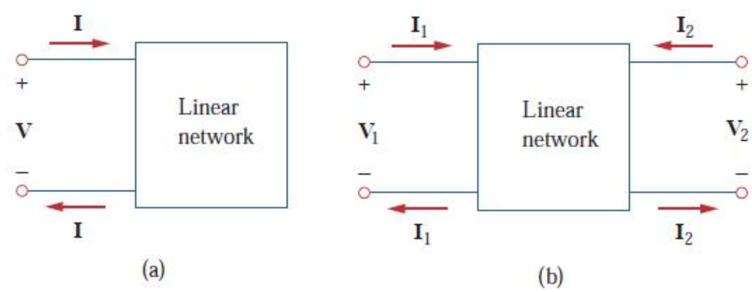
مدارهای الکتریکی

درس (20)

فصل 18 کتاب نیلسون، فصل 19 کتاب الکساندر

دوقطبی‌ها

دو قطبی‌ها در مقابل تک‌قطبی‌ها



- پارامترهای امپدانس

$$\begin{aligned} V_1 &= z_{11}I_1 + z_{12}I_2 \\ V_2 &= z_{21}I_1 + z_{22}I_2 \end{aligned}$$

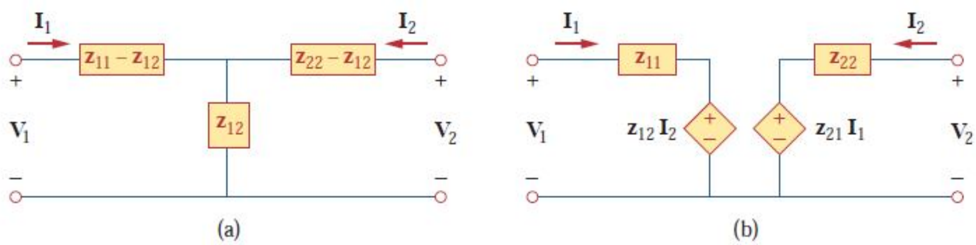
$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = [z] \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2=0}, \qquad z_{12} = \left.\frac{V_1}{I_2}\right|_{I_1=0}$$

$$z_{21} = \left.\frac{V_2}{I_1}\right|_{I_2=0}, \qquad z_{22} = \left.\frac{V_2}{I_2}\right|_{I_1=0}$$

z_{11} = Open-circuit input impedance
z_{12} = Open-circuit transfer impedance from port 1 to port 2
z_{21} = Open-circuit transfer impedance from port 2 to port 1
z_{22} = Open-circuit output impedance

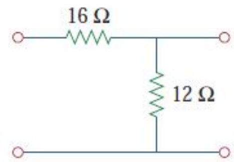
برای بعضی مدارهای دوقطبی، پارامترهای امپدانس وجود ندارد: مثلا ترانسفورماتور ایده‌آل



Practice Problem 19.1

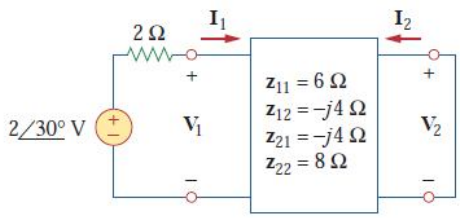
Find the z parameters of the two-port network in Fig. 19.9.

Answer: $\mathbf{z}_{11} = 28\ \Omega$, $\mathbf{z}_{12} = \mathbf{z}_{21} = \mathbf{z}_{22} = 12\ \Omega$.



Practice Problem 19.2

Calculate $\mathbf{I}_1$ and $\mathbf{I}_2$ in the two-port of Fig. 19.11.



