BEEE203L
CIRCUIT THEORY

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MODULE – VII

TWO PORT NETWORKS

Contents

- Open circuit impedance parameters
- Short circuit admittance parameters
- Transmission parameters
- Hybrid parameters
- Relationship between parameter sets
- Interconnection of two port networks

Hybrid parameters

- The hybrid parameters of a two-port network may be defined by expressing the voltage of input port V_1 and current of output port I_2 in terms of current of input port I_1 and voltage of output port V_2.

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

- They are very useful for describing electronic devices such as transistors ; it is much easier to measure experimentally the *h* parameters of such devices than to measure their *z* or *y* parameters
- The individual h parameters can be defined by setting $I_1 = 0$ and $V_2 = 0$.

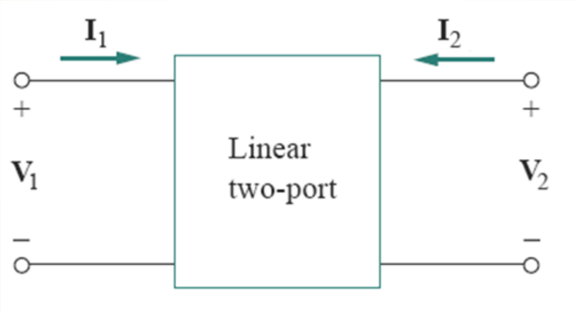
$$h_{11} = \left.\frac{V_1}{I_1}\right|_{V_2=0} \quad h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0}$$

$$h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0} \quad h_{22} = \left.\frac{I_2}{V_2}\right|_{I_1=0}$$

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

Since h parameters represent dimensionally an impedance, an admittance, a voltage gain and a current gain, these are called hybrid parameters.

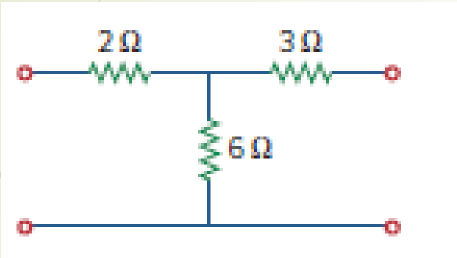
- h11 is the short-circuit input impedance.
- h21 is the short-circuit forward current gain.
- h12 is the open-circuit reverse voltage gain.
- h22 is the open-circuit output admittance.

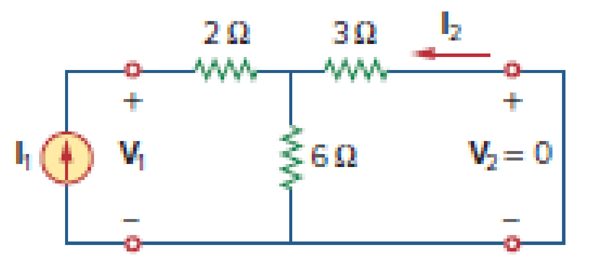


When $h_{11\ 22} - h_{12}h_{21} = 1$, the two-port network is said to be *symmetrical*. For reciprocal networks, $h_{12} = -h_{21}$

Problems

P.7.15 Find the hybrid parameters for the two-port network of Fig





(a)

$V_1 = I_1(2 + 3 \parallel 6) = 4{*}I_1$

$$h_{11} = \frac{V_1}{I_1} = 4\,\Omega$$

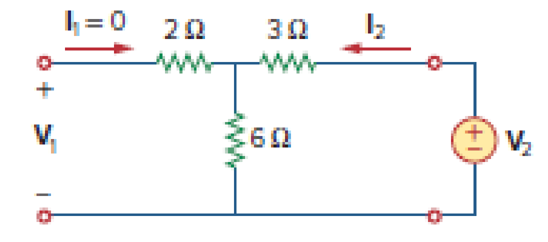
Also, from Fig. (a) we obtain, by current division,

$$-I_2 = \frac{6}{6+3} I_1 = \frac{2}{3} I_1$$

Hence,

$$h_{21} = \frac{I_2}{I_1} = -\frac{2}{3}$$

To obtain $\mathbf{h}_{12}$ and $\mathbf{h}_{22}$, we open-circuit the input port and connect a voltage source V_2 to the output port as in Fig. (b).



(b)

By voltage division,

$$\mathbf{V}_1 = \frac{6}{6+3}\mathbf{V}_2 = \frac{2}{3}\mathbf{V}_2$$

Hence,

$$\mathbf{h}_{12} = \frac{\mathbf{V}_1}{\mathbf{V}_2} = \frac{2}{3}$$

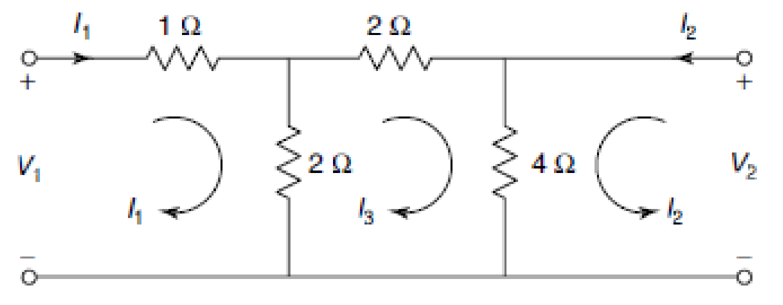
Also,

$$\mathbf{V}_2 = (3+6)\mathbf{I}_2 = 9\mathbf{I}_2$$

Thus,

$$\mathbf{h}_{22} = \frac{\mathbf{I}_2}{\mathbf{V}_2} = \frac{1}{9}\ \text{S}$$

P.7.16 Determine hybrid parameters for the network of Fig. Also Determine whether the network is reciprocal.



