Electric Circuits and Networks **26-09-2018**

Lecture 24: Hybrid and Transmission Parameters

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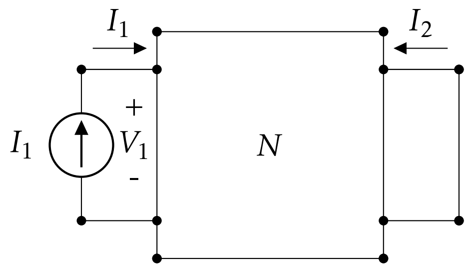
Hybrid Parameters - h and g

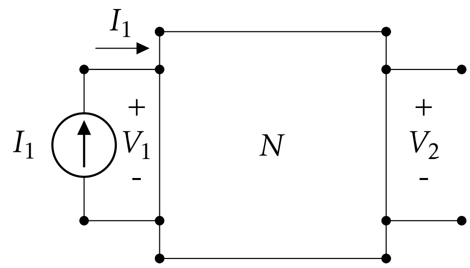
$$V_1 = h_{11}I_1 + h_{12}V_2$$
$$I_2 = h_{21}I_1 + h_{22}V_2$$

$$h_{11} = \frac{V_1}{I_1}\bigg|_{V_2=0} \qquad h_{21} = \frac{I_2}{I_1}\bigg|_{V_2=0}$$

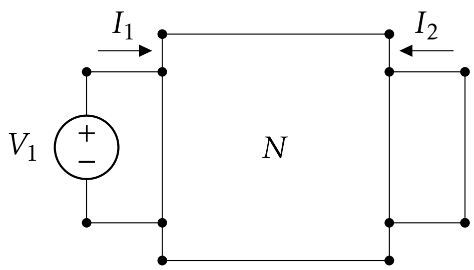
$$h_{12} = \frac{V_1}{V_2}\bigg|_{I_1=0} \qquad h_{22} = \frac{I_2}{V_2}\bigg|_{I_1=0}$$



To calculate h_{11}, h_{21}



To calculate h_{12}, h_{22}



$$h_{11} = \frac{1}{Y_{11}}$$

g Parameter

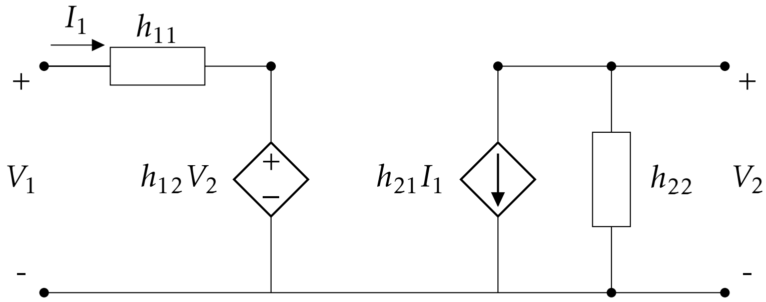
$$I_1 = g_{11}V_1 + g_{12}I_2$$
$$V_2 = g_{21}V_1 + g_{22}I_2$$

$$g_{11} = \frac{I_1}{V_1}\bigg|_{I_2=0} \qquad g_{21} = \frac{V_2}{V_1}\bigg|_{I_2=0}$$

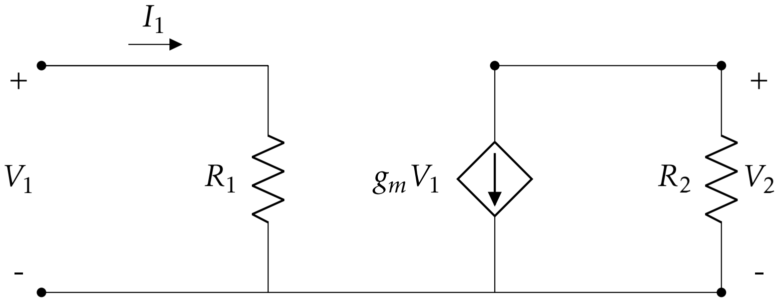
$$g_{12} = \frac{I_1}{I_2}\bigg|_{V_1=0} \qquad g_{22} = \frac{V_2}{I_2}\bigg|_{V_1=0}$$

Therefore $H = G^{-1}$.

If we know the h parameters of a two-port network then the network can be represented as follows

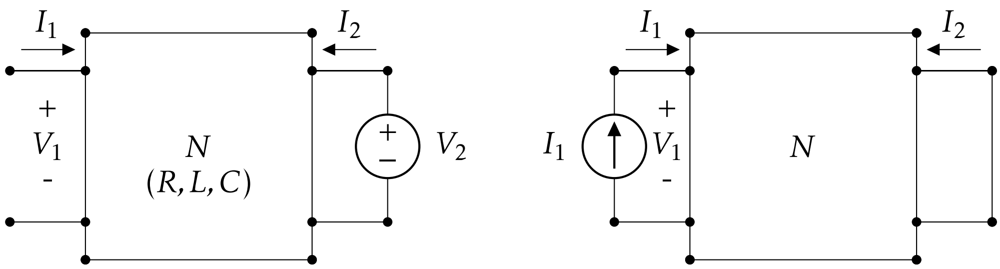


Exercise 1 : Find h and g parameter.



