Lecture-19

On

INTRODUCTION TO ELECTRICAL ENGINEERING (ESO203)

- Hybrid Parameters.
- Transmission Parameters.

Hybrid Parameters

- The z and y parameters of a two-port network do not always exist.
- So there is a need for developing another set of parameters.
- This third set of parameters is based on making $\mathbf{V}_1$ and $\mathbf{I}_2$ the dependent variables.
- 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.
- In fact, we have seen that the ideal transformer does not have z parameters.
- However, the ideal transformer can be described using the hybrid parameters.

Hybrid Parameters (Cont…)

- The relation between the terminal voltage and the terminal current can established using the following equations:

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

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

- This can alternatively be expressed in matrix form as,

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

- Here the **h** terms are known as the hybrid parameters or the h parameters.
- They are called so because they are a hybrid combination of ratios.

Hybrid Parameters (Cont…)

- The values of the parameters can be evaluated by setting $\mathbf{V_2 = 0}$ (output port short-circuited) or $\mathbf{I_1 = 0}$ (input port open-circuited).
- The individual parameters are evaluated as follows:

If $\mathbf{V_2} = 0$, then

$$\mathbf{h_{11}} = \frac{\mathbf{V_1}}{\mathbf{I_1}}, \mathbf{h_{21}} = \frac{\mathbf{I_2}}{\mathbf{I_1}}$$

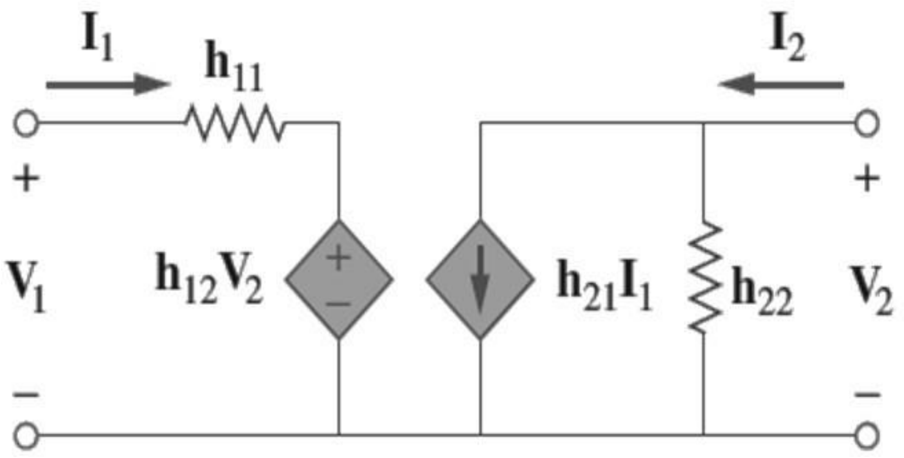
If $\mathbf{I_1} = 0$, then

$$\mathbf{h_{12}} = \frac{\mathbf{V_1}}{\mathbf{V_2}}, \mathbf{h_{22}} = \frac{\mathbf{I_2}}{\mathbf{V_2}}$$

- The parameters $\mathbf{h_{11}}$, $\mathbf{h_{12}}$, $\mathbf{h_{21}}$, and $\mathbf{h_{22}}$ represent an impedance, a voltage gain, a current gain, and an admittance, respectively.
- This is why they are called the hybrid parameters.

Hybrid Parameters (Cont…)

- Specifically,
  - $\mathbf{h}_{11}$ = 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
- The **h** parameters are determined similar to the **z** or **y** parameters.
- For reciprocal circuits, $\mathbf{h}_{12} = -\mathbf{h}_{21}$.
- The hybrid model of a two-port network is as shown in the below figure.



Hybrid Parameters (Cont…)

- Another set of parameter closely related to the **h** parameters are the **g** parameters or the inverse hybrid parameters.
- They are used to describe terminal currents and voltages as

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

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

- This can alternatively be expressed in matrix form as,

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

- Here the **g** terms are known as the inverse hybrid parameters or the g parameters.

Hybrid Parameters (Cont…)

- The values of the parameters can be evaluated by setting $\mathbf{V}_1 = \mathbf{0}$ (input port short-circuited) or $\mathbf{I}_2 = \mathbf{0}$ (output port open-circuited).
- The individual parameters are evaluated as follows:

If $\mathbf{I}_2 = 0$, then

$$\mathbf{g}_{11} = \frac{\mathbf{I}_1}{\mathbf{V}_1}, \mathbf{g}_{21} = \frac{\mathbf{V}_2}{\mathbf{V}_1}$$

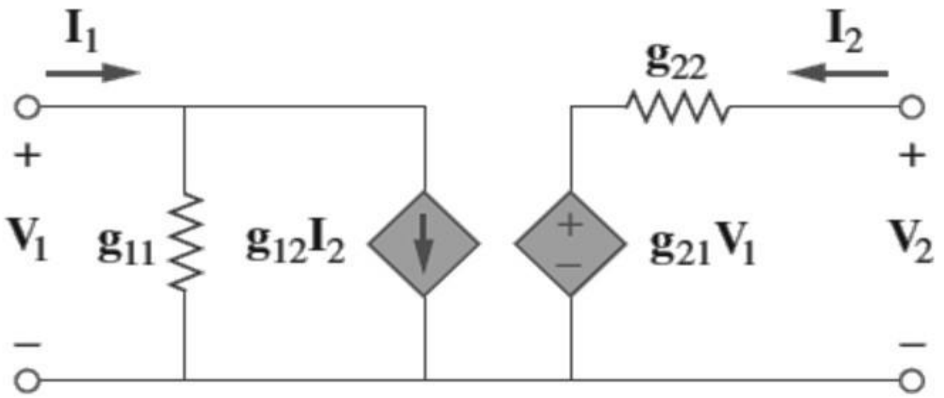
If $\mathbf{V}_1 = 0$, then

$$\mathbf{g}_{12} = \frac{\mathbf{I}_1}{\mathbf{I}_2}, \mathbf{g}_{22} = \frac{\mathbf{V}_2}{\mathbf{I}_2}$$

- The parameters $\mathbf{g}_{11}$, $\mathbf{g}_{12}$, $\mathbf{g}_{21}$, and $\mathbf{g}_{22}$ represent an admittance, a current gain, a voltage gain, and an impedance, respectively.