Applying KVL to Mesh 1,

$$V_1 = 3I_1 - 2I_3 \qquad \text{...(i)}$$

Applying KVL to Mesh 2,

$$V_2 = 4I_2 + 4I_3 \qquad \text{...(ii)}$$

Applying KVL to Mesh 3,

$$-2(I_3 - I_1) - 2I_3 - 4(I_3 + I_2) = 0$$

$$8I_3 = 2I_1 - 4I_2$$

or

$$I_3 = \frac{I_1}{4} - \frac{I_2}{2} \qquad \text{...(iii)}$$

Substituting Eq. (iii) in Eq. (i),

$$V_1 = 3I_1 - 2\left(\frac{I_1}{4} - \frac{I_2}{2}\right) = \frac{5}{2}I_1 + I_2 \qquad \text{...(iv)}$$

Substituting Eq. (iii) in Eq. (ii),

$$V_2 = 4I_2 + 4\left(\frac{I_1}{4} - \frac{I_2}{2}\right) \quad \text{or} \quad I_2 = -\frac{1}{2}I_1 + \frac{1}{2}V_2 \qquad \text{...(v)}$$

Substituting Eq. (v) in Eq. (iv),

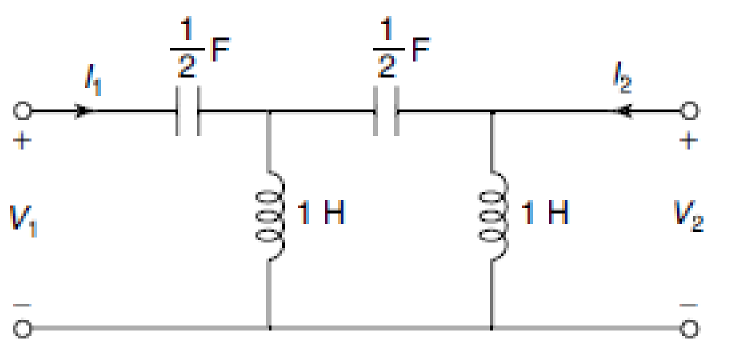
$$V_1 = \frac{5}{2}I_1 - \frac{1}{2}I_1 + \frac{1}{2}V_2 = 2I_1 + \frac{1}{2}V_2 \quad \text{...(vi)}$$

Comparing Eqs (v) and (vi) with h-parameter equations,

$$\begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} = \begin{bmatrix} 2 & \frac{1}{2} \\ -\frac{1}{2} & \frac{1}{2} \end{bmatrix}$$

Since $h_{12} = -h_{21}$, the network is reciprocal

P.7.17 Find h-parameters for the network shown in Fig.



From Y parameter problem, we have

$$I_1 = \frac{s^3+2s}{4(s^2+1)}V_1 - \frac{s^3}{4(s^2+1)}V_2$$

Or

$$V_1 = \frac{4(s^2+1)}{s(s^2+2)}I_1 + \frac{s^2}{s^2+2}V_2$$

And

$$I_2 = -\frac{s^3}{4(s^2+1)}V_1 + \frac{s^4+6s^2+4}{4s(s^2+1)}V_2$$

Or

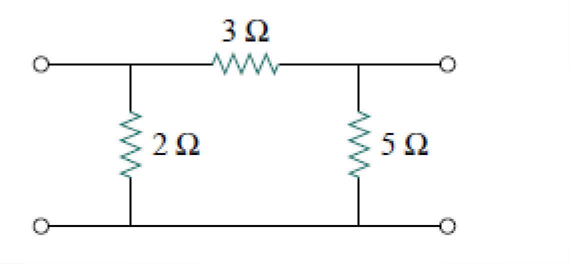
$$I_2 = -\frac{s^3}{4(s^2+1)}\left[\frac{4(s^2+1)}{s(s^2+2)}I_1 + \frac{s^2}{s^2+2}V_2\right] + \frac{s^4+6s^2+4}{4s(s^2+1)}V_2$$

$$= -\frac{s^2}{s^2+2}I_1 + \frac{2(s^2+1)}{s(s^2+2)}V_2$$

Hence

$$\begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} = \begin{bmatrix} \frac{4(s^2+1)}{s(s^2+2)} & \frac{s^2}{s^2+2} \\ -\frac{s^2}{s^2+2} & \frac{2(s^2+1)}{s(s^2+2)} \end{bmatrix}$$

P.7.18 Determine the h parameters for the circuit shown in figure below



Answer: $\mathbf{h}_{11} = 1.2\ \Omega$, $\mathbf{h}_{12} = 0.4$, $\mathbf{h}_{21} = -0.4$, $\mathbf{h}_{22} = 0.4$ S.