ST 1 – Tutorium, Blatt 5 (1.12.09)

Quellenbehaftete Zweitore

Versuch: Quellen sollen aus dem Zweitor entfernt werden und lediglich als Beschaltung an den Toren auftauchen

Vorgehen: - LL/KS-Methode verwenden + eventuell vorhandene Quellen werden durch KS (Spg-quelle) oder durch eine LL ersetzt
- setze die jeweils steuernden Torgrößen auf 0V/0A und berechne die Auswirkungen der Quellen auf die gesuchten Torgröße

Bsp: $\underset{\sim}{R}$

$$\begin{pmatrix} u_1 \\ u_2 \end{pmatrix} = \underset{\sim}{R} \begin{pmatrix} i_1 \\ i_2 \end{pmatrix} = \begin{pmatrix} r_{11} i_1 + r_{12} i_2 \\ r_{21} i_1 + r_{22} i_2 \end{pmatrix}$$

1. $r_{11} = \left.\frac{u_1}{i_1}\right|_{i_2 = 0 \wedge U_q = 0V}$ ....

2. $\left. u_1 \right|_{i_1 = 0, i_2 = 0} = f(U_{q1}, U_{q2}, \ldots, I_{q1} \ldots)$

$\left. u_2 \right|_{i_1 = 0, i_2 = 0} = f(\ldots)$

Linearisierung von Zweitoren:

$$y = \frac{dy}{dx}\Big|_{AP}(x - x_0) + y_0 \quad \text{(Eintore)}$$

Großsignal: $\underline{y} = \underline{y}_{AP} + \underline{J}\,\underline{x} = \begin{pmatrix} y_{1,AP} \\ y_{2,AP} \end{pmatrix} + \begin{pmatrix} \frac{\partial y_1}{\partial x_1} & \frac{\partial y_1}{\partial x_2} \\ \frac{\partial y_2}{\partial x_1} & \frac{\partial y_2}{\partial x_2} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$

Kleinsignal: $\Delta \underline{y} = \underline{J}\,\Delta x$

Beispiel: $\begin{pmatrix} u_1 \\ u_2 \end{pmatrix} = \begin{pmatrix} 3e^{\frac{i_1}{1}} + i_2^2 R \\ \ln\left(\frac{i_1}{1}\right) + i_2 i_1 C \end{pmatrix}$

$$\frac{\partial u_1}{\partial i_1} = 3\,\frac{1}{1}\,e^{\frac{i_1}{1}} \qquad \frac{\partial u_1}{\partial i_2} = 2 i_2 R$$

$$\frac{\partial u_2}{\partial i_1} = \frac{1}{\frac{i_1}{1}} \cdot \frac{1}{1} + C i_2 \qquad \frac{\partial u_2}{\partial i_2} = i_1 \cdot C$$

Blatt 5

Aufgabe 1

$$\begin{pmatrix} u_1 \\ i_2 \end{pmatrix} = \begin{pmatrix} U_T \cdot \ln\left(\frac{i_1}{I_S} + 1\right) \\ \beta_0 i_1 \ln\left(\frac{i_1}{I_S} + 1\right) \end{pmatrix}$$

1. Hybridbeschreibung $\begin{pmatrix} u_1 \\ i_2 \end{pmatrix} = \underline{H} \begin{pmatrix} i_1 \\ u_2 \end{pmatrix}$

2. $\left.\begin{array}{l} u_1(0,0) = 0 \\ i_2(0,0) = 0 \end{array}\right\} \Rightarrow$ quellenfrei ✓

