

1.8 Zweitore, Zusammenfassung

Z	$u_1 = z_{11}i_1 + z_{12}i_2$ $u_2 = z_{21}i_1 + z_{22}i_2$	$\begin{pmatrix} u_1 \\ u_2 \end{pmatrix} = \begin{pmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{pmatrix} \begin{pmatrix} i_1 \\ i_2 \end{pmatrix}$	$\mathbf{Z} = \begin{pmatrix} \left. \frac{u_1}{i_1} \right _{i_2=0} & \left. \frac{u_1}{i_2} \right _{i_1=0} \\ \left. \frac{u_2}{i_1} \right _{i_2=0} & \left. \frac{u_2}{i_2} \right _{i_1=0} \end{pmatrix}$
Y	$i_1 = y_{11}u_1 + y_{12}u_2$ $i_2 = y_{21}u_1 + y_{22}u_2$	$\begin{pmatrix} i_1 \\ i_2 \end{pmatrix} = \begin{pmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{pmatrix} \begin{pmatrix} u_1 \\ u_2 \end{pmatrix}$	$\mathbf{Y} = \begin{pmatrix} \left. \frac{i_1}{u_1} \right _{u_2=0} & \left. \frac{i_1}{u_2} \right _{u_1=0} \\ \left. \frac{i_2}{u_1} \right _{u_2=0} & \left. \frac{i_2}{u_2} \right _{u_1=0} \end{pmatrix}$
H	$u_1 = h_{11}i_1 + h_{12}u_2$ $i_2 = h_{21}i_1 + h_{22}u_2$	$\begin{pmatrix} u_1 \\ i_2 \end{pmatrix} = \begin{pmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{pmatrix} \begin{pmatrix} i_1 \\ u_2 \end{pmatrix}$	$\mathbf{H} = \begin{pmatrix} \left. \frac{u_1}{i_1} \right _{u_2=0} & \left. \frac{u_1}{u_2} \right _{i_1=0} \\ \left. \frac{i_2}{i_1} \right _{u_2=0} & \left. \frac{i_2}{u_2} \right _{i_1=0} \end{pmatrix}$
G	$i_1 = g_{11}u_1 + g_{12}i_2$ $u_2 = g_{21}u_1 + g_{22}i_2$	$\begin{pmatrix} i_1 \\ u_2 \end{pmatrix} = \begin{pmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{pmatrix} \begin{pmatrix} u_1 \\ i_2 \end{pmatrix}$	$\mathbf{G} = \begin{pmatrix} \left. \frac{i_1}{u_1} \right _{i_2=0} & \left. \frac{i_1}{i_2} \right _{u_1=0} \\ \left. \frac{u_2}{u_1} \right _{i_2=0} & \left. \frac{u_2}{i_2} \right _{u_1=0} \end{pmatrix}$
A	$u_1 = A_{11}u_2 - A_{12}i_2$ $i_1 = A_{21}u_2 - A_{22}i_2$	$\begin{pmatrix} u_1 \\ i_1 \end{pmatrix} = \begin{pmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{pmatrix} \begin{pmatrix} u_2 \\ -i_2 \end{pmatrix}$	$\mathbf{A} = \begin{pmatrix} \left. \frac{u_1}{u_2} \right _{i_2=0} & \left. \frac{-u_1}{i_2} \right _{u_2=0} \\ \left. \frac{i_1}{u_2} \right _{i_2=0} & \left. \frac{-i_1}{i_2} \right _{u_2=0} \end{pmatrix}$

