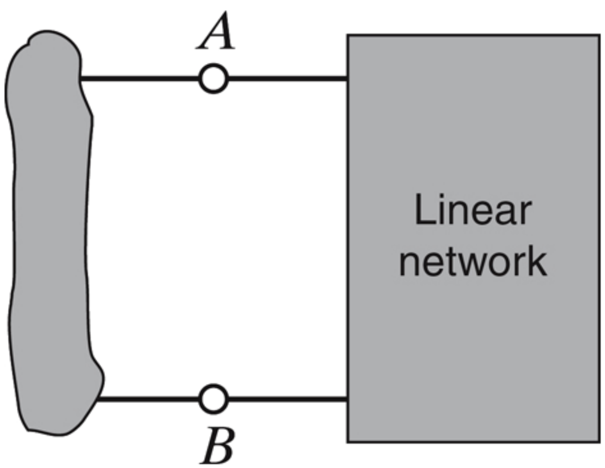
Lineaire Schakelingen, ET1300

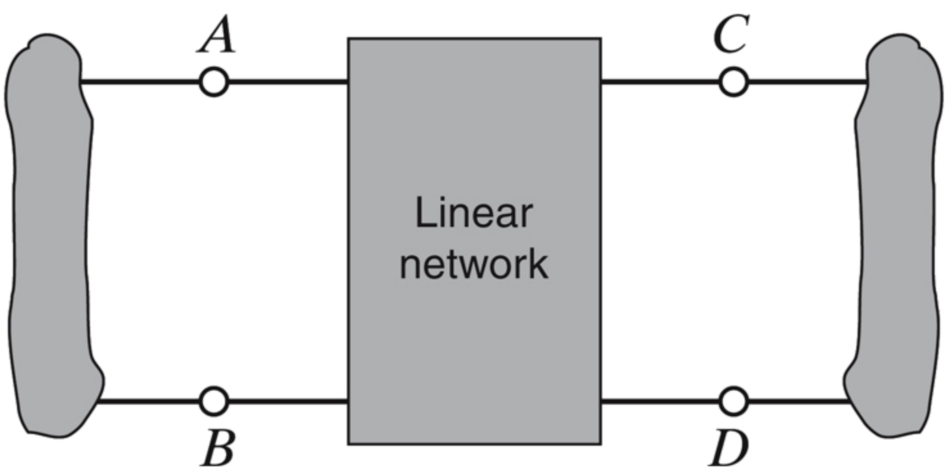
Instructie, week 2.8

Slides by Marijn van dongen, et al.

Tweepoorten (1)



- Een-poort
  - Twee klemmen
    - Resistantie
    - Inductantie
    - Capaciteit
  - 1 relatie tussen spanning en stroom

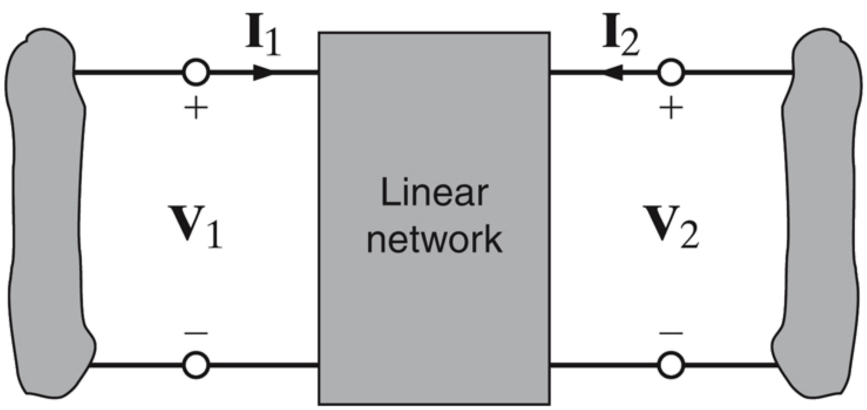


- Tweepoort
  - Twee poorten
  - Vier klemmen
    - Magnetisch gekoppeld paar inductanties
    - Transformator
    - Elektronische schakeling
  - 4 relaties tussen spanningen en stromen

Tweepoorten (2)

- 4 (belangrijkste) soorten parameters
  - Admittantie-parameters
    - Drukken de 2 stromen uit als functie van de 2 spanningen
  - Impedantie-parameters
    - Drukken de 2 spanningen uit als functie van de 2 stromen
  - Hybride parameters
    - V_1 en I_2 als functie van V_2 en I_1
  - Ketting- of transmissie-parameters
    - V_1 en I_1 als functie van V_2 en I_2
    - Handig voor cascade-schakelingen
- Vaak uitgedrukt en geschreven in matrix-vorm
- Kan alleen wanneer relaties linear en dus superpositie geldt; dus geen onafhankelijke bronnen en alle beginvoorwaarden zijn nul