3. linearer Fall: $\begin{pmatrix} i_1 \\ i_2 \end{pmatrix} = \underset{\sim}{G} \begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$

$$u_1 = U_T \cdot \ln\left(\frac{i_1}{I_S} + 1\right)$$

$$\frac{u_1}{u_T} = \ln\left(\frac{i_1}{I_s} + 1\right) \Leftrightarrow \frac{i_1}{I_s} + 1 = e^{\frac{u_1}{u_T}}$$

$$i_1 = \left(e^{\frac{u_1}{u_T}} - 1\right) \cdot I_s$$ (in die zweite Zeile einsetzen)

$$i_2 = \beta_0 I_s \left(e^{\frac{u_1}{u_T}} - 1\right) \ln\left(\frac{\cancel{I_s}\left(e^{\frac{u_1}{u_T}} \cancel{-1}\right)}{\cancel{I_s}} \cancel{+1}\right) =$$

$$= \beta_0 I_s \left(e^{\frac{u_1}{u_T}} - 1\right) \frac{u_1}{u_T}$$

Leitwertsdarstellung: $\begin{pmatrix} i_1 \\ i_2 \end{pmatrix} = \begin{pmatrix} I_s \left(e^{\frac{u_1}{u_T}} - 1\right) \\ \beta_0 I_s \frac{u_1}{u_T} \left(e^{\frac{u_1}{u_T}} - 1\right) \end{pmatrix}$

4. Linearisierung

$$\begin{pmatrix} u_1 \\ i_2 \end{pmatrix} = \begin{pmatrix} u_{1,AP} \\ I_{2,AP} \end{pmatrix} + J_H \left(U_{AP}, I_{AP}\right) \begin{pmatrix} \Delta i_1 \\ \Delta u_2 \end{pmatrix}$$

$$j_{11} = \left.\frac{\partial u_1}{\partial i_1}\right|_{AP} = \left. u_T \cdot \frac{1}{\frac{i_1}{I_s} + 1} \cdot \frac{1}{I_s} \right|_{AP} = \frac{U_T}{I_s} \cdot \frac{1}{\frac{I_{1,AP}}{I_s} + 1} = r$$

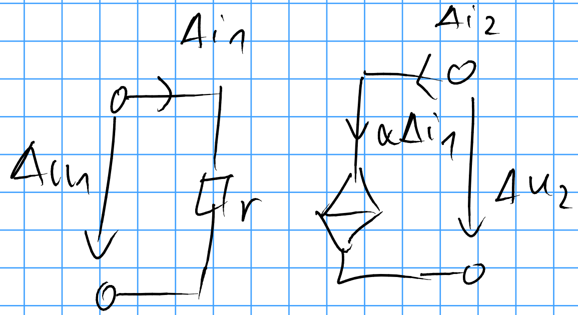
$$j_{12} = \frac{\partial u_1}{\partial u_2} = 0$$

$$j_{21} = \left.\frac{\partial i_2}{\partial i_1}\right|_{AP} = \left.\beta_0 \ln\left(\frac{i_1}{I_s} + 1\right)\right|_{AP} + \left.\beta_0 i_1 \cdot \frac{1}{\frac{i_1}{I_s} + 1} \cdot \frac{1}{I_s}\right|_{AP}$$

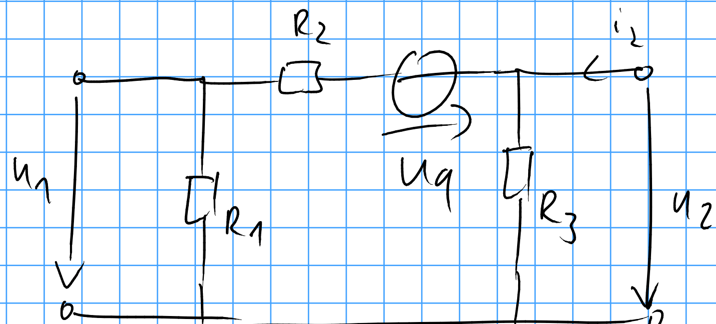
$$= \beta_0 \ln\left(\frac{I_{1,AP}}{I_s} + 1\right) + \beta_0 \frac{I_{1,AP}}{I_s} \frac{1}{\frac{I_{1,AP}}{I_s} + 1} = \alpha$$

5. $\begin{pmatrix} \Delta u_1 \\ \Delta i_2 \end{pmatrix} = J_H \Big|_{AP} \cdot \begin{pmatrix} \Delta i_1 \\ \Delta u_2 \end{pmatrix} = \begin{pmatrix} r & 0 \\ \alpha & 0 \end{pmatrix} \begin{pmatrix} \Delta i_1 \\ \Delta u_2 \end{pmatrix} = \begin{pmatrix} r \Delta i_1 \\ \alpha \Delta i_1 \end{pmatrix}$