Hybrid Parameters (Cont…)

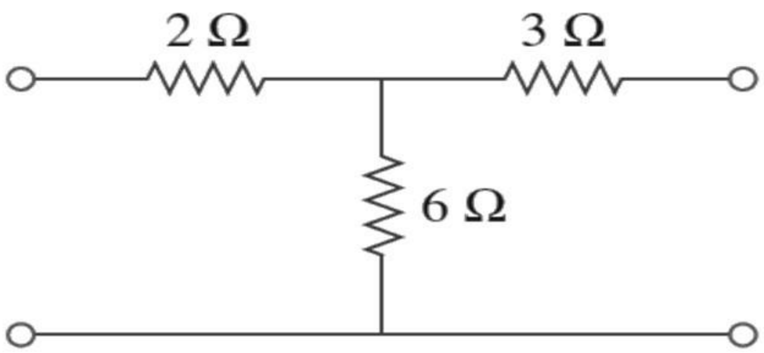
- Specifically,
  - g_{11} = Open-circuit input admittance
  - g_{12} = Short-circuit reverse current gain
  - g_{21} = Open-circuit forward voltage gain
  - g_{22} = Short-circuit output impedance
- The **g** parameters are determined similar to the **z** or **y** parameters.
- The inverse hybrid model of a two-port network is as shown in the below figure.



Hybrid Parameters (Cont…)

❑ Example:

- Determine the **h**-parameters for the below circuit?

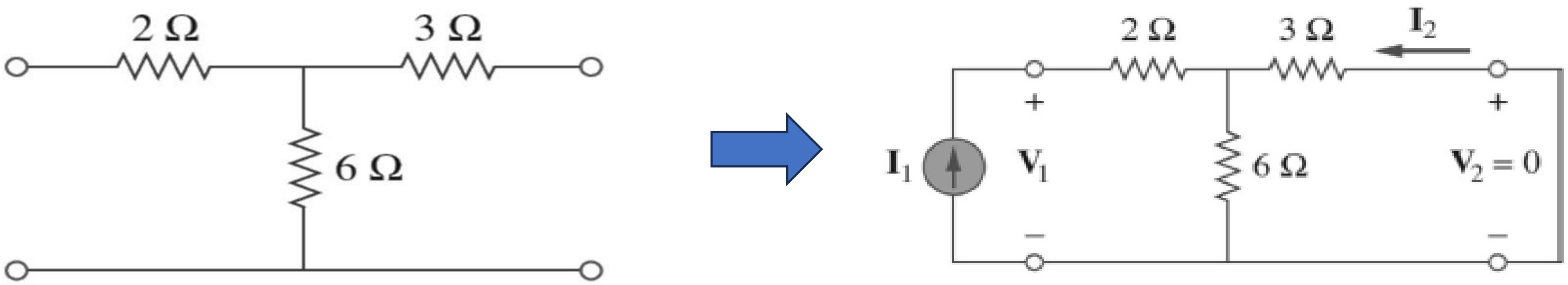


Solution: The parameters are determined using the equations discussed earlier in the lecture.

Hybrid Parameters (Cont…)

- To determine $\mathbf{h_{11}}$ and $\mathbf{h_{21}}$, we connect a current source $\mathbf{I_1}$ to the input port and short the output port as in the following figure.

- Since the terminal is shorted, 3 and 6 ohm resistors are in parallel.



$$\mathbf{V_1} = \mathbf{I_1}(2 + 3||6) = 4\mathbf{I_1}$$

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

If $\mathbf{V_2} = 0$, then

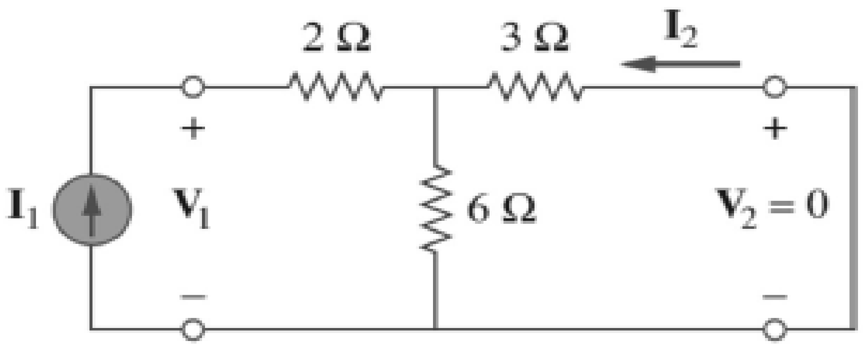
$$\mathbf{h_{11}} = \frac{\mathbf{V_1}}{\mathbf{I_1}}, \mathbf{h_{21}} = \frac{\mathbf{I_2}}{\mathbf{I_1}}$$

If $\mathbf{I_1} = 0$, then

$$\mathbf{h_{12}} = \frac{\mathbf{V_1}}{\mathbf{V_2}}, \mathbf{h_{22}} = \frac{\mathbf{I_2}}{\mathbf{V_2}}$$

Hybrid Parameters (Cont…)

- By current division,



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

$$\mathbf{h}_{21} = \frac{\mathbf{I}_2}{\mathbf{I}_1} = \frac{-\frac{2}{3}\mathbf{I}_1}{\mathbf{I}_1} = -\frac{2}{3}$$

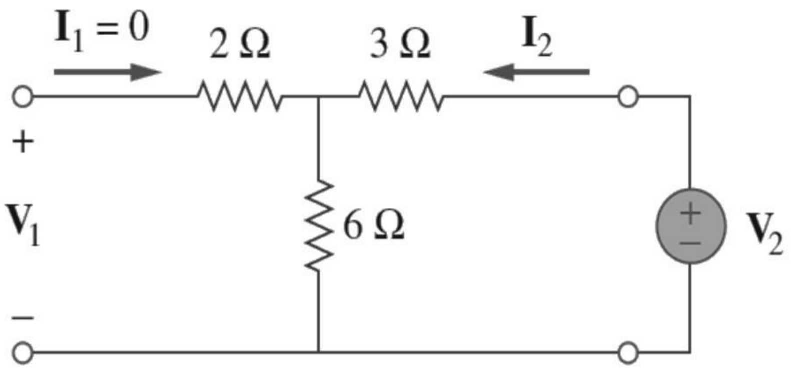
If $\mathbf{V}_2 = 0$, then

$$\mathbf{h}_{11} = \frac{\mathbf{V}_1}{\mathbf{I}_1}, \mathbf{h}_{21} = \frac{\mathbf{I}_2}{\mathbf{I}_1}$$

If $\mathbf{I}_1 = 0$, then

$$\mathbf{h}_{12} = \frac{\mathbf{V}_1}{\mathbf{V}_2}, \mathbf{h}_{22} = \frac{\mathbf{I}_2}{\mathbf{V}_2}$$

- To determine $\mathbf{h}_{12}$ and $\mathbf{h}_{22}$, we connect a voltage source $\mathbf{V}_2$ to the output port and open-circuit the input port as in the following figure.