Admittantie-parameters



$$\mathbf{I}_1 = \mathbf{y}_{11}\mathbf{V}_1 + \mathbf{y}_{12}\mathbf{V}_2$$

$$\mathbf{I}_2 = \mathbf{y}_{21}\mathbf{V}_1 + \mathbf{y}_{22}\mathbf{V}_2$$

$$\begin{bmatrix} \mathbf{I}_1 \\ \mathbf{I}_2 \end{bmatrix} = \begin{bmatrix} \mathbf{y}_{11} & \mathbf{y}_{12} \\ \mathbf{y}_{21} & \mathbf{y}_{22} \end{bmatrix} \begin{bmatrix} \mathbf{V}_1 \\ \mathbf{V}_2 \end{bmatrix}$$

Kortsluit-ingangsadmittantie

$$\mathbf{y}_{11} = \left.\frac{\mathbf{I}_1}{\mathbf{V}_1}\right|_{\mathbf{V}_2=0}$$

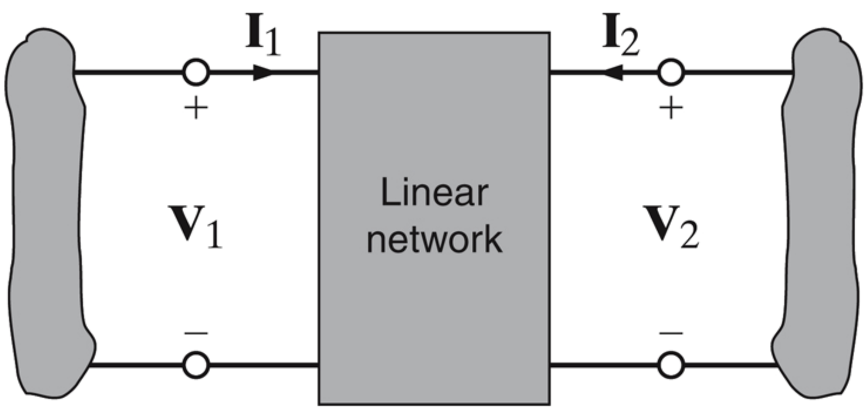
$$\mathbf{y}_{12} = \left.\frac{\mathbf{I}_1}{\mathbf{V}_2}\right|_{\mathbf{V}_1=0}$$

$$\mathbf{y}_{21} = \left.\frac{\mathbf{I}_2}{\mathbf{V}_1}\right|_{\mathbf{V}_2=0}$$

$$\mathbf{y}_{22} = \left.\frac{\mathbf{I}_2}{\mathbf{V}_2}\right|_{\mathbf{V}_1=0}$$

Kortsluit-uitgangsadmittantie

Impedantie-parameters



$$\mathbf{V}_1 = \mathbf{z}_{11}\mathbf{I}_1 + \mathbf{z}_{12}\mathbf{I}_2$$
$$\mathbf{V}_2 = \mathbf{z}_{21}\mathbf{I}_1 + \mathbf{z}_{22}\mathbf{I}_2$$

$$\begin{bmatrix} \mathbf{V}_1 \\ \mathbf{V}_2 \end{bmatrix} = \begin{bmatrix} \mathbf{z}_{11} & \mathbf{z}_{12} \\ \mathbf{z}_{21} & \mathbf{z}_{22} \end{bmatrix} \begin{bmatrix} \mathbf{I}_1 \\ \mathbf{I}_2 \end{bmatrix}$$

Open-klem ingangsimpedantie

$$\mathbf{z}_{11} = \left.\frac{\mathbf{V}_1}{\mathbf{I}_1}\right|_{\mathbf{I}_2=0}$$

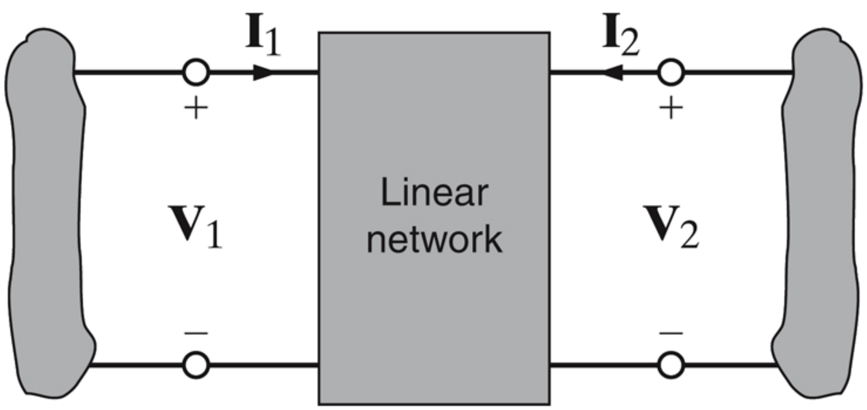
$$\mathbf{z}_{12} = \left.\frac{\mathbf{V}_1}{\mathbf{I}_2}\right|_{\mathbf{I}_1=0}$$