Exercise 2 : Verify $G = H^{-1}$

Example 1 : Apply Tellegen's theorem and find out what will be relation between h_{12} and h_{21} of a reciprocal network.



$$\left(\hat{V}_1(s)I_1(s) - V_1(s)\hat{I}_1(s)\right) + \left(\hat{V}_2(s)I_2(s) - v_2(s)\hat{I}_2(s)\right) = 0$$

As

$$\hat{V}_2 = 0, I_1 = 0$$

$$V_1(s)\hat{I}_1(s) + V_2(s)\hat{I}_2(s) = 0$$

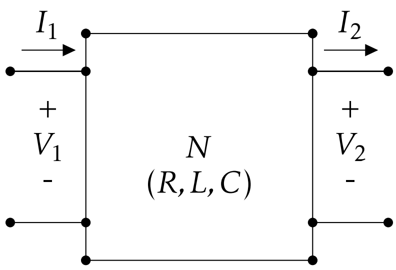
Hence, we have

$$\frac{\hat{I}_2}{\hat{I}_1} = -\frac{V_1}{V_2}$$

$$h_{21}(s) = -h_{12}(s)$$

Similarly, we can also show that $g_{12}(s) = -g_{21}(s)$. **Transmission Parameter**

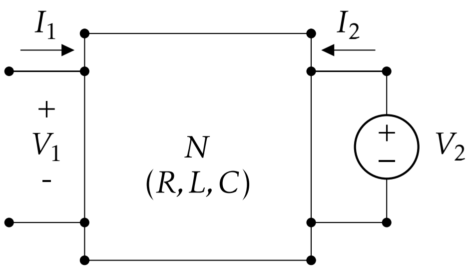
$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$



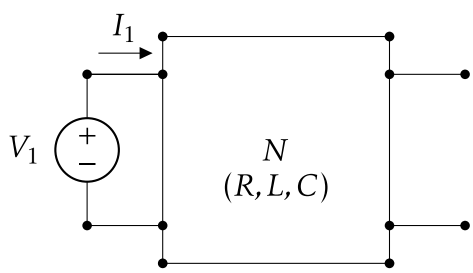
$$A = \left.\frac{V_1}{V_2}\right|_{I_2=0} \qquad C = \left.\frac{I_1}{V_2}\right|_{I_2=0}$$

$$B = \left.\frac{V_1}{-I_2}\right|_{V_2=0} \qquad D = \left.\frac{I_1}{-I_2}\right|_{V_2=0}$$

In order to calculate A, we need $I_2 = 0$ so we cannot do the following



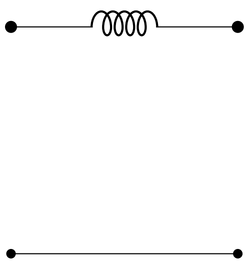
But we can use the following



$$A = \frac{1}{(V_2/V_1)|_{I_2=0}}$$

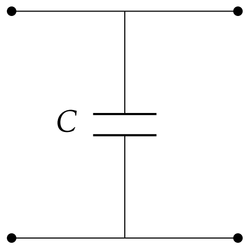
Exercise 3 : Find Transmission Parameters for the following networks

N_1 :



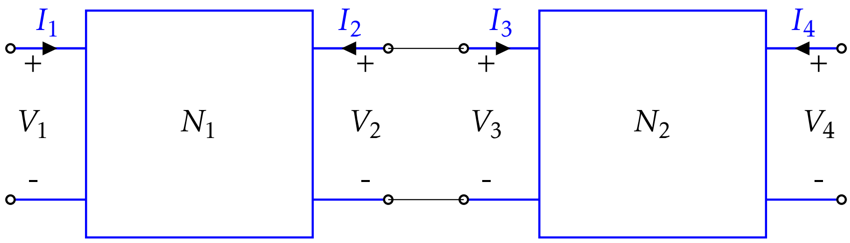
$$T_1 = \begin{bmatrix} 1 & sL \\ 0 & 1 \end{bmatrix}$$

N_2 :



$$T_2 = \begin{bmatrix} 1 & 0 \\ sC & 1 \end{bmatrix}$$

Cascade of two networks



Note that $V_3 = V_2$ and $I_3 = -I_2$. Therefore,

$$\begin{aligned} \begin{bmatrix} V_1 \\ I_1 \end{bmatrix} &= \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix} \\ &= \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} V_3 \\ I_3 \end{bmatrix} \end{aligned}$$

Also

$$\begin{bmatrix} V_3 \\ I_3 \end{bmatrix} = \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} V_4 \\ -I_4 \end{bmatrix}$$

Hence,

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} V_4 \\ -I_4 \end{bmatrix}$$

The T parameters of cascaded networks can be obtained by multiplying the T-matrices of the individual networks. Use this and the results of the previous exercise to find the T parameters of the following network.