1.8.2 Parameter Umrechnung

	Z	Y	H	G	A
Z	$\begin{matrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{matrix}$	$\begin{matrix} \frac{y_{22}}{\Delta y} & \frac{-y_{12}}{\Delta y} \\ \frac{-y_{21}}{\Delta y} & \frac{y_{11}}{\Delta y} \end{matrix}$	$\begin{matrix} \frac{\Delta h}{h_{22}} & \frac{h_{12}}{h_{22}} \\ \frac{-h_{21}}{h_{22}} & \frac{1}{h_{22}} \end{matrix}$	$\begin{matrix} \frac{1}{g_{11}} & \frac{-g_{12}}{g_{11}} \\ \frac{g_{21}}{g_{11}} & \frac{\Delta g}{g_{11}} \end{matrix}$	$\begin{matrix} \frac{A_{11}}{A_{21}} & \frac{\Delta A}{A_{21}} \\ \frac{1}{A_{21}} & \frac{A_{22}}{A_{21}} \end{matrix}$
Y	$\begin{matrix} \frac{z_{22}}{\Delta z} & \frac{-z_{12}}{\Delta z} \\ \frac{-z_{21}}{\Delta z} & \frac{z_{11}}{\Delta z} \end{matrix}$	$\begin{matrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{matrix}$	$\begin{matrix} \frac{1}{h_{11}} & \frac{-h_{12}}{h_{11}} \\ \frac{h_{21}}{h_{11}} & \frac{\Delta h}{h_{11}} \end{matrix}$	$\begin{matrix} \frac{\Delta g}{g_{22}} & \frac{g_{12}}{g_{22}} \\ \frac{-g_{21}}{g_{22}} & \frac{1}{g_{22}} \end{matrix}$	$\begin{matrix} \frac{A_{22}}{A_{12}} & \frac{-\Delta A}{A_{12}} \\ \frac{-1}{A_{12}} & \frac{A_{11}}{A_{12}} \end{matrix}$
H	$\begin{matrix} \frac{\Delta z}{z_{22}} & \frac{z_{12}}{z_{22}} \\ \frac{-z_{21}}{z_{22}} & \frac{1}{z_{22}} \end{matrix}$	$\begin{matrix} \frac{1}{y_{11}} & \frac{-y_{12}}{y_{11}} \\ \frac{y_{21}}{y_{11}} & \frac{\Delta y}{y_{11}} \end{matrix}$	$\begin{matrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{matrix}$	$\begin{matrix} \frac{g_{22}}{\Delta g} & \frac{-g_{12}}{\Delta g} \\ \frac{-g_{21}}{\Delta g} & \frac{g_{11}}{\Delta g} \end{matrix}$	$\begin{matrix} \frac{A_{12}}{A_{22}} & \frac{\Delta A}{A_{22}} \\ \frac{-1}{A_{22}} & \frac{A_{21}}{A_{22}} \end{matrix}$
G	$\begin{matrix} \frac{1}{z_{11}} & \frac{-z_{12}}{z_{11}} \\ \frac{z_{21}}{z_{11}} & \frac{\Delta z}{z_{11}} \end{matrix}$	$\begin{matrix} \frac{\Delta y}{y_{22}} & \frac{y_{12}}{y_{22}} \\ \frac{-y_{21}}{y_{22}} & \frac{1}{y_{22}} \end{matrix}$	$\begin{matrix} \frac{h_{22}}{\Delta h} & \frac{-h_{12}}{\Delta h} \\ \frac{-h_{21}}{\Delta h} & \frac{h_{11}}{\Delta h} \end{matrix}$	$\begin{matrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{matrix}$	$\begin{matrix} \frac{A_{21}}{A_{11}} & \frac{-\Delta A}{A_{11}} \\ \frac{1}{A_{11}} & \frac{A_{12}}{A_{11}} \end{matrix}$
A	$\begin{matrix} \frac{z_{11}}{z_{21}} & \frac{\Delta z}{z_{21}} \\ \frac{1}{z_{21}} & \frac{z_{22}}{z_{21}} \end{matrix}$	$\begin{matrix} \frac{-y_{22}}{y_{21}} & \frac{-1}{y_{21}} \\ \frac{-\Delta y}{y_{21}} & \frac{-y_{11}}{y_{21}} \end{matrix}$	$\begin{matrix} \frac{-\Delta h}{h_{21}} & \frac{-h_{11}}{h_{21}} \\ \frac{-h_{22}}{h_{21}} & \frac{-1}{h_{21}} \end{matrix}$	$\begin{matrix} \frac{1}{g_{21}} & \frac{g_{22}}{g_{21}} \\ \frac{g_{11}}{g_{21}} & \frac{\Delta g}{g_{21}} \end{matrix}$	$\begin{matrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{matrix}$