- پارامترهای ادمیتانس

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

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

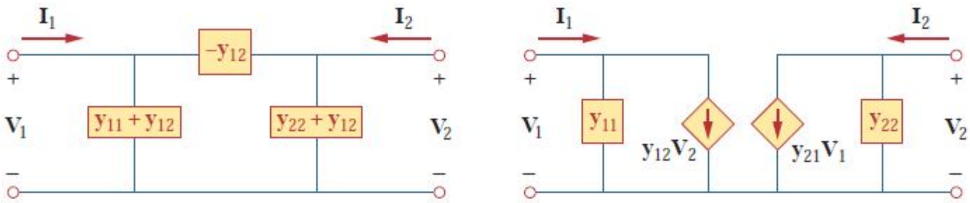
$$\mathbf{y}_{11} = \left.\frac{\mathbf{I}_1}{\mathbf{V}_1}\right|_{\mathbf{V}_2=0}, \qquad \mathbf{y}_{12} = \left.\frac{\mathbf{I}_1}{\mathbf{V}_2}\right|_{\mathbf{V}_1=0}$$
$$\mathbf{y}_{21} = \left.\frac{\mathbf{I}_2}{\mathbf{V}_1}\right|_{\mathbf{V}_2=0}, \qquad \mathbf{y}_{22} = \left.\frac{\mathbf{I}_2}{\mathbf{V}_2}\right|_{\mathbf{V}_1=0}$$

$\mathbf{y}_{11}$ = Short-circuit input admittance

$\mathbf{y}_{12}$ = Short-circuit transfer admittance from port 2 to port 1

$\mathbf{y}_{21}$ = Short-circuit transfer admittance from port 1 to port 2

$\mathbf{y}_{22}$ = Short-circuit output admittance

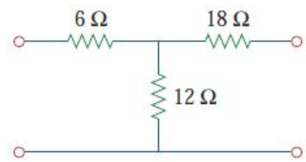


(a) (b)

Practice Problem 19.3

Obtain the y parameters for the T network shown in Fig. 19.16.

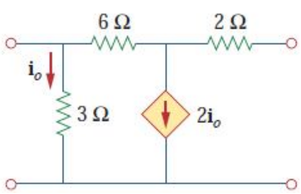
Answer: $\mathbf{y}_{11} = 75.77$ mS, $\mathbf{y}_{12} = \mathbf{y}_{21} = -30.3$ mS, $\mathbf{y}_{22} = 45.47$ mS.



Practice Problem 19.4

Obtain the y parameters for the circuit in Fig. 19.19.

Answer: $\mathbf{y}_{11} = 0.625$ S, $\mathbf{y}_{12} = -0.125$ S, $\mathbf{y}_{21} = 0.375$ S, $\mathbf{y}_{22} = 0.125$ S.



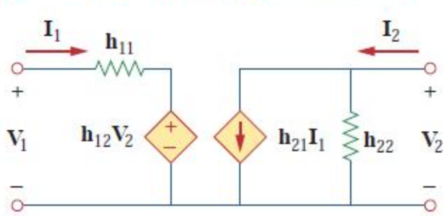
- پارامترهای هیبرید (ترکیبی)

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

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

$$\mathbf{h}_{11} = \frac{\mathbf{V}_1}{\mathbf{I}_1}\bigg|_{\mathbf{V}_2=0}, \qquad \mathbf{h}_{12} = \frac{\mathbf{V}_1}{\mathbf{V}_2}\bigg|_{\mathbf{I}_1=0}$$
$$\mathbf{h}_{21} = \frac{\mathbf{I}_2}{\mathbf{I}_1}\bigg|_{\mathbf{V}_2=0}, \qquad \mathbf{h}_{22} = \frac{\mathbf{I}_2}{\mathbf{V}_2}\bigg|_{\mathbf{I}_1=0}$$

$\mathbf{h}_{11}$ = Short-circuit input impedance
$\mathbf{h}_{12}$ = Open-circuit reverse voltage gain
$\mathbf{h}_{21}$ = Short-circuit forward current gain
$\mathbf{h}_{22}$ = Open-circuit output admittance



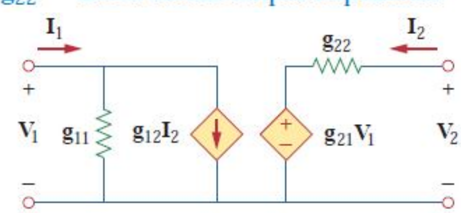
- پارامترهای g (پارامترهای معکوس h)