$$\mathbf{z}_{21} = \left.\frac{\mathbf{V}_2}{\mathbf{I}_1}\right|_{\mathbf{I}_2=0}$$

$$\mathbf{z}_{22} = \left.\frac{\mathbf{V}_2}{\mathbf{I}_2}\right|_{\mathbf{I}_1=0}$$

Open-klem uitgangsimpedantie

Hybride parameters



$$V_1 = h_{11} I_1 + h_{12} V_2$$
$$I_2 = h_{21} I_1 + h_{22} V_2$$

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

Kortsluit-ingangsimpedantie

$$h_{11} = \left. \frac{V_1}{I_1} \right|_{V_2 = 0}$$

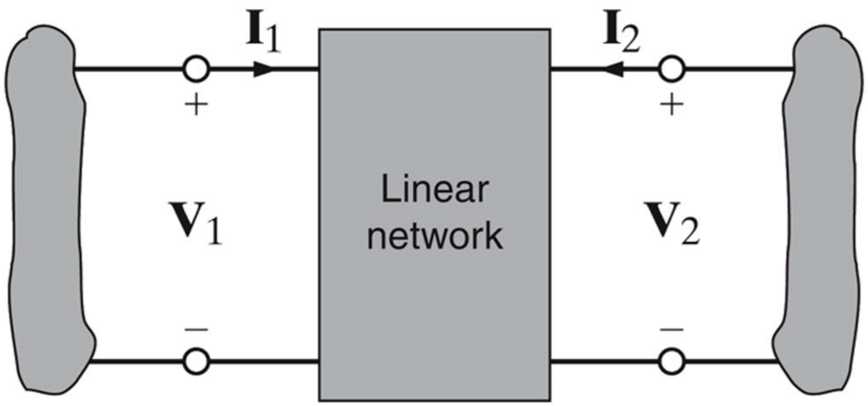
$$h_{12} = \left. \frac{V_1}{V_2} \right|_{I_1 = 0}$$

$$h_{21} = \left. \frac{I_2}{I_1} \right|_{V_2 = 0}$$

$$h_{22} = \left. \frac{I_2}{V_2} \right|_{I_1 = 0}$$

Open-klem uitgangsadmittantie

Transmissie- of ketting-parameters (1)



Leggen een relatie vast tussen de uitgangs and ingangsgrootheden

$$V_1 = k_{11}V_2 - k_{12}I_2$$
$$I_1 = k_{21}V_2 - k_{22}I_2$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

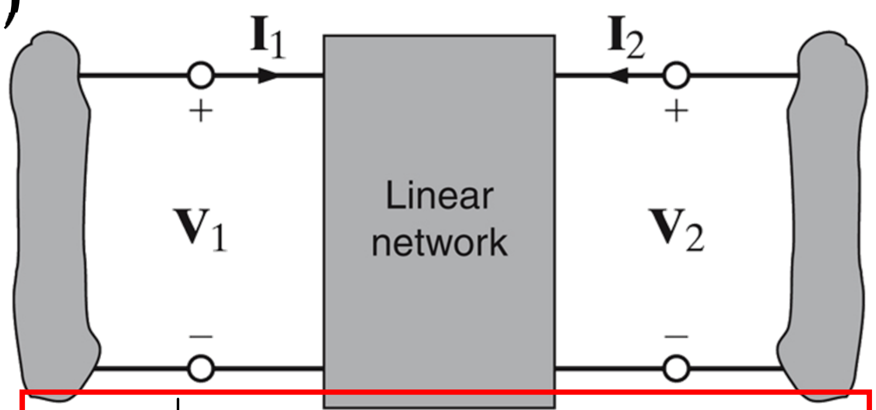
$$k_{11} = A = \left.\frac{V_1}{V_2}\right|_{I_2=0}$$

$$k_{12} = B = \left.\frac{V_1}{-I_2}\right|_{V_2=0}$$

$$k_{21} = C = \left.\frac{I_1}{V_2}\right|_{I_2=0}$$

$$k_{22} = D = \left.\frac{I_1}{-I_2}\right|_{V_2=0}$$

Transmissie- of ketting-parameters (2)