Hybrid Parameters (Cont…)

If $\mathbf{V}_2 = 0$, then

$$\mathbf{h}_{11} = \frac{\mathbf{V}_1}{\mathbf{I}_1}, \mathbf{h}_{21} = \frac{\mathbf{I}_2}{\mathbf{I}_1}$$

If $\mathbf{I}_1 = 0$, then

$$\mathbf{h}_{12} = \frac{\mathbf{V}_1}{\mathbf{V}_2}, \mathbf{h}_{22} = \frac{\mathbf{I}_2}{\mathbf{V}_2}$$

- The 2 ohm resistor is open circuited. Hence, by voltage division

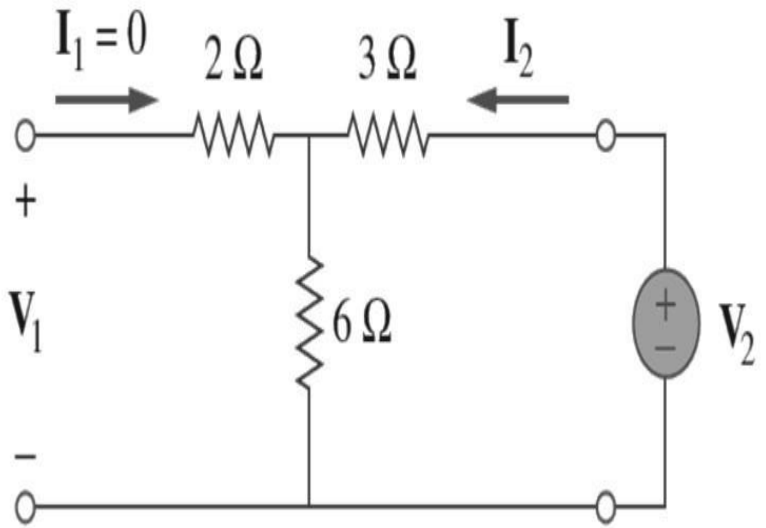
$$\mathbf{V}_1 = \frac{6}{6+3}\mathbf{V}_2 = \frac{2}{3}\mathbf{V}_2$$

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

- Also,

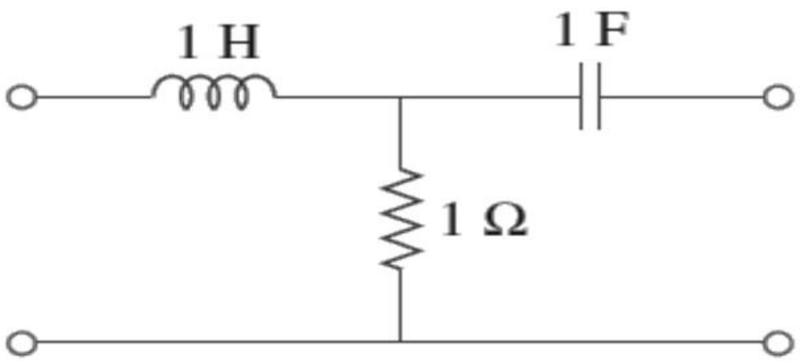
$$\mathbf{V}_2 = \mathbf{I}_2(3+6) = 9\mathbf{I}_2$$

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



❑ Example:

- Determine g-parameters as function of s for the following circuit?

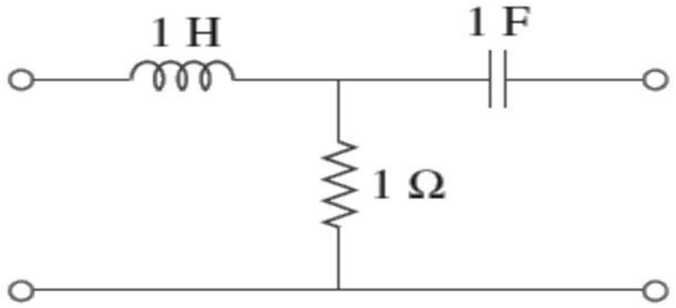


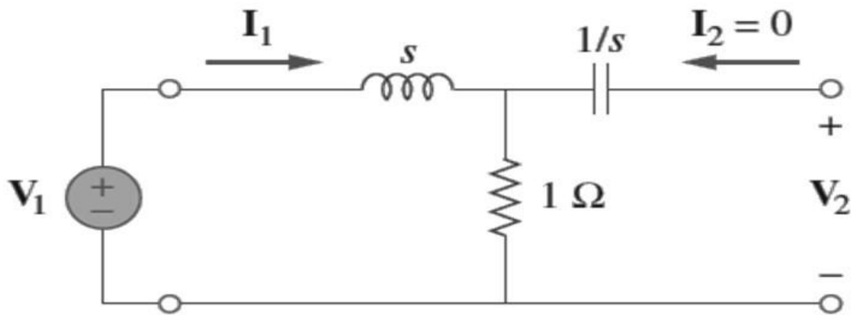
Solution: The above circuit can be solved using the same procedure discussed in the previous example.

First we need to convert the circuit into s-domain.