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

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

$$\mathbf{g}_{11} = \left.\frac{\mathbf{I}_1}{\mathbf{V}_1}\right|_{\mathbf{I}_2=0}, \qquad \mathbf{g}_{12} = \left.\frac{\mathbf{I}_1}{\mathbf{I}_2}\right|_{\mathbf{V}_1=0}$$
$$\mathbf{g}_{21} = \left.\frac{\mathbf{V}_2}{\mathbf{V}_1}\right|_{\mathbf{I}_2=0}, \qquad \mathbf{g}_{22} = \left.\frac{\mathbf{V}_2}{\mathbf{I}_2}\right|_{\mathbf{V}_1=0}$$

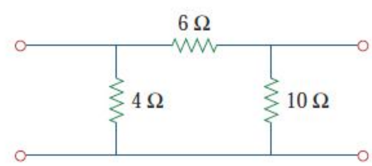
$\mathbf{g}_{11}$ = Open-circuit input admittance
$\mathbf{g}_{12}$ = Short-circuit reverse current gain
$\mathbf{g}_{21}$ = Open-circuit forward voltage gain
$\mathbf{g}_{22}$ = Short-circuit output impedance



Practice Problem 19.5

Determine the h parameters for the circuit in Fig. 19.24.

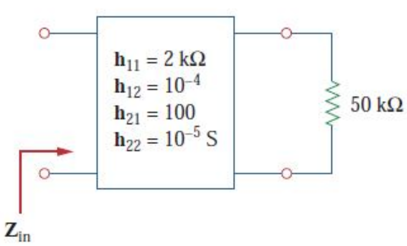
Answer: $\mathbf{h}_{11} = 2.4\ \Omega$, $\mathbf{h}_{12} = 0.4$, $\mathbf{h}_{21} = -0.4$, $\mathbf{h}_{22} = 200$ mS.



Practice Problem 19.6

Find the impedance at the input port of the circuit in Fig. 19.27.

Answer: 1.6667 kΩ.



Practice Problem 19.7

For the ladder network in Fig. 19.30, determine the g parameters in the s domain.

Answer: $[\mathbf{g}] = \begin{bmatrix} \dfrac{s+2}{s^2+3s+1} & -\dfrac{1}{s^2+3s+1} \\ \dfrac{1}{s^2+3s+1} & \dfrac{s(s+2)}{s^2+3s+1} \end{bmatrix}$.

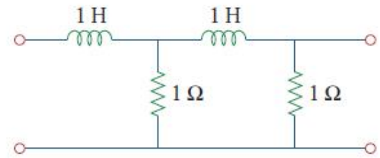


Figure 19.30
For Practice Prob. 19.7.

- پارامترهای *t*

$$\mathbf{V}_1 = \mathbf{A}\mathbf{V}_2 - \mathbf{B}\mathbf{I}_2$$
$$\mathbf{I}_1 = \mathbf{C}\mathbf{V}_2 - \mathbf{D}\mathbf{I}_2$$

$$\begin{bmatrix} \mathbf{V}_1 \\ \mathbf{I}_1 \end{bmatrix} = \begin{bmatrix} \mathbf{A} & \mathbf{B} \\ \mathbf{C} & \mathbf{D} \end{bmatrix} \begin{bmatrix} \mathbf{V}_2 \\ -\mathbf{I}_2 \end{bmatrix} = [\mathbf{T}] \begin{bmatrix} \mathbf{V}_2 \\ -\mathbf{I}_2 \end{bmatrix}$$