$$\mu = \left.\frac{V_2}{V_1}\right|_{I_2=0} = \text{spanningsversterkingsfactor}$$

$$\gamma = \left.\frac{I_2}{V_1}\right|_{V_2=0} = \text{transadmittantiefactor}$$

$$\zeta = \left.\frac{V_2}{I_1}\right|_{V_2=0} = \text{transimpedantiefactor}$$

$$\alpha = \left.\frac{I_2}{I_1}\right|_{V_2=0} = \text{stroomversterkingsfactor}$$

$$k_{11} = A = \frac{1}{\mu} = \left.\frac{V_1}{V_2}\right|_{I_2=0}$$

$$k_{12} = B = \frac{1}{\gamma} = \left.\frac{V_1}{-I_2}\right|_{V_2=0}$$

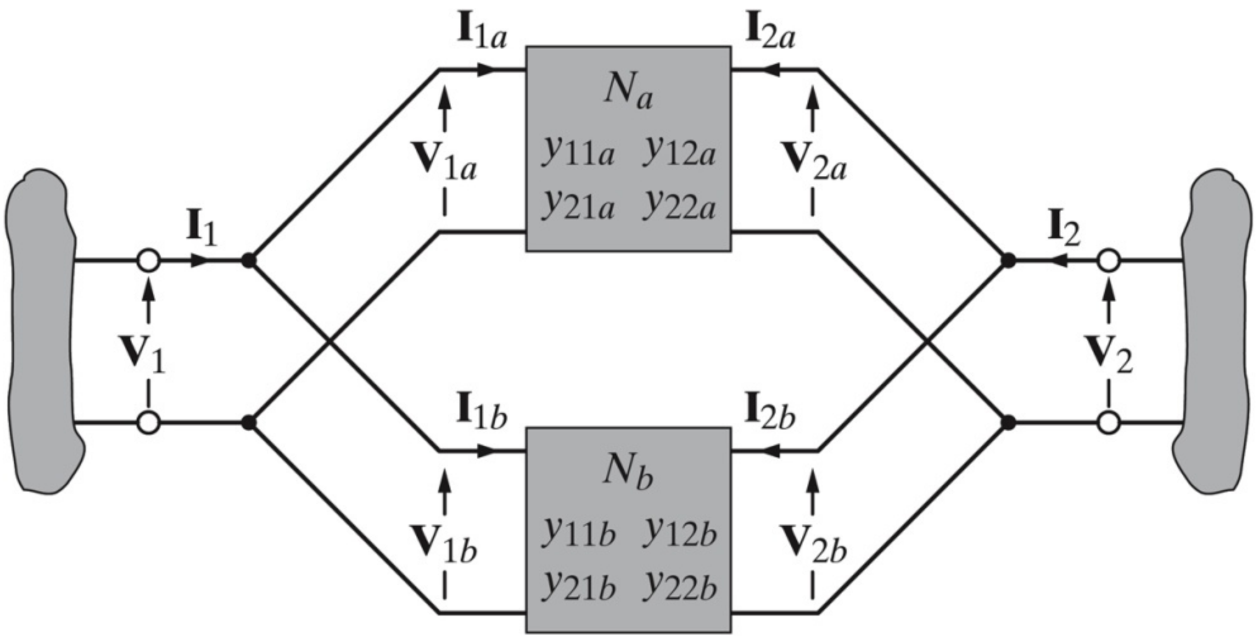
$$k_{21} = C = \frac{1}{\zeta} = \left.\frac{I_1}{V_2}\right|_{I_2=0}$$