$$\Delta z = z_{11}z_{22} - z_{12}z_{21}$$

$$\Delta y = y_{11}y_{22} - y_{12}y_{21}$$

$$\Delta h = h_{11}h_{22} - h_{12}h_{21}$$

$$\Delta g = g_{11}g_{22} - g_{12}g_{21}$$

$$\Delta A = A_{11}A_{22} - A_{12}A_{21}$$

$$\mathbf{A} = \begin{pmatrix} A_{11A} & A_{12A} \\ A_{21A} & A_{22A} \end{pmatrix} \begin{pmatrix} A_{11B} & A_{12B} \\ A_{21B} & A_{22B} \end{pmatrix} = \begin{pmatrix} A_{11A}A_{11B} + A_{12A}A_{21B} & A_{11A}A_{12B} + A_{12A}A_{22B} \\ A_{21A}A_{11B} + A_{22A}A_{21B} & A_{21A}A_{12B} + A_{22A}A_{22B} \end{pmatrix}$$

(1.46)

1.8.3 Umrechnung der y-Parameter zwischen Emitter-, Kollektor- und Basisschaltung

$$y_{11e} = y_{11b} + y_{12b} + y_{21b} + y_{22b} = y_{11c}$$

$$y_{12e} = -(y_{12b} + y_{22b}) = -(y_{11c} + y_{12c})$$

$$y_{21e} = -(y_{21b} + y_{22b}) = -(y_{11c} + y_{21c})$$

$$y_{22e} = y_{22b} = y_{11c} + y_{12c} + y_{21c} + y_{22c}$$

$$y_{11b} = y_{11e} + y_{12e} + y_{21e} + y_{22e} = y_{22c}$$

$$y_{12b} = -(y_{12e} + y_{22e}) = -(y_{21c} + y_{22c})$$

$$y_{21b} = -(y_{21e} + y_{22e}) = -(y_{12c} + y_{22c})$$

$$y_{22b} = y_{22e} = y_{11c} + y_{12c} + y_{21c} + y_{22c}$$

$$y_{11c} = y_{11e} = y_{11b} + y_{12b} + y_{21b} + y_{22b}$$

$$y_{12c} = -(y_{11e} + y_{12e}) = -(y_{11b} + y_{21b})$$

$$y_{21c} = -(y_{11e} + y_{21e}) = -(y_{11b} + y_{12b})$$

$$y_{22c} = y_{11e} + y_{12e} + y_{21e} + y_{22e} = y_{11b}$$

1.8.4 Umrechnung der h-Parameter der Emitterschaltung in h-Parameter der Basis- und Kollektorschaltung

Emitter- nach Basisschaltung:

$$h_{11b} = \frac{h_{11e}}{Ne} \quad h_{12b} = \frac{\Delta h_e - h_{12e}}{Ne}$$

$$h_{21b} = \frac{-(\Delta h_e + h_{21e})}{Ne} \quad h_{22b} = \frac{h_{22e}}{Ne}$$

$$Ne = 1 - h_{12e} + h_{21e} + \Delta h_e$$

$$\Delta h_b = \frac{\Delta h_e}{Ne}$$

Approximationen

$$h_{21e} \gg 1 \quad h_{12e} \ll 1 \quad h_{22e} h_{11e} \ll 1$$

$$h_{11b} \approx \frac{h_{11e}}{h_{21e}} \quad h_{12b} \approx \frac{\Delta h_e - h_{12e}}{h_{21e}}$$

$$h_{21b} \approx \frac{-h_{21e}}{h_{21e} + 1} \approx -1 \quad h_{22b} \approx \frac{h_{22e}}{h_{21e}}$$

