UNIT-2

(Lecture-7)

Transfer Functions Using Two Port Parameters

Two Port Networks

Transmission parameters (A,B,C,D):

The defining equations are:

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

$$A = \frac{V_1}{V_2} \Bigg| \; I_2 = 0$$

$$B = \frac{V_1}{-I_2} \Bigg| \; V_2 = 0$$

$$C = \frac{I_1}{V_2} \Bigg| \; I_2 = 0$$

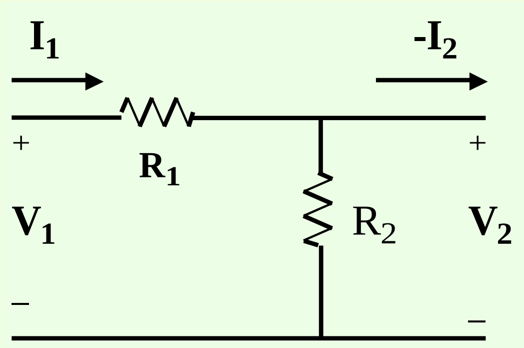
$$D = \frac{I_1}{-I_2} \Bigg| \; V_2 = 0$$

Two Port Networks

Transmission parameters (A,B,C,D):

Example

Given the network below with assumed voltage polarities and Current directions compatible with the A,B,C,D parameters.



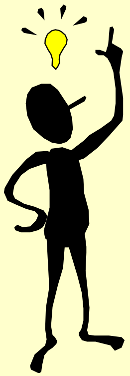
We can write the following equations.

$$V_1 = (R_1 + R_2)I_1 + R_2I_2$$

$$V_2 = R_2I_1 + R_2I_2$$

It is not always possible to write 2 equations in terms of the V's and I's Of the parameter set.

Two Port Networks



Transmission parameters (A,B,C,D):

Example (cont.)

$$V_1 = (R_1 + R_2)I_1 + R_2 I_2$$

$$V_2 = R_2 I_1 + R_2 I_2$$

From these equations we can directly evaluate the A,B,C,D parameters.

$$A = \frac{V_1}{V_2}\Big|_{I_2 = 0} = \frac{R_1 + R_2}{R_2}$$

$$B = \frac{V_1}{-I_2}\Big|_{V_2 = 0} = R_1$$

$$C = \frac{I_1}{V_2}\Big|_{I_2 = 0} = \frac{1}{R_2}$$

$$D = \frac{I_1}{-I_2}\Big|_{V_2 = 0} = 1$$

Later we will see how to interconnect two of these networks together for a final answer

Two Port Networks

Hybrid Parameters:

The equations for the hybrid parameters are:

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

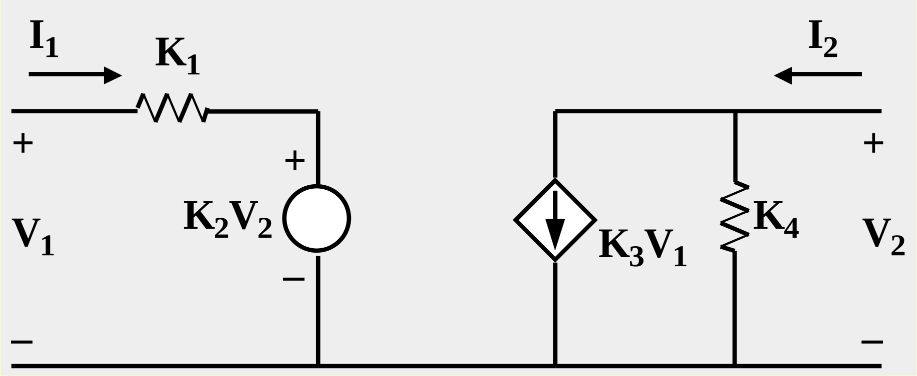
$$h_{11} = \frac{V_1}{I_1}\bigg|_{V_2 = 0} \qquad h_{12} = \frac{V_1}{V_2}\bigg|_{I_1 = 0}$$

$$h_{21} = \frac{I_2}{I_1}\bigg|_{V_2 = 0} \qquad h_{22} = \frac{I_2}{V_2}\bigg|_{I_1 = 0}$$

Two Port Networks

Hybrid Parameters:

The following is a popular model used to represent a particular variety of transistors.



We can write the following equations:

$$V_1 = AI_1 + BV_2$$

$$I_2 = CI_1 + \frac{V_2}{D}$$

Two Port Networks

Hybrid Parameters:

$$V_1 = AI_1 + BV_2$$

$$I_2 = CI_1 + \frac{V_2}{D}$$

We want to evaluate the H parameters from the above set of equations.

$$h_{11} = \frac{V_1}{I_1}\bigg|_{V_2 = 0} = K_1$$

$$h_{12} = \frac{V_1}{V_2}\bigg|_{I_1 = 0} = K_2$$

$$h_{21} = \frac{I_2}{I_1}\bigg|_{V_2 = 0} = K_3$$

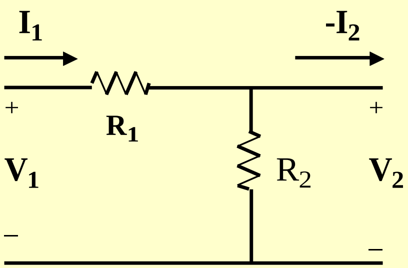
$$h_{22} = \frac{I_2}{V_2}\bigg|_{I_1 = 0} = \frac{1}{K_4}$$

Two Port Networks

Hybrid Parameters:

Another example with hybrid parameters.