Hybrid Parameters (Cont…)

- To determine $\mathbf{g}_{11}$ and $\mathbf{g}_{21}$, we connect a voltage source $\mathbf{V}_1$ to the input port and open-circuit the output port as in the following figure.
- Since the terminal is open-circuited, the capacitor need not be considered in calculating $\mathbf{I}_1$.





$$\mathbf{I}_1 = \frac{\mathbf{V}_1}{s+1}$$

$$\mathbf{g}_{11} = \frac{\mathbf{I}_1}{\mathbf{V}_1} = \frac{1}{s+1}$$

If $\mathbf{I}_2 = 0$, then

$$\mathbf{g}_{11} = \frac{\mathbf{I}_1}{\mathbf{V}_1}, \mathbf{g}_{21} = \frac{\mathbf{V}_2}{\mathbf{V}_1}$$

If $\mathbf{V}_1 = 0$, then

$$\mathbf{g}_{12} = \frac{\mathbf{I}_1}{\mathbf{I}_2}, \mathbf{g}_{22} = \frac{\mathbf{V}_2}{\mathbf{I}_2}$$

Hybrid Parameters (Cont…)

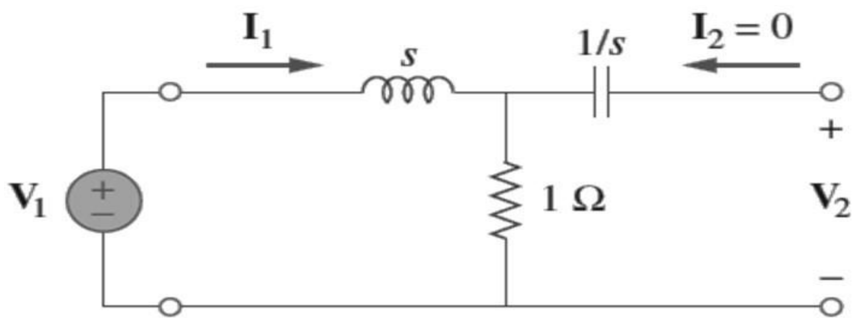
If $\mathbf{I}_2 = 0$, then

$$\mathbf{g}_{11} = \frac{\mathbf{I}_1}{\mathbf{V}_1}, \mathbf{g}_{21} = \frac{\mathbf{V}_2}{\mathbf{V}_1}$$

If $\mathbf{V}_1 = 0$, then

$$\mathbf{g}_{12} = \frac{\mathbf{I}_1}{\mathbf{I}_2}, \mathbf{g}_{22} = \frac{\mathbf{V}_2}{\mathbf{I}_2}$$

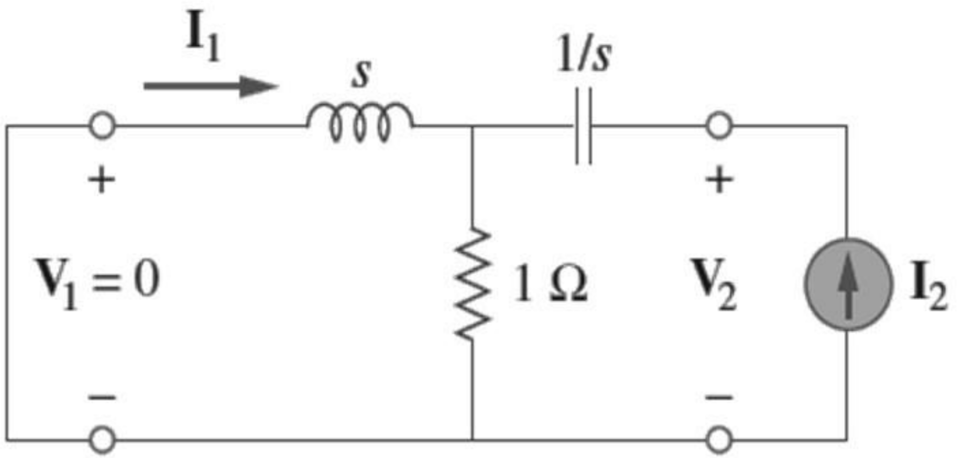
- By voltage division,



$$\mathbf{V}_2 = \frac{1}{s+1}\mathbf{V}_1$$

$$\mathbf{g}_{21} = \frac{\mathbf{V}_2}{\mathbf{V}_1} = \frac{1}{s+1}$$

- To determine $\mathbf{g}_{12}$ and $\mathbf{g}_{22}$, we connect a current source $\mathbf{I}_2$ to the output port and short-circuit the input port as in the following figure.



Hybrid Parameters (Cont…)

If $\mathbf{I}_2 = 0$, then

$$\mathbf{g}_{11} = \frac{\mathbf{I}_1}{\mathbf{V}_1}, \mathbf{g}_{21} = \frac{\mathbf{V}_2}{\mathbf{V}_1}$$

If $\mathbf{V}_1 = 0$, then

$$\mathbf{g}_{12} = \frac{\mathbf{I}_1}{\mathbf{I}_2}, \mathbf{g}_{22} = \frac{\mathbf{V}_2}{\mathbf{I}_2}$$

- By current division

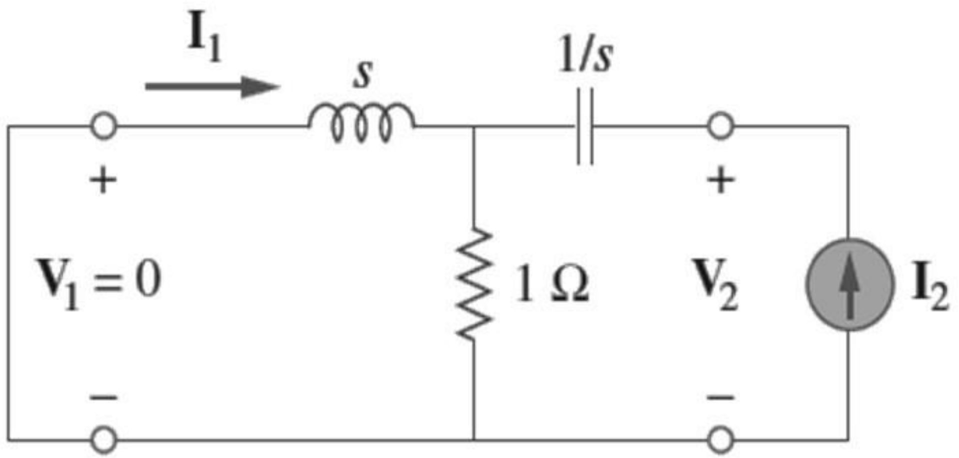
$$\mathbf{I}_1 = -\frac{1}{s+1}\mathbf{I}_2$$

$$\mathbf{g}_{12} = \frac{\mathbf{I}_1}{\mathbf{I}_2} = -\frac{1}{s+1}$$

- Also,

$$\mathbf{V}_2 = \mathbf{I}_2\left(\frac{1}{s} + s||1\right)$$

$$\mathbf{g}_{22} = \frac{\mathbf{V}_2}{\mathbf{I}_2} = \frac{1}{s} + \frac{s}{s+1} = \frac{(s^2+s+1)}{s(s+1)}$$



Transmission Parameters

- As there are no restrictions on which terminal voltages and currents should be considered independent and which should be dependent variables, we can generate many sets of parameters.
- Today we will discuss another set of parameters that relates the variables at the input port to those at the output port.
- This set of parameters are known as ABCD parameters or transmission parameters.
- The ABCD parameters provide a measure of how a circuit transmits voltage and current from a source to a load.