Emitter- nach Kollektorschaltung:

$$h_{11c} = h_{11e} \quad h_{12c} = 1 - h_{12e}$$

$$h_{21c} = -(1 + h_{21e}) \quad h_{22c} = h_{22e}$$

$$\Delta h_c = Ne = 1 - h_{12e} + h_{21e} + \Delta h_e$$

1.8.5 Umrechnung zwischen S- und T-Parameter

Z: Impedanzparameter

Y: Admittanzparameter

H: Hybridparameter

G: Inverse Hybridparameter

A: Kettenparameter

S: Streuparameter

T: Transmissionsparameter

$$X = \begin{bmatrix} X_{11} & X_{12} \\ X_{21} & X_{22} \end{bmatrix}$$

S ↔ Z:

$$S_{11} = \frac{(z'_{11}-1)(z'_{22}+1) - z'_{12} z'_{21}}{(z'_{11}+1)(z'_{22}+1) - z'_{12} z'_{21}}$$

$$z'_{11} = \frac{(1+S_{11})(1-S_{22}) + S_{12}S_{21}}{(1-S_{11})(1-S_{22}) - S_{12}S_{21}}$$

$$S_{12} = \frac{2z'_{12}}{(z'_{11}+1)(z'_{22}+1) - z'_{12} z'_{21}}$$

$$z'_{12} = \frac{2S_{12}}{(1-S_{11})(1-S_{22}) - S_{12}S_{21}}$$

$$S_{21} = \frac{2z'_{21}}{(z'_{11}+1)(z'_{22}+1) - z'_{12} z'_{21}}$$

$$z'_{21} = \frac{2S_{21}}{(1-S_{11})(1-S_{22}) - S_{12}S_{21}}$$

$$S_{22} = \frac{(z'_{11}+1)(z'_{22}-1) - z'_{12} z'_{21}}{(z'_{11}+1)(z'_{22}+1) - z'_{12} z'_{21}}$$

$$z'_{22} = \frac{(1-S_{11})(1+S_{22}) + S_{12}S_{21}}{(1-S_{11})(1-S_{22}) - S_{12}S_{21}}$$

$$z'_{11} = \frac{Z_{11}}{Z_0}$$

$$z'_{12} = \frac{Z_{12}}{Z_0}$$

$$z'_{21} = \frac{Z_{21}}{Z_0}$$

$$z'_{22} = \frac{Z_{22}}{Z_0}$$

S ↔ Y:

$$S_{11} = \frac{(1-y'_{11})(1+y'_{22}) + y'_{12} y'_{21}}{(1+y'_{11})(1+y'_{22}) - y'_{12} y'_{21}}$$

$$y'_{11} = \frac{(1-S_{11})(1+S_{22}) + S_{12}S_{21}}{(1+S_{11})(1+S_{22}) - S_{12}S_{21}}$$

$$S_{12} = \frac{-2y'_{12}}{(1+y'_{11})(1+y'_{22}) - y'_{12} y'_{21}}$$

$$y'_{12} = \frac{-2S_{12}}{(1+S_{11})(1+S_{22}) - S_{12}S_{21}}$$

$$S_{21} = \frac{-2y'_{21}}{(1+y'_{11})(1+y'_{22}) - y'_{12} y'_{21}}$$

$$y'_{21} = \frac{-2S_{21}}{(1+S_{11})(1+S_{22}) - S_{12}S_{21}}$$

$$S_{22} = \frac{(1+y'_{11})(1-y'_{22}) + y'_{12} y'_{21}}{(1+y'_{11})(1+y'_{22}) - y'_{12} y'_{21}}$$

$$y'_{22} = \frac{(1+S_{11})(1-S_{22}) + S_{12}S_{21}}{(1+S_{11})(1+S_{22}) - S_{12}S_{21}}$$

$$y'_{11} = y_{11}Z_0$$

$$y'_{12} = y_{12}Z_0$$

$$y'_{21} = y_{21}Z_0$$

$$y'_{22} = y_{22}Z_0$$

S ↔ H:

$$S_{11} = \frac{(h'_{11}-1)(h'_{22}+1)h'_{12}h'_{21}}{(h'_{11}+1)(h'_{22}+1)-h'_{12}h'_{21}}$$

$$h'_{11} = \frac{(1+S_{11})(1+S_{22})-S_{12}S_{21}}{(1-S_{11})(1+S_{22})+S_{12}S_{21}}$$

$$S_{12} = \frac{2h'_{12}}{(h'_{11}+1)(h'_{22}+1)-h'_{12}h'_{21}}$$

$$h'_{12} = \frac{2S_{12}}{(1-S_{11})(1+S_{22})+S_{12}S_{21}}$$

$$S_{21} = \frac{-2h'_{21}}{(h'_{11}+1)(h'_{22}+1)-h'_{12}h'_{21}}$$

$$h'_{21} = \frac{-2S_{21}}{(1-S_{11})(1+S_{22})+S_{12}S_{21}}$$

$$S_{22} = \frac{(1+h'_{11})(1-h'_{22})+h'_{12}h'_{21}}{(h'_{11}+1)(h'_{22}+1)-h'_{12}h'_{21}}$$

$$h'_{22} = \frac{(1-S_{22})(1-S_{11})-S_{12}S_{21}}{(1-S_{11})(1+S_{22})+S_{12}S_{21}}$$

$$h'_{11} = \frac{h_{11}}{Z_0}$$

$$h'_{12} = h_{12}$$

$$h'_{21} = h_{21}$$

$$h'_{22} = h_{22}Z_0$$

S ↔ A:

$$A = \frac{1}{2S_{21}} \begin{bmatrix} (1+S_{11})(1-S_{22})+S_{12}S_{21} & Z_0[(1+S_{11})(1+S_{22})-S_{12}S_{21}] \\ Y_0[(1-S_{11})(1-S_{22})-S_{12}S_{21}] & (1-S_{11})(1+S_{22})+S_{12}S_{21} \end{bmatrix}$$

$$S = \frac{1}{\Delta_1} \begin{bmatrix} A_{11} + A_{12}Y_0 - A_{21}Z_0 - A_{22} & 2(A_{11}A_{22} - A_{12}A_{21}) \\ 2 & -A_{11} + A_{12}Y_0 - A_{21}Z_0 + A_{22} \end{bmatrix}$$

$$\Delta_1 = A_{11} + A_{12}Y_0 + A_{21}Z_0 + A_{22}$$

S ↔ T:

$$T = \frac{1}{S_{21}} \begin{bmatrix} 1 & -S_{22} \\ S_{11} & S_{12}S_{21} - S_{11}S_{22} \end{bmatrix}$$

$$S = \frac{1}{T_{11}} \begin{bmatrix} T_{21} & T_{11}T_{22} - T_{12}T_{21} \\ 1 & -T_{12} \end{bmatrix}$$

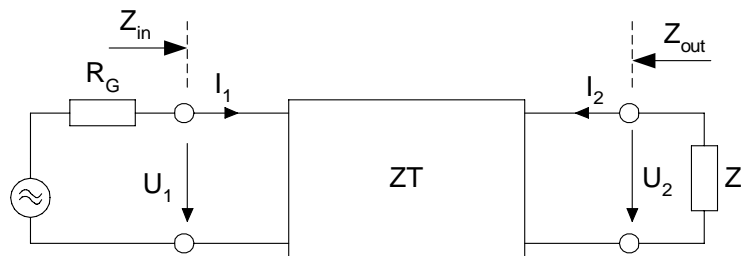
1.8.6 Zweitorparameter der wichtigsten Elemente