Given the circuit below.



The equations for the circuit are:

$$V_1 = (R_1 + R_2)I_1 + R_2I_2$$

$$V_2 = R_2I_1 + R_2I_2$$

The H parameters are as follows.

$$h_{11} = \frac{V_1}{I_1}\Bigg|_{V_2=0} = R_1$$

$$h_{12} = \frac{V_1}{V_2}\Bigg|_{I_1=0} = 1$$

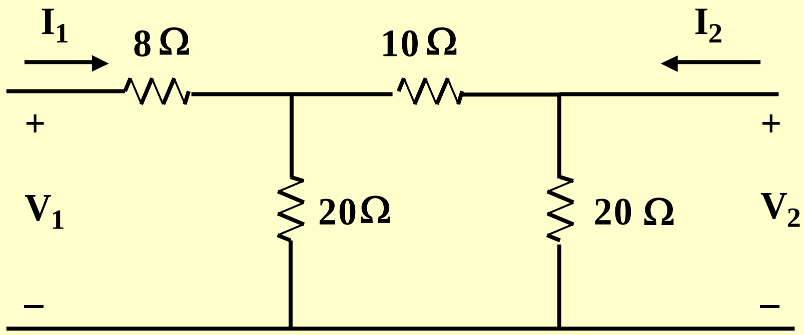
$$h_{21} = \frac{I_2}{I_1}\Bigg|_{V_2=0} = -1$$

$$h_{22} = \frac{I_2}{V_2}\Bigg|_{I_1=0} = \frac{1}{R_2}$$

Two Port Networks

Modifying the two port network:

Earlier we found the z parameters of the following network.

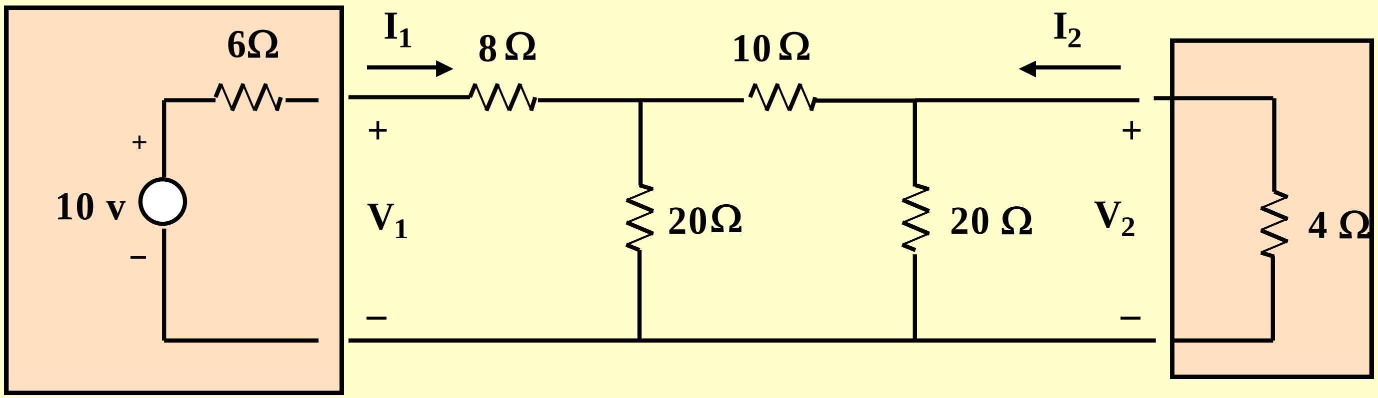


$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 20 & 8 \\ 8 & 12 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

Two Port Networks

Modifying the two port network:

We modify the network as shown be adding elements outside the two ports



We now have:

$$V_1 = 10 - 6I_1$$

$$V_2 = -4I_2$$

Two Port Networks

Modifying the two port network:

We take a look at the original equations and the equations describing the new port conditions.

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} 20 & 8 \\ 8 & 12 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$V_1 = 10 - 6I_1$

$V_2 = -4I_2$

So we have,

$$10 - 6I_1 = 20I_1 + 8I_2$$

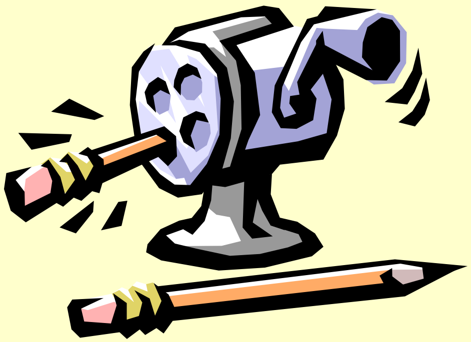
$$-4I_2 = 8I_1 + 12I_2$$

Two Port Networks

Modifying the two port network:

Rearranging the equations gives,

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 26 & 8 \\ 8 & 16 \end{bmatrix}^{-1} \begin{bmatrix} 10 \\ 0 \end{bmatrix}$$



$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 0.4545 \\ -0.2273 \end{bmatrix}$$