$$k_{22} = D = \frac{1}{\alpha} = \left.\frac{I_1}{-I_2}\right|_{V_2=0}$$

TABLE 16.1 Two-port parameter conversion formulas

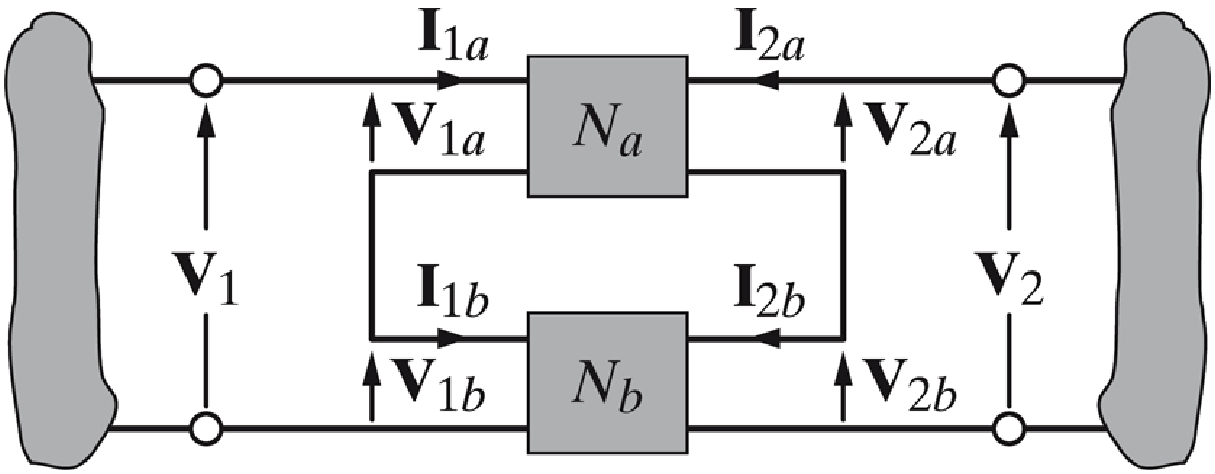
$\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}$	$\begin{bmatrix} \frac{y_{22}}{\Delta_Y} & \frac{-y_{12}}{\Delta_Y} \\ \frac{-y_{21}}{\Delta_Y} & \frac{y_{11}}{\Delta_Y} \end{bmatrix}$	$\begin{bmatrix} \frac{A}{C} & \frac{\Delta_T}{C} \\ \frac{1}{C} & \frac{D}{C} \end{bmatrix}$	$\begin{bmatrix} \frac{\Delta_H}{h_{22}} & \frac{h_{12}}{h_{22}} \\ \frac{-h_{21}}{h_{22}} & \frac{1}{h_{22}} \end{bmatrix}$
$\begin{bmatrix} \frac{z_{22}}{\Delta_Z} & \frac{-z_{12}}{\Delta_Z} \\ \frac{-z_{21}}{\Delta_Z} & \frac{z_{11}}{\Delta_Z} \end{bmatrix}$	$\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}$	$\begin{bmatrix} \frac{D}{B} & \frac{-\Delta_T}{B} \\ -\frac{1}{B} & \frac{A}{B} \end{bmatrix}$	$\begin{bmatrix} \frac{1}{h_{11}} & \frac{-h_{12}}{h_{11}} \\ \frac{h_{21}}{h_{11}} & \frac{\Delta_H}{h_{11}} \end{bmatrix}$
$\begin{bmatrix} \frac{z_{11}}{z_{21}} & \frac{\Delta_Z}{z_{21}} \\ \frac{1}{z_{21}} & \frac{z_{22}}{z_{21}} \end{bmatrix}$	$\begin{bmatrix} \frac{-y_{22}}{y_{21}} & \frac{-1}{y_{21}} \\ \frac{-\Delta_Y}{y_{21}} & \frac{-y_{11}}{y_{21}} \end{bmatrix}$	$\begin{bmatrix} A & B \\ C & D \end{bmatrix}$	$\begin{bmatrix} \frac{-\Delta_H}{h_{21}} & \frac{-h_{11}}{h_{21}} \\ \frac{-h_{22}}{h_{21}} & \frac{-1}{h_{21}} \end{bmatrix}$
$\begin{bmatrix} \frac{\Delta_Z}{z_{22}} & \frac{z_{12}}{z_{22}} \\ \frac{-z_{21}}{z_{22}} & \frac{1}{z_{22}} \end{bmatrix}$	$\begin{bmatrix} \frac{1}{y_{11}} & \frac{-y_{12}}{y_{11}} \\ \frac{y_{21}}{y_{11}} & \frac{\Delta_Y}{y_{11}} \end{bmatrix}$	$\begin{bmatrix} \frac{B}{D} & \frac{\Delta_T}{D} \\ -\frac{1}{D} & \frac{C}{D} \end{bmatrix}$	$\begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix}$

