR_2 Z_0} \cdot \frac{Z_0 U_0}{p(Z_0 + 2R_1)}$$

$$U_2(p) = \frac{2R_2 Z_0 U_0}{p^2 (Z_0 + 2R_1) CR_2 Z_0 + p(Z_0 + 2R_1)(Z_0 + R_2)} = \frac{2R_2 Z_0 U_0}{(Z_0 + 2R_1)(CR_2 Z_0)} \cdot \frac{1}{p^2 + p \frac{Z_0 + R_2}{CR_2 Z_0}}$$

$$\circ\!-\!\bullet$$

$$u_2(t) = \frac{2R_2 Z_0 U_0}{(Z_0 + 2R_1)(CR_2 Z_0)} \cdot \frac{e^{-\frac{Z_0 + R_2}{CR_2 Z_0} t} - 1}{\frac{Z_0 + R_2}{CR_2 Z_0}} \sigma(t) = \frac{2R_2 Z_0 U_0}{(Z_0 + 2R_2)(Z_0 + R_2)} \left(e^{-\frac{Z_0 + R_2}{CR_2 Z_0} t} - 1\right) \sigma(t)$$

Elektroenergiesysteme – Gedächtnisprotokoll (2.)

zu Aufgabe (3.)

a) $U_{V3}(p)$ gegeben

$$U_{r3}(p) = B_3(p) \cdot U_{V3}(p) = \frac{Z_{A,3} - Z_0}{Z_{A,3} + Z_0} U_{V3}$$ mit $Z_{A,3} = \infty$, da Leerlauf folgt

$$U_{r3}(p) = \frac{1 - \frac{Z_0}{Z_{A,3}}}{1 + \frac{Z_0}{Z_{A,3}}} U_{V3} \rightarrow 1 \cdot U_{V3} \text{ für } Z_{A,3} \rightarrow \infty$$

$U_{V4}(p)$ gegeben

$$U_{r4}(p) = B_4(p) \cdot U_4(p) = \frac{Z_{A,4} - Z_0}{Z_{A,4} + Z_0} U_{4V}$$ mit $Z_{A,4} = 0$, da kurzgeschlossene Leitung folgt

$$U_{r4}(p) = \frac{0 - Z_0}{0 + Z_0} U_{4V} = -U_{4V} \,//$$

Aufgabe (4.)

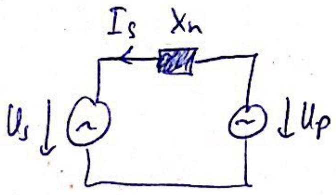
a) gegeben: $\cos(\varphi)$, 4polig $\rightarrow$ $2 = p$, S_N, U_N, L_0, L_h $\rightarrow X_h = 2\pi f (L_0 + L_h)$

$\hookrightarrow \varphi_N = \cos^{-1}(\cos(\varphi))$

$P = \mathrm{Re}\{S_N\}$ $\qquad Q = \mathrm{Im}\{S_N\}$ $\qquad n = \frac{f}{p}$ hat man f gegeben?

oder: $P = S \cos(\varphi)$ $\qquad Q = S \cdot \sin(\varphi)$

$$M_N = \frac{P}{\Omega} = \frac{P}{2\pi n}$$ hier n oder f



b) $\underline{U}_P = \underline{U}_S + \underline{X}_h \cdot \underline{I}_S = \underline{U}_S + jX_h \cdot \underline{I}_S^*$ $\quad || \underline{U}_S = U_1$ da rein reell

mit $\underline{I}_S = \left(\frac{S_1}{3 \cdot U_1}\right)^* = \left(\frac{S_1}{\sqrt{3} \cdot U_N}\right)^*$

$\underline{U}_P = U_S + jX_h \cdot \left(\frac{S_1}{\sqrt{3} U_N}\right)^*$ $\qquad U_P = |\underline{U}_P|$ $\qquad \theta = \measuredangle(\underline{U}_P)$

c) Ie reduzieren bis $Q=0$ $\Leftrightarrow$ U_p verringern bis $Q=0$

$Q \overset{!}{=} 0 \rightarrow$ (I) $\frac{U_1 U_{p,neu} \cos(\theta_{neu})}{X_d} = \frac{U_1^2}{X_d}$

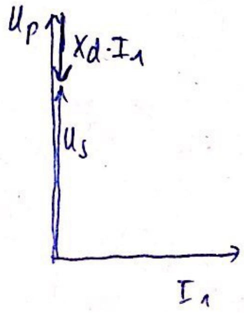
P bleibt Palt (II) $P_{alt} = 3 \cdot \frac{U_1 \cdot U_{p,neu}}{X_d} \cdot \sin(\theta_{neu})$

aus (I) $U_{p,neu} = \frac{U_1}{\cos(\theta_{neu})}$ in (II) $P_{alt} = 3 \cdot \frac{U_1^2}{X_d} \cdot \tan(\theta_{neu})$

$\Rightarrow \theta_{neu} = \tan^{-1}\left(\frac{P_{alt} \cdot X_d}{3U_1^2}\right)$

$$\Rightarrow U_{p,neu} = \frac{U_1}{\cos\left(\tan^{-1}\left(\frac{P_{alt} \cdot X_d}{3U_1^2}\right)\right)}$$

d) $Q=0$ $\rightarrow$ U_p muss theoretisch in Phase zu U_1 damit reine Wirkleistungsübertragung. Zudem muss I_1 um $-90°$ verschoben zu U_p & U_1, da Induktivität & $\underline{I_1} \cdot \underline{X}_d$ muss rein reell da $\underline{X}_d$ rein komplex muss $\underline{I}_1$ rein komplex.



← stimmt das ??

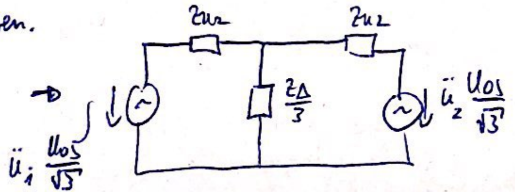
Aufgabe (5)

a) da $Z_k = (u_{kr} + j u_{kx}) \cdot \frac{U_{os}^2}{S_N}$ & $u_{kr} + j u_{kx} = 0 + j0$ folgt

$Z_k = 0$

b) Dreieckverbraucher in Sternverbraucher Transformieren.

$Z_Y = \frac{Z_\Delta}{3}$ $\rightarrow$



c) $I_A = \frac{\underline{\ddot{u}}_2 - \underline{\ddot{u}}_1}{Z_{k1} + Z_{k2}} \cdot \frac{U_{os}}{\sqrt{3}}$

mit $\underline{\ddot{u}}_2 = \frac{U_{os}}{U_{us}} \cdot e^{j330°}$ $\underline{\ddot{u}}_1 = \frac{U_{os}}{U_{us}} \cdot e^{j60°}$