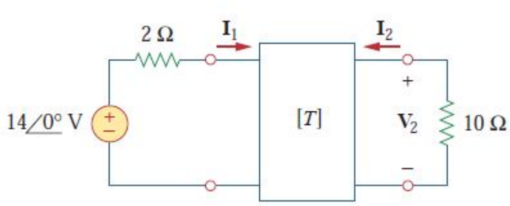
$$\mathbf{A} = \frac{\mathbf{V}_1}{\mathbf{V}_2}\bigg|_{\mathbf{I}_2=0}, \qquad \mathbf{B} = -\frac{\mathbf{V}_1}{\mathbf{I}_2}\bigg|_{\mathbf{V}_2=0}$$
$$\mathbf{C} = \frac{\mathbf{I}_1}{\mathbf{V}_2}\bigg|_{\mathbf{I}_2=0}, \qquad \mathbf{D} = -\frac{\mathbf{I}_1}{\mathbf{I}_2}\bigg|_{\mathbf{V}_2=0}$$

A = Open-circuit voltage ratio
B = Negative short-circuit transfer impedance
C = Open-circuit transfer admittance
D = Negative short-circuit current ratio

Practice Problem 19.9

Find $\mathbf{I}_1$ and $\mathbf{I}_2$ if the transmission parameters for the two-port in Fig. 19.36 are

$$\begin{bmatrix} 5 & 10\ \Omega \\ 0.4\ \text{S} & 1 \end{bmatrix}$$

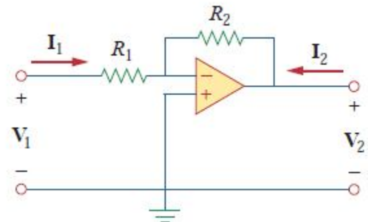


- ارتباط بین پارامترها

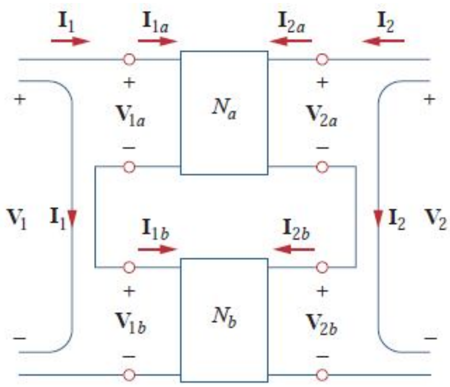
Find the z parameters of the op amp circuit in Fig. 19.38. Show that the circuit has no y parameters.

Practice Problem 19.11

Answer: $[\mathbf{z}] = \begin{bmatrix} R_1 & 0 \\ -R_2 & 0 \end{bmatrix}$. Since $[\mathbf{z}]^{-1}$ does not exist, $[\mathbf{y}]$ does not exist.

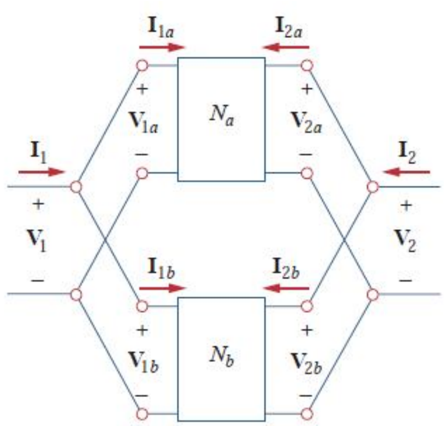


- اتصال شبکه‌ها
  - اتصال سری: با استفاده از پارامترهای z



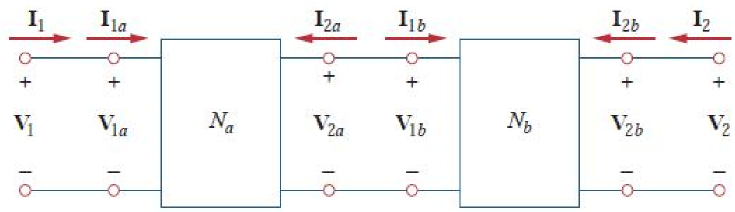
$$[\mathbf{z}] = [\mathbf{z}_a] + [\mathbf{z}_b]$$

  - اتصال موازی: با استفاده از پارامترهای y



$$[\mathbf{y}] = [\mathbf{y}_a] + [\mathbf{y}_b]$$

  - اتصال آبشاری: با استفاده از پارامترهای t



$$[\mathbf{T}] = [\mathbf{T}_a][\mathbf{T}_b]$$