Parallel-parallel schakeling van tweepoorten



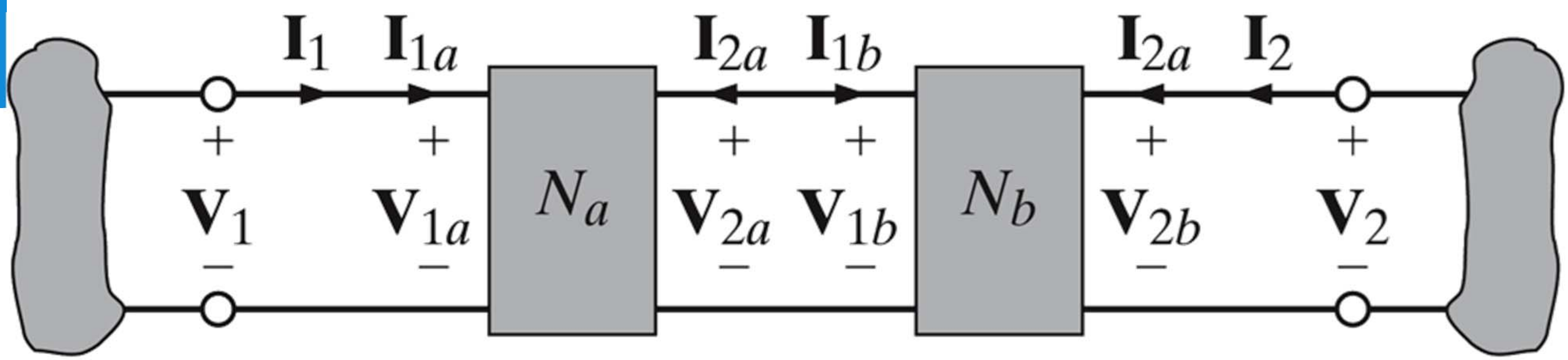
$$\begin{bmatrix} \mathbf{y}_{11} & \mathbf{y}_{12} \\ \mathbf{y}_{21} & \mathbf{y}_{22} \end{bmatrix} = \begin{bmatrix} \mathbf{y}_{11a} + \mathbf{y}_{11b} & \mathbf{y}_{12a} + \mathbf{y}_{12b} \\ \mathbf{y}_{21a} + \mathbf{y}_{21b} & \mathbf{y}_{22a} + \mathbf{y}_{22b} \end{bmatrix}$$

Serie-serie schakeling van tweepoorten



$$\begin{bmatrix} \mathbf{z}_{11} & \mathbf{z}_{12} \\ \mathbf{z}_{21} & \mathbf{z}_{22} \end{bmatrix} = \begin{bmatrix} \mathbf{z}_{11a} + \mathbf{z}_{11b} & \mathbf{z}_{12a} + \mathbf{z}_{12b} \\ \mathbf{z}_{21a} + \mathbf{z}_{21b} & \mathbf{z}_{22a} + \mathbf{z}_{22b} \end{bmatrix}$$

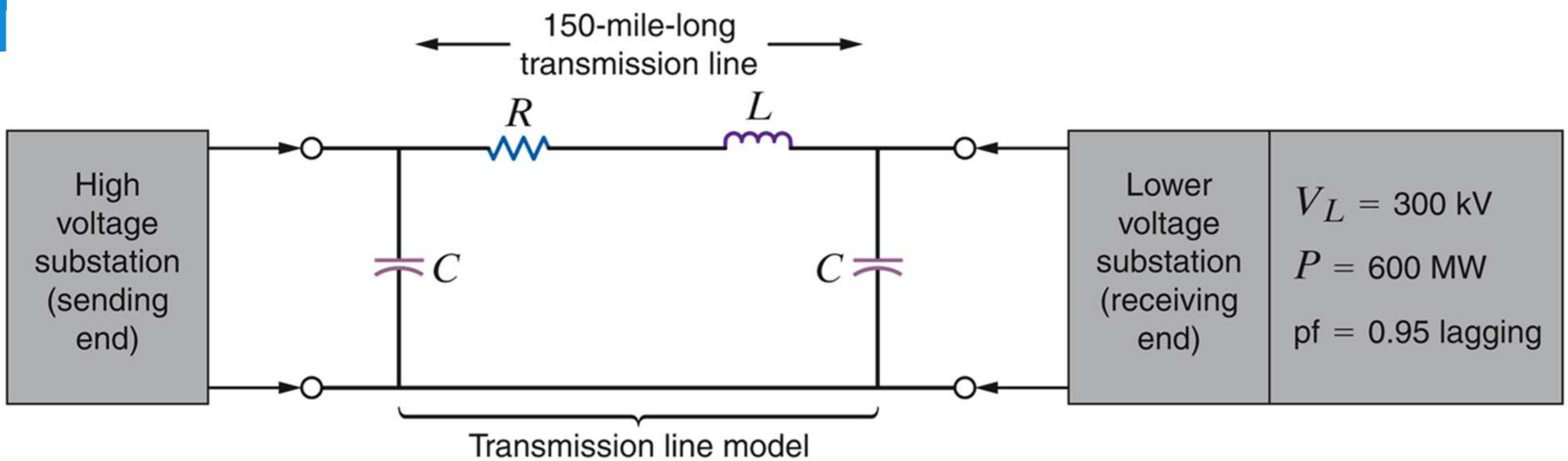
Cascade-schakeling van tweepoorten



$$\begin{bmatrix} \mathbf{k}_{11} & \mathbf{k}_{12} \\ \mathbf{k}_{21} & \mathbf{k}_{22} \end{bmatrix} = \begin{bmatrix} \mathbf{k}_{11a} & \mathbf{k}_{12a} \\ \mathbf{k}_{21a} & \mathbf{k}_{22a} \end{bmatrix} \begin{bmatrix} \mathbf{k}_{11b} & \mathbf{k}_{12b} \\ \mathbf{k}_{21b} & \mathbf{k}_{22b} \end{bmatrix}$$