Transmission Parameters (Cont…)

- The relation between the terminal voltage and the terminal current can be established using the following equations:

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

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

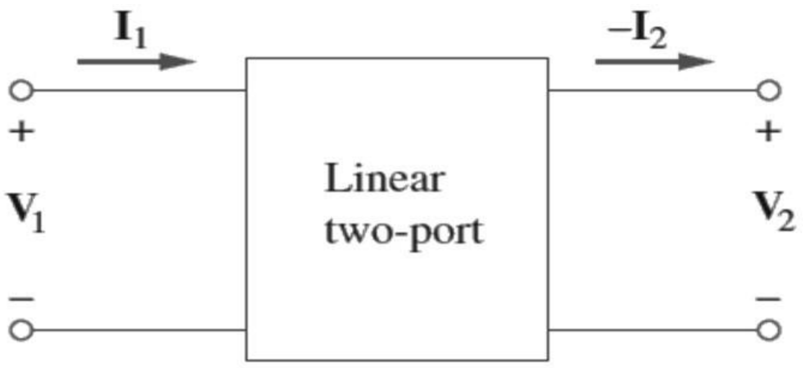
- This can alternatively be expressed in matrix form as,

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

- Here the **T** terms are known as the ABCD parameters or the transmission parameters.
- They are useful in the analysis of transmission lines because they express sending-end variables in terms of the receiving-end variables.
- For this reason, they are called transmission parameters.

Transmission Parameters (Cont…)

- The above equations relate the input variables (**V_1** and **I_1**) to the output variables (**V_2** and **$-I_2$**).
- Notice that in computing the transmission parameters, **$-I_2$** is used rather than **I_2**, because the current is considered to be leaving the network, as shown in below figure.
- It is so, because in the power systems we consider **I_2** as leaving the port.



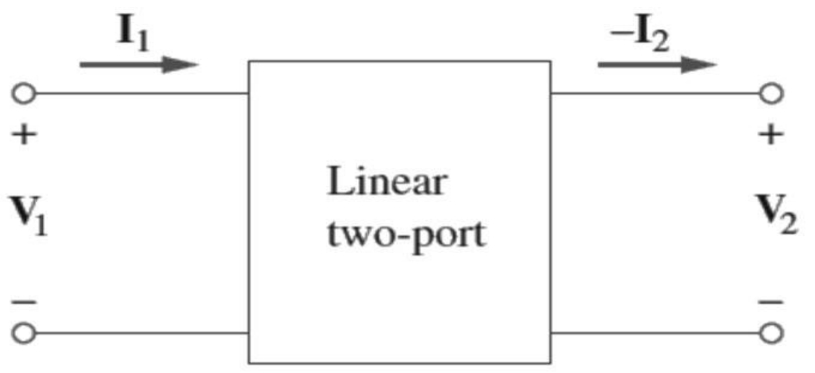
Transmission Parameters (Cont…)

- The values of the parameters can be evaluated by setting $\mathbf{V_2 = 0}$ (output port short-circuited) or $\mathbf{I_2 = 0}$ (output port open-circuited) in the following equations –

$$\mathbf{V_1 = AV_2 - BI_2}$$

$$\mathbf{I_1 = CV_2 - DI_2}$$

- The individual parameters are evaluated as follows:



If $I_2 = 0$, then

$$\mathbf{A = \frac{V_1}{V_2}, C = \frac{I_1}{V_2}}$$

If $V_2 = 0$, then

$$\mathbf{B = -\frac{V_1}{I_2}, D = -\frac{I_1}{I_2}}$$

- The parameters **A**, **B**, **C**, and **D** represent a voltage gain, an impedance, an admittance, and a current gain, respectively.

Transmission Parameters (Cont…)

- Since the transmission parameters provide a direct relationship between input and output variables, they are very useful in cascaded networks.
- Specifically,
  - $\mathbf{A}$ = Open-circuit voltage ratio
  - $\mathbf{B}$ = Negative short-circuit transfer impedance
  - $\mathbf{C}$ = Open-circuit transfer admittance
  - $\mathbf{D}$ = Negative short-circuit current ratio
- The $\mathbf{T}$ parameters can also be determined similar to the $\mathbf{z}$ or $\mathbf{y}$ parameters.
- For reciprocal circuits, $\mathbf{AD} - \mathbf{BC} = 1$.

Transmission Parameters (Cont…)

- The last set of parameter is obtained by expressing the variables at the output port in terms of variables at the input port:

$$\mathbf{V}_2 = \mathbf{a}\mathbf{V}_1 - \mathbf{b}\mathbf{I}_1$$

$$\mathbf{I}_2 = \mathbf{c}\mathbf{V}_1 - \mathbf{d}\mathbf{I}_1$$

- This can alternatively be expressed in matrix form as,

$$\begin{bmatrix} \mathbf{V}_2 \\ \mathbf{I}_2 \end{bmatrix} = \begin{bmatrix} \mathbf{a} & \mathbf{b} \\ \mathbf{c} & \mathbf{d} \end{bmatrix} \begin{bmatrix} \mathbf{V}_1 \\ -\mathbf{I}_1 \end{bmatrix} = [\mathbf{t}] \begin{bmatrix} \mathbf{V}_1 \\ -\mathbf{I}_1 \end{bmatrix}$$

- Here the parameters are known as the inverse transmission or **t** -parameters.
- The values of the parameters can be evaluated by setting $\mathbf{V}_1 = \mathbf{0}$ (input port short-circuited) or $\mathbf{I}_1 = \mathbf{0}$ (input port open-circuited).