Zweitor	Z	Y	H	G	A
	nicht definiert	$\frac{1}{Z} \quad -\frac{1}{Z}$ $-\frac{1}{Z} \quad \frac{1}{Z}$	$Z \quad 1$ $-1 \quad 0$	$0 \quad -1$ $1 \quad Z$	$1 \quad Z$ $0 \quad 1$
	$\frac{1}{Y} \quad \frac{1}{Y}$ $\frac{1}{Y} \quad \frac{1}{Y}$	nicht definiert	$0 \quad 1$ $-1 \quad Y$	$Y \quad -1$ $1 \quad 0$	$1 \quad 0$ $Y \quad 1$
	nicht definiert	$j\omega C \quad -j\omega C$ $-j\omega C \quad j\omega C$	$\frac{1}{j\omega C} \quad 1$ $-1 \quad 0$	$0 \quad -1$ $1 \quad \frac{1}{j\omega C}$	$1 \quad \frac{1}{j\omega C}$ $0 \quad 1$
	$\frac{1}{j\omega C} \quad \frac{1}{j\omega C}$ $\frac{1}{j\omega C} \quad \frac{1}{j\omega C}$	nicht definiert	$0 \quad 1$ $-1 \quad j\omega C$	$j\omega C \quad -1$ $1 \quad 0$	$1 \quad 0$ $j\omega C \quad 1$
	nicht definiert	$\frac{1}{j\omega L} \quad -\frac{1}{j\omega L}$ $-\frac{1}{j\omega L} \quad \frac{1}{j\omega L}$	$j\omega L \quad 1$ $-1 \quad 0$	$0 \quad -1$ $1 \quad j\omega L$	$1 \quad j\omega L$ $0 \quad 1$
	$j\omega L \quad j\omega L$ $j\omega L \quad j\omega L$	nicht definiert	$0 \quad 1$ $-1 \quad \frac{1}{j\omega L}$	$\frac{1}{j\omega L} \quad -1$ $1 \quad 0$	$1 \quad 0$ $\frac{1}{j\omega L} \quad 1$
	nicht definiert	$\frac{1-\omega^2 LC}{j\omega L} \quad \frac{\omega^2 LC-1}{j\omega L}$ $\frac{\omega^2 LC-1}{j\omega L} \quad \frac{1-\omega^2 LC}{j\omega L}$	$\frac{j\omega L}{1-\omega^2 LC} \quad 1$ $-1 \quad 0$	$0 \quad -1$ $1 \quad \frac{j\omega C}{1-\omega^2 LC}$	$1 \quad \frac{j\omega L}{1-\omega^2 LC}$ $0 \quad 1$
	$\frac{1-\omega^2 LC}{j\omega C} \quad \frac{1-\omega^2 LC}{j\omega C}$ $\frac{1-\omega^2 LC}{j\omega C} \quad \frac{1-\omega^2 LC}{j\omega C}$	nicht definiert	$0 \quad 1$ $-1 \quad \frac{j\omega C}{1-\omega^2 LC}$	$\frac{j\omega C}{1-\omega^2 LC} \quad -1$ $1 \quad 0$	$1 \quad 0$ $\frac{j\omega C}{1-\omega^2 LC} \quad 1$