Voorbeeld, 1

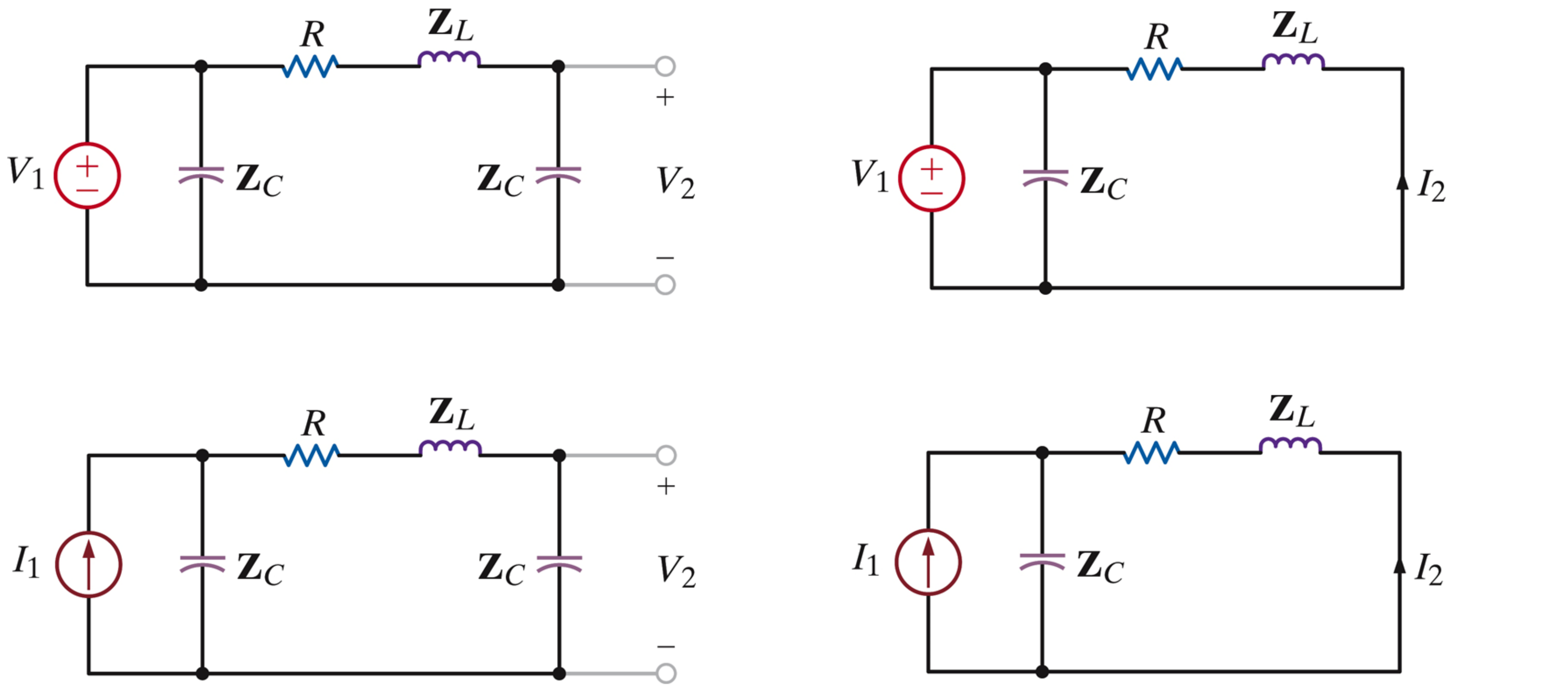
Gegeven:



Gevraagd: transmissie-parameters

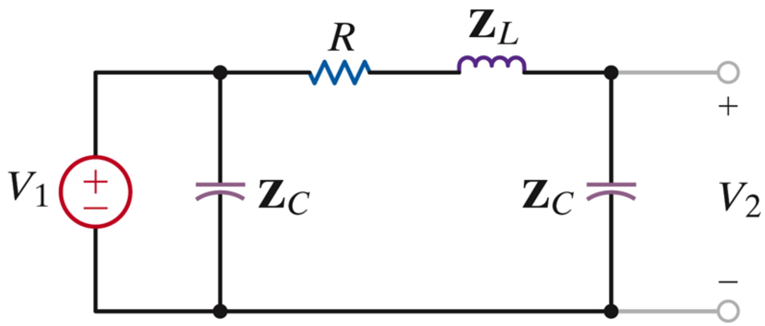
Voorbeeld, 2

Transmissie-parameters



Voorbeeld, 3

Transmissie-parameter: A

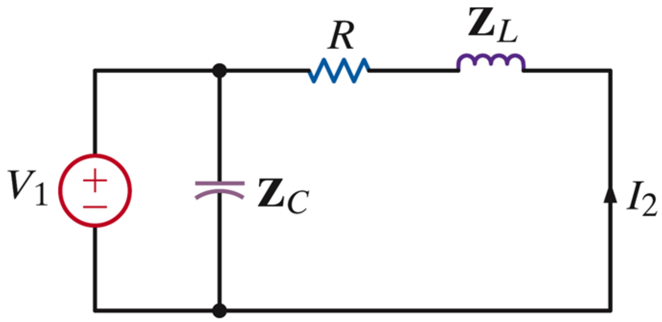


$$\mu = \left.\frac{V_2}{V_1}\right|_{I_2=0} = \frac{Z_C}{Z_C + Z_L + R}$$

$$k_{11} = A = \left.\frac{V_1}{V_2}\right|_{I_2=0} = \frac{Z_C + Z_L + R}{Z_C}$$

Voorbeeld, 4

Transmissie-parameters: B



$$\gamma = \left.\frac{-I_2}{V_1}\right|_{V_2=0} = \frac{1}{Z_L + R}$$

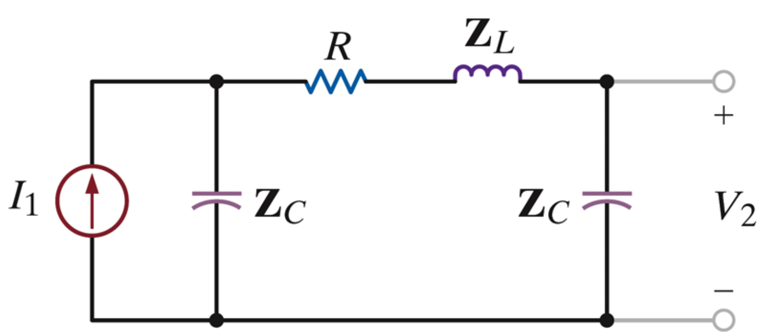
$$k_{12} = B = \left.\frac{V_1}{I_2}\right|_{V_2=0} = Z_L + R$$

Voorbeeld, 5

Transmissie-parameters: C

$$\zeta = \left.\frac{V_2}{I_1}\right|_{I_2=0} = \frac{Z_C^2}{2Z_C + Z_L + R}$$

$$k_{21} = C = \left.\frac{I_1}{V_2}\right|_{I_2=0} = \frac{2Z_C + Z_L + R}{Z_C^2}$$

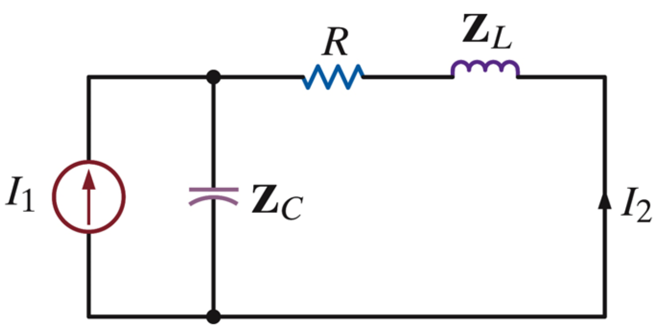


Voorbeeld, 6

Transmissie-parameters: D

$$\alpha = \left.\frac{-I_2}{I_1}\right|_{V_2=0} = \frac{Z_C}{Z_C + Z_L + R}$$

$$k_{22} = D = \left.\frac{I_1}{-I_2}\right|_{V_2=0} = \frac{Z_C + Z_L + R}{Z_C}$$



Voorbeeld, 7

Transmissie-parameters:

$$V_1 = k_{11}V_2 - k_{12}I_2$$
$$I_1 = k_{21}V_2 - k_{22}I_2$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

So,

$$\begin{bmatrix} k_{11} & k_{12} \\ k_{21} & k_{22} \end{bmatrix} = \begin{bmatrix} \dfrac{Z_C + Z_L + R}{Z_C} & Z_L + R \\ \dfrac{2Z_C + Z_L + R}{Z_C^2} & \dfrac{Z_C + Z_L + R}{Z_C} \end{bmatrix}$$