Transmission Parameters (Cont…)

- The individual parameters are evaluated as follows:

If $\mathbf{I}_1 = 0$, then

$$\mathbf{a} = \frac{\mathbf{V}_2}{\mathbf{V}_1}, \mathbf{c} = \frac{\mathbf{I}_2}{\mathbf{V}_1}$$

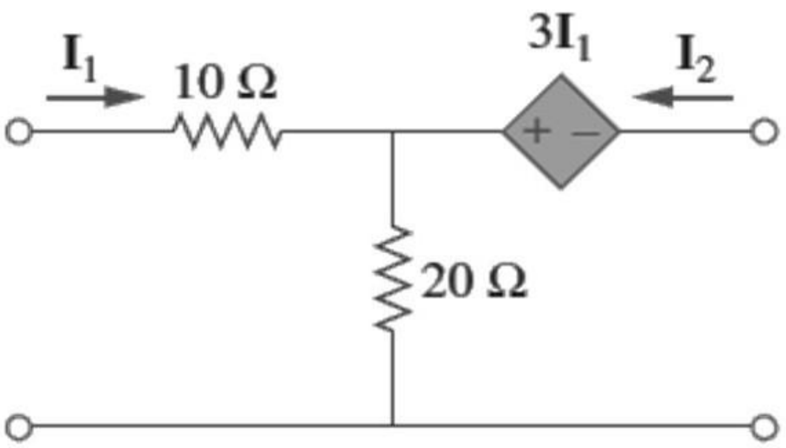
If $\mathbf{V}_1 = 0$, then

$$\mathbf{b} = -\frac{\mathbf{V}_2}{\mathbf{I}_1}, \mathbf{d} = -\frac{\mathbf{I}_2}{\mathbf{I}_1}$$

- Specifically,
  - $\mathbf{a}$ = Open-circuit voltage ratio
  - $\mathbf{b}$ = Negative short-circuit transfer impedance
  - $\mathbf{c}$ = Open-circuit transfer admittance
  - $\mathbf{d}$ = Negative short-circuit current ratio
- For reciprocal circuits, $\mathbf{ad} - \mathbf{bc} = 1$.

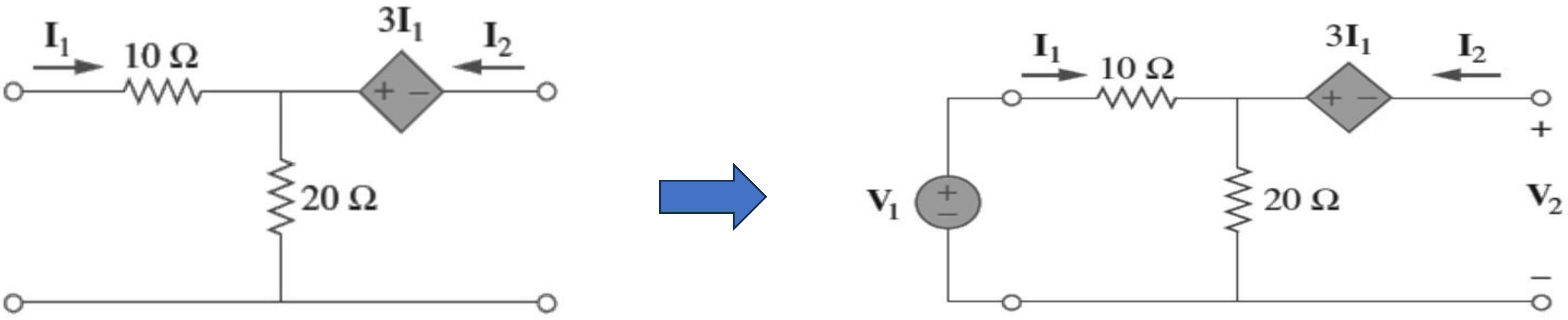
❑ Example:

- Determine the transmission parameters for the below circuit?



Solution: The parameters are determined using the equations discussed earlier in the lecture.

- To determine **A** and **C**, we connect a voltage source $\mathbf{V}_1$ to the input port and open the output port as in the following figure.



$$\mathbf{V}_1 = \mathbf{I}_1\ (10 + 20) = 30\mathbf{I}_1$$

$$\mathbf{V}_2 = \mathbf{I}_1(20 - 3) = 17\mathbf{I}_1$$

If $\mathbf{I}_2 = 0$, then

$$\mathbf{A} = \frac{\mathbf{V}_1}{\mathbf{V}_2}, \mathbf{C} = \frac{\mathbf{I}_1}{\mathbf{V}_2}$$

If $\mathbf{V}_2 = 0$, then

$$\mathbf{B} = -\frac{\mathbf{V}_1}{\mathbf{I}_2}, \mathbf{D} = -\frac{\mathbf{I}_1}{\mathbf{I}_2}$$

Transmission Parameters (Cont…)

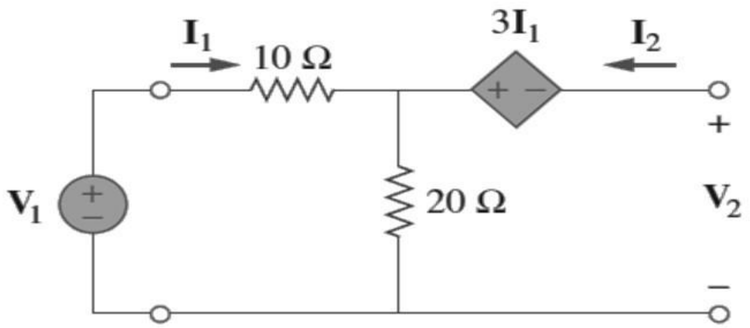
If $\mathbf{I}_2 = 0$, then

$$\mathbf{A} = \frac{\mathbf{V}_1}{\mathbf{V}_2}, \mathbf{C} = \frac{\mathbf{I}_1}{\mathbf{V}_2}$$

If $\mathbf{V}_2 = 0$, then

$$\mathbf{B} = -\frac{\mathbf{V}_1}{\mathbf{I}_2}, \mathbf{D} = -\frac{\mathbf{I}_1}{\mathbf{I}_2}$$