$r = \frac{\Delta u_1}{\Delta i_1} \qquad \alpha = \frac{\Delta i_2}{\Delta i_1} \qquad \Delta i_2 = \alpha \Delta i_1$

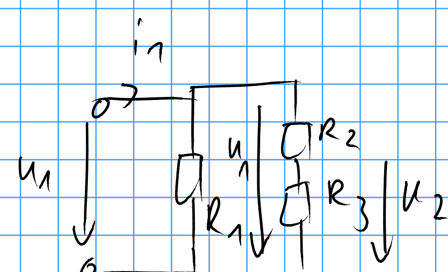


Aufgabe 2



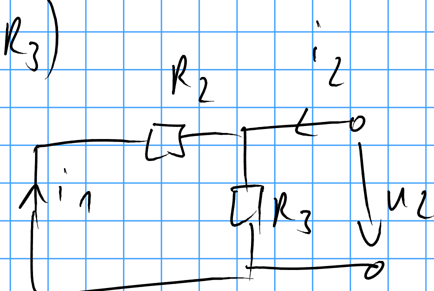
inverse Kettenmatrix:

$\begin{pmatrix} i_1 \\ u_2 \end{pmatrix} = \underset{\sim}{H}' \begin{pmatrix} u_1 \\ i_2 \end{pmatrix} + \begin{pmatrix} I_1 \\ U_2 \end{pmatrix}$



$h'_{11} = \frac{i_1}{u_1} \Big|_{i_2 = 0 \wedge u_q = 0V}$

$= G_1 + \frac{G_2 \cdot G_3}{G_2 + G_3} = \frac{1}{R_1 \| (R_2 + R_3)}$



$h'_{12} = \frac{i_1}{i_2} \Big|_{u_1 = 0 \wedge u_q = 0}$

Stromteiler: $i_1 = -i_2 \cdot \frac{G_2}{G_2 + G_3}$

$$h'_{12} = -\frac{G_2}{G_2+G_3}$$

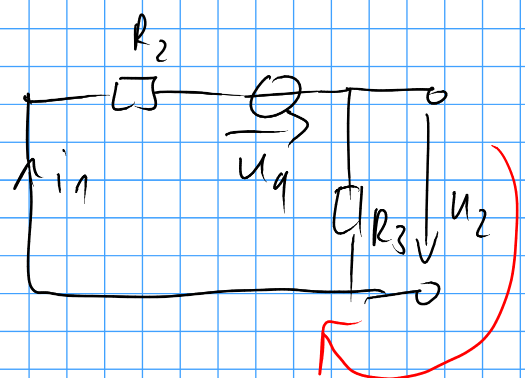
$$h'_{21} = \frac{u_2}{u_1}\Big|_{i_2=0 \wedge u_q=0}$$

$$u_2 = u_1 \cdot \frac{R_3}{R_2+R_3}$$

$$= \frac{R_3}{R_2+R_3}$$

$$h'_{22} = \frac{u_2}{i_2}\Big|_{u_1=0 \wedge u_q=0} = R_2 \| R_3$$

Schritt 2:

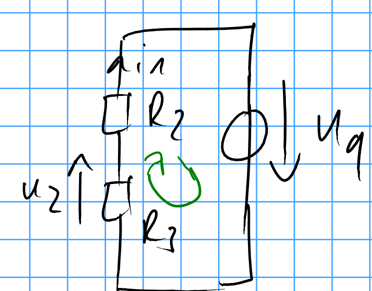


$$I_1 = i_1\Big|_{u_1=0 \wedge i_2=0}$$

$$= -\frac{U_q}{R_2+R_3}$$

$$U_2 = u_2\Big|_{u_1=0 \wedge i_2=0}$$

$$u_2 = -U_q \cdot \frac{R_3}{R_2+R_3}$$



$$u_q = (R_2+R_3)\cdot(-i_1)$$

b)