Zweitor	Z	Y	H	G	A
	$Z_1 + Z_2$ Z_2 Z_2 Z_2	$\frac{1}{Z_1}$ $-\frac{1}{Z_1}$ $-\frac{1}{Z_1}$ $\frac{Z_1 + Z_2}{Z_1 Z_2}$	Z_1 1 -1 $\frac{1}{Z_2}$	$\frac{1}{Z_1 + Z_2}$ $\frac{-Z_2}{Z_1 + Z_2}$ $\frac{Z_2}{Z_1 + Z_2}$ $\frac{Z_1 Z_2}{Z_1 + Z_2}$	$\frac{Z_1 + Z_2}{Z_2}$ Z_1 $\frac{1}{Z_2}$ 1
	Z_1 Z_1 Z_1 $Z_1 + Z_2$	$\frac{Z_1 + Z_2}{Z_1 Z_2}$ $-\frac{1}{Z_2}$ $-\frac{1}{Z_2}$ $\frac{1}{Z_2}$	$\frac{Z_1 Z_2}{Z_1 + Z_2}$ $\frac{Z_1}{Z_1 + Z_2}$ $\frac{-Z_1}{Z_1 + Z_2}$ $\frac{1}{Z_1 + Z_2}$	$\frac{1}{Z_1}$ -1 1 Z_2	1 Z_2 $\frac{1}{Z_1}$ $\frac{Z_1 + Z_2}{Z_1}$
	$Z_1 + Z_2$ Z_2 Z_2 $Z_2 + Z_3$	$\frac{Z_2 + Z_3}{P}$ $-\frac{Z_2}{P}$ $-\frac{Z_2}{P}$ $\frac{Z_1 + Z_2}{P}$	$\frac{P}{Z_2 + Z_3}$ $\frac{Z_2}{Z_2 + Z_3}$ $-\frac{Z_2}{Z_2 + Z_3}$ $\frac{1}{Z_2 + Z_3}$	$\frac{1}{Z_1 + Z_2}$ $\frac{-Z_2}{Z_1 + Z_2}$ $\frac{Z_2}{Z_1 + Z_2}$ $\frac{P}{Z_1 + Z_2}$	$\frac{Z_1 + Z_2}{Z_2}$ $\frac{P}{Z_2}$ $\frac{1}{Z_2}$ $\frac{Z_2 + Z_3}{Z_2}$
	$\frac{L \cdot Z_1}{M}$ $\frac{Z_1 Z_3}{M}$ $\frac{Z_1 Z_3}{M}$ $\frac{K \cdot Z_3}{M}$	$\frac{Z_1 + Z_2}{Z_1 Z_2}$ $-\frac{1}{Z_2}$ $-\frac{1}{Z_2}$ $\frac{Z_2 + Z_3}{Z_2 Z_3}$	$\frac{Z_1 Z_2}{K}$ $\frac{Z_1}{K}$ $-\frac{Z_1}{K}$ $\frac{M}{K \cdot Z_3}$	$\frac{M}{L \cdot Z_1}$ $\frac{-Z_3}{L}$ $\frac{Z_3}{L}$ $\frac{Z_2 Z_3}{L}$	$\frac{Z_2 + Z_3}{Z_3}$ Z_2 $\frac{M}{Z_1 Z_3}$ $\frac{Z_1 + Z_2}{Z_1}$
	$\frac{R}{N}$ $\frac{Q}{N}$ $\frac{Q}{N}$ $\frac{S}{N}$	$\frac{L}{P} + \frac{1}{Z_4}$ $\frac{-Z_2}{P} - \frac{1}{Z_4}$ $\frac{-Z_2}{P} - \frac{1}{Z_4}$ $\frac{K}{P} + \frac{1}{Z_4}$	$\frac{P Z_4}{S}$ $\frac{Q}{S}$ $-\frac{Q}{S}$ $\frac{N}{S}$	$\frac{N}{R}$ $\frac{-Q}{R}$ $\frac{Q}{R}$ $\frac{P Z_4}{R}$	$\frac{R}{Q}$ $\frac{P Z_4}{Q}$ $\frac{N}{Q}$ $\frac{S}{Q}$
$K = Z_1 + Z_2$ $L = Z_2 + Z_3$ $M = Z_1 + Z_2 + Z_3$ $N = Z_1 + Z_3 + Z_4$		$P = Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3$ $Q = Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3 + Z_2 Z_4 = P + Z_2 Z_4$ $R = Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3 + Z_2 Z_4 + Z_1 Z_4 = Q + Z_1 Z_4$ $S = Z_1 Z_2 + Z_1 Z_3 + Z_2 Z_3 + Z_2 Z_4 + Z_3 Z_4 = Q + Z_3 Z_4$			