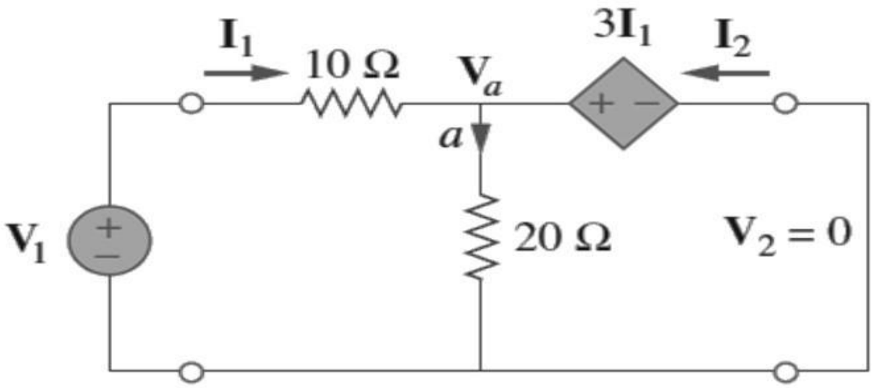
- Thus,



$$\mathbf{A} = \frac{\mathbf{V}_1}{\mathbf{V}_2} = \frac{30\mathbf{I}_1}{17\mathbf{I}_1} = 1.765$$

$$\mathbf{C} = \frac{\mathbf{I}_1}{\mathbf{V}_2} = \frac{\mathbf{I}_1}{17\mathbf{I}_1} = 0.0588\mathbf{S}$$

- To determine **B** and **D**, we connect a voltage source $\mathbf{V}_1$ to the input port and short the output port as in the following figure.



Transmission Parameters (Cont…)

If $\mathbf{I}_2 = 0$, then

$$\mathbf{A} = \frac{\mathbf{V}_1}{\mathbf{V}_2}, \mathbf{C} = \frac{\mathbf{I}_1}{\mathbf{V}_2}$$

If $\mathbf{V}_2 = 0$, then

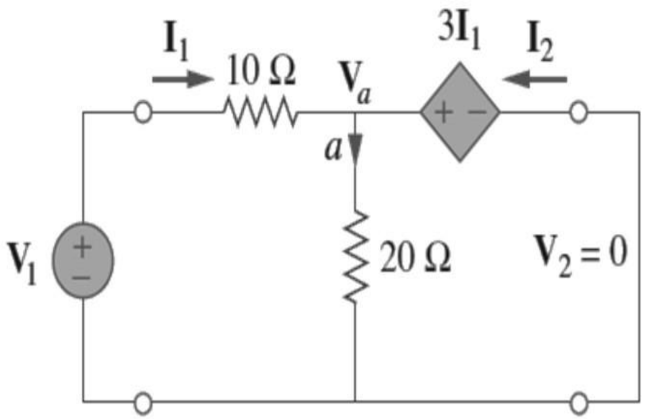
$$\mathbf{B} = -\frac{\mathbf{V}_1}{\mathbf{I}_2}, \mathbf{D} = -\frac{\mathbf{I}_1}{\mathbf{I}_2}$$

- At node a in the circuit, KCL gives,

$$\frac{\mathbf{V}_1 - \mathbf{V}_a}{10} - \frac{\mathbf{V}_a}{20} + \mathbf{I}_2 = 0$$

- But $\mathbf{V}_a = 3\mathbf{I}_1$ and $\mathbf{I}_1 = (\mathbf{V}_1 - \mathbf{V}_a)/10$. Using these we get,

$$\mathbf{V}_a = 3\mathbf{I}_1 \text{ and } \mathbf{V}_1 = 13\mathbf{I}_1$$



- Substituting the above values in the KCL,

$$\mathbf{I}_1 - \frac{3\mathbf{I}_1}{20} + \mathbf{I}_2 = 0 \Rightarrow \frac{17}{20}\mathbf{I}_1 = -\mathbf{I}_2$$

- Therefore,

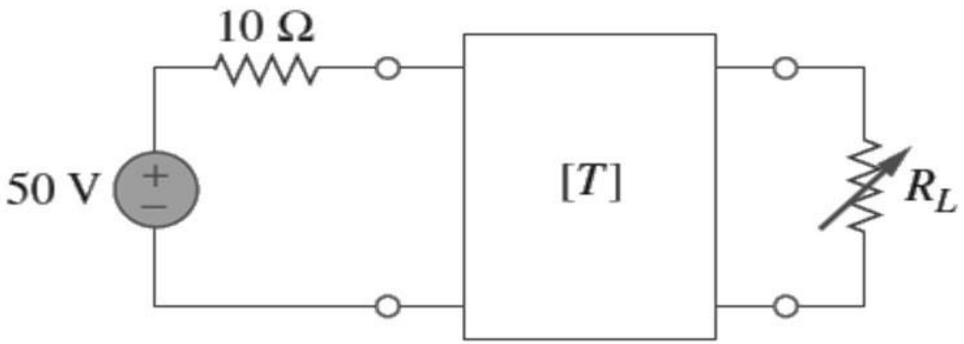
$$\mathbf{D} = -\frac{\mathbf{I}_1}{\mathbf{I}_2} = \frac{20}{17} = 1.176, \quad \mathbf{B} = -\frac{\mathbf{V}_1}{\mathbf{I}_2} = \frac{-13\mathbf{I}_1}{\left(-\frac{17}{20}\right)\mathbf{I}_1}$$

$$= 15.29\Omega$$

Transmission Parameters (Cont…)

❑ Example:

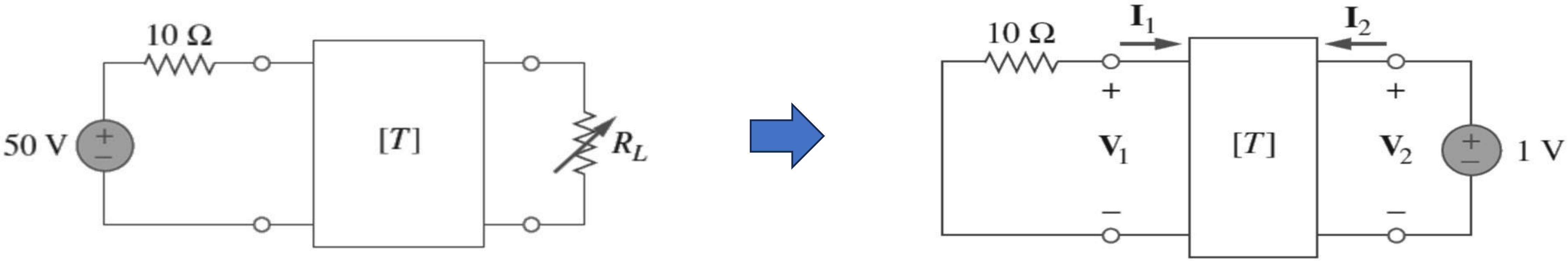
- The transmission parameters for the below circuit are $\begin{bmatrix} 4 & 20\Omega \\ 0.1S & 2 \end{bmatrix}$. The output port is connected to a variable load for maximum power transfer. Find R_L and maximum power transferred?



Solution: The parameters are determined using the equations discussed earlier in the lecture.

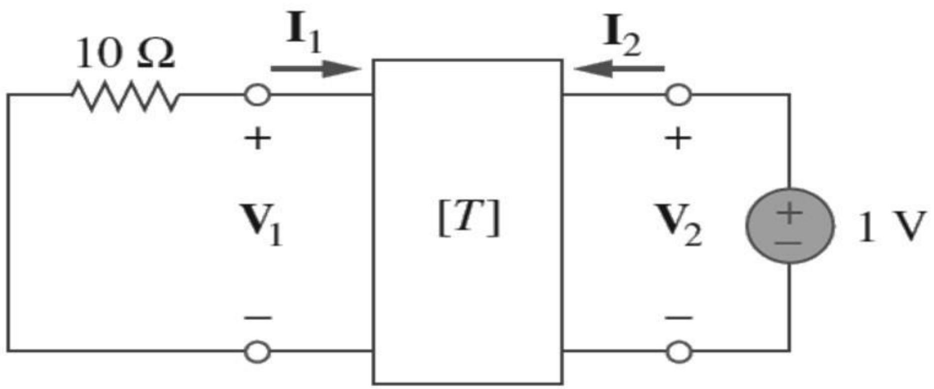
Transmission Parameters (Cont…)

- We need to determine the Thevenin equivalent (Z_{Th} and V_{Th}), at the load or output port.
- We find Z_{Th} using the below circuit.



- Our goal here is to set $Z_{\mathrm{Th}} = \mathbf{V}_2/\mathbf{I}_2$
- This can be found out using the **ABCD** parameters.

Transmission Parameters (Cont…)



- Substituting the given parameters we obtain,

$$\mathbf{V}_1 = 4\mathbf{V}_2 - 20\mathbf{I}_2$$

$$\mathbf{I}_1 = 0.1\mathbf{V}_2 - 2\mathbf{I}_2$$

- At the input port $\mathbf{V}_1 = -10\mathbf{I}_1$
- Substituting this relation in the first equation, we get,

$$-10\mathbf{I}_1 = 4\mathbf{V}_2 - 20\mathbf{I}_2 \rightarrow \mathbf{I}_1 = -0.4\mathbf{V}_2 + 2\mathbf{I}_2$$

- Applying the above value to the second equation of the ABCD parameters, we get,

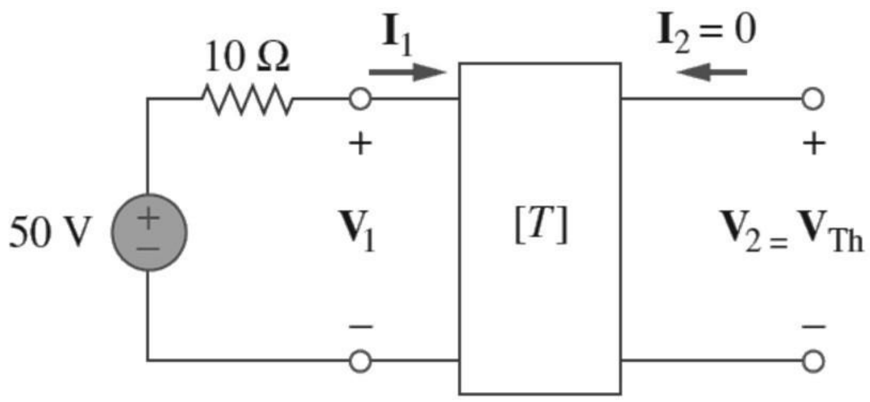
$$-0.4\mathbf{V}_2 + 2\mathbf{I}_2 = 0.1\mathbf{V}_2 - 2\mathbf{I}_2 \rightarrow 0.5\mathbf{V}_2 = 4\mathbf{I}_2$$

$$Z_{Th} = \frac{\mathbf{V}_2}{\mathbf{I}_2} = \frac{4}{0.5} = 8\Omega$$

Transmission Parameters (Cont…)

$$\mathbf{V}_1 = 4\mathbf{V}_2 - 20\mathbf{I}_2$$
$$\mathbf{I}_1 = 0.1\mathbf{V}_2 - 2\mathbf{I}_2$$

- To determine V_{Th}, we use the below circuit.



- At the output $\mathbf{I}_2 = 0$ and the input port $\mathbf{V}_1 = 50 - 10\mathbf{I}_1$
- Applying the above to the ABCD parameter equations,

$$50 - 10\mathbf{I}_1 = 4\mathbf{V}_2$$

$$\mathbf{I}_1 = 0.1\mathbf{V}_2 \rightarrow \mathbf{V}_2 = 10\mathbf{I}_1$$

Transmission Parameters (Cont…)

- Therefore,

$$50 - 10\mathbf{I}_1 = 4\mathbf{V}_2 \rightarrow 50 - \mathbf{V}_2 = 4\mathbf{V}_2$$

$$5\mathbf{V}_2 = 50 \rightarrow \mathbf{V}_2 = 10$$

- Thus,

$$V_{\mathrm{Th}} = \mathbf{V}_2 = 10\mathrm{V}$$

- For maximum power transfer,

$$R_{\mathrm{L}} = Z_{\mathrm{Th}} = 8\Omega$$

- The maximum power transfer is therefore,

$$P = I^2 R_L = \left(\frac{V_{Th}}{2R_L}\right)^2 R_L = 3.125\mathrm{W}$$


THANKS
FOR YOUR
ATTENTION