Zweitor	Z	Y	H	G	A
<p>Leitung Z_0 $\theta = \beta l$ $\alpha = 0$</p>					$\begin{matrix} \cos \theta & jZ_0 \sin \theta \\ \frac{j \sin \theta}{Z_0} & \cos \theta \end{matrix}$
<p>Leitung Z_0 γl</p>					$\begin{matrix} \cosh \gamma l & Z_0 \sinh \gamma l \\ \frac{\sinh \gamma l}{Z_0} & \cosh \gamma l \end{matrix}$
<p>Stub offen Z_0 $\theta = \beta l$</p>					$\begin{matrix} 1 & 0 \\ \frac{j \tan \theta}{Z_0} & 1 \end{matrix}$
<p>Stub kurzgeschl. Z_0 $\theta = \beta l$</p>					$\begin{matrix} 1 & 0 \\ \frac{\cot \theta}{jZ_0} & 1 \end{matrix}$
<p>n:1 Trafo</p>	nicht definiert	nicht definiert	$\begin{matrix} 0 & n \\ -n & 0 \end{matrix}$	$\begin{matrix} 0 & -\frac{1}{n} \\ \frac{1}{n} & 0 \end{matrix}$	$\begin{matrix} n & 0 \\ 0 & \frac{1}{n} \end{matrix}$
<p>VCCS α $g \cdot u_1$</p>	nicht definiert				$\begin{matrix} 0 & -\frac{1}{g} \\ 0 & -\frac{1}{R \cdot g} \end{matrix}$
<p>CCCS $\beta \cdot i_1$</p>	nicht definiert				$\begin{matrix} 0 & -\frac{R}{\beta} \\ 0 & -\frac{1}{\beta} \end{matrix}$

1.8.7 Beschalteter Zweitor



	Z	Y	H	G	A
$v_u = \frac{u_2}{u_1}$	$\frac{z_{21}Z_L}{z_{11}Z_L + \Delta z}$	$\frac{-y_{21}Z_L}{y_{22}Z_L + 1}$	$\frac{-h_{21}Z_L}{h_{11} + \Delta hZ_L}$	$\frac{g_{21}Z_L}{g_{22} + Z_L}$	$\frac{Z_L}{A_{12} + A_{11}Z_L}$
$v_i = \frac{i_2}{i_1}$	$\frac{-z_{21}}{z_{22} + Z_L}$	$\frac{y_{21}}{y_{11} + \Delta yZ_L}$	$\frac{h_{21}}{1 + h_{22}Z_L}$	$\frac{-g_{21}}{g_{11}Z_L + \Delta g}$	$\frac{-1}{A_{21}Z_L + A_{22}}$
$v_p = \frac{P_2}{P_1}$			$H, R_L = \text{reell}$ $\frac{h_{21}^2 R_L}{(1 + h_{22}R_L)(h_{11} + \Delta hR_L)}$		$v_u^2 \frac{\text{Re}[Z_{in}]}{\text{Re}[Z_L]}$
$Z_{in} = \frac{u_1}{i_1}$	$\frac{z_{11}Z_L + \Delta z}{z_{22} + Z_L}$ $= z_{11} - \frac{z_{12}z_{21}}{z_{22} + Z_L}$	$\frac{1 + y_{22}Z_L}{y_{11} + \Delta yZ_L}$	$\frac{h_{11} + \Delta hZ_L}{1 + h_{22}Z_L}$	$\frac{g_{22} + Z_L}{g_{11}Z_L + \Delta g}$	$\frac{A_{11}Z_L + A_{12}}{A_{21}Z_L + A_{22}}$
Z_{out}	$\frac{z_{22}Z_G + \Delta z}{z_{11} + Z_G}$ $= z_{22} - \frac{z_{12}z_{21}}{z_{11} + Z_G}$	$\frac{1 + y_{11}Z_G}{y_{22} + \Delta yZ_G}$	$\frac{h_{11} + Z_G}{h_{22}Z_G + \Delta h}$	$\frac{g_{22} + Z_G \Delta g}{1 + g_{11}Z_G}$	$\frac{A_{22}Z_G + A_{12}}{A_{21}Z_G + A_{11}}$