Two Port Network

CHARACTERISTICS AND PARAMETERS OF TWO PORT NETWORKS:

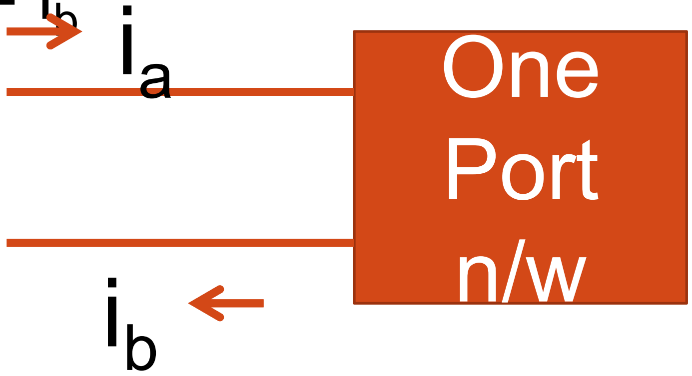
- Relationship of two-port variables,
- short-circuit Admittance parameters,
- open circuit impedance Parameters,
- Transmission parameters,
- hybrid parameters,
- relationships between parameter sets,
- Inter-connection of two port networks.

What is network

- When a number of impedances are connected together to form a system that consist of set of interconnected circuits performing specific function, is called as a network

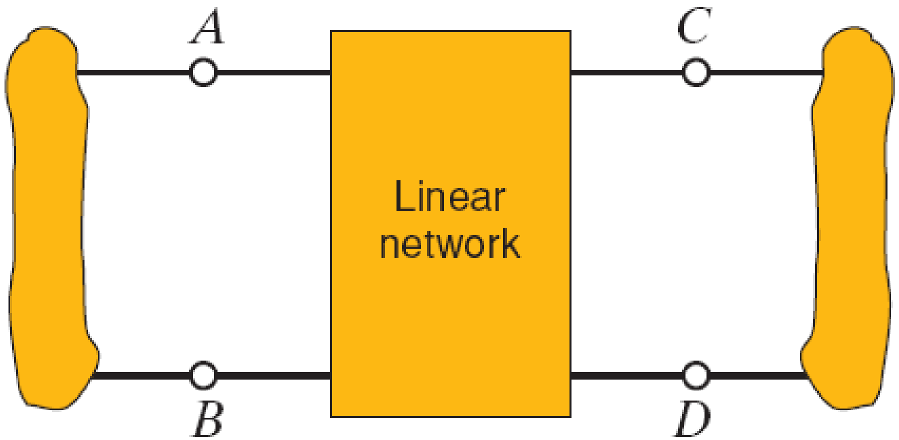
One Port Network

- A pair of terminals at which a signal may enter or leave a network is called a port n/w or one port n/w.
- By KCL, $i_a = i_b$



Two Port Parameters

- It represented by a black box with four variables, two voltage (V_1, V_2) and two currents (I_1, I_2), which are available for measurements
- Out of these four variables, which two variables may be considered ‘independent’ and which two ‘dependent’ is generally decided by the problem under consideration.



A two-port model is a description of a network that relates voltages a
at two pairs of terminals

LEARNING GOALS

Study the basic types of two-port models

- Admittance parameters
- Impedance parameters
- Hybrid parameters
- Transmission parameters

Two Port Networks

Network Equations:

Impedance
Z parameters

$$V_1 = z_{11}I_1 + z_{12}I_2$$

$$V_2 = z_{21}I_1 + z_{22}I_2$$

Admittance
Y parameters

$$I_1 = y_{11}V_1 + y_{12}V$$

$$I_2 = y_{21}V_1 + y_{22}V$$

Transmission
A, B, C, D
parameters

$$V_1 = AV_2 - BI_2$$

$$I_1 = CV_2 - DI_2$$

Inverse
Transmission
parameters

$$V_2 = b_{11}V_1 - b_{12}I$$

$$I_2 = b_{21}V_1 - b_{22}I$$

Hybrid
H parameters

$$V_1 = h_{11}I_1 + h_{12}V_2$$

$$I_2 = h_{21}I_1 + h_{22}V_2$$

Inverse
Hybrid
H parameters

$$I_1 = g_{11}V_1 + g_{12}I_2$$

$$V_2 = g_{21}V_1 + g_{22}I$$

Open circuit Impedance (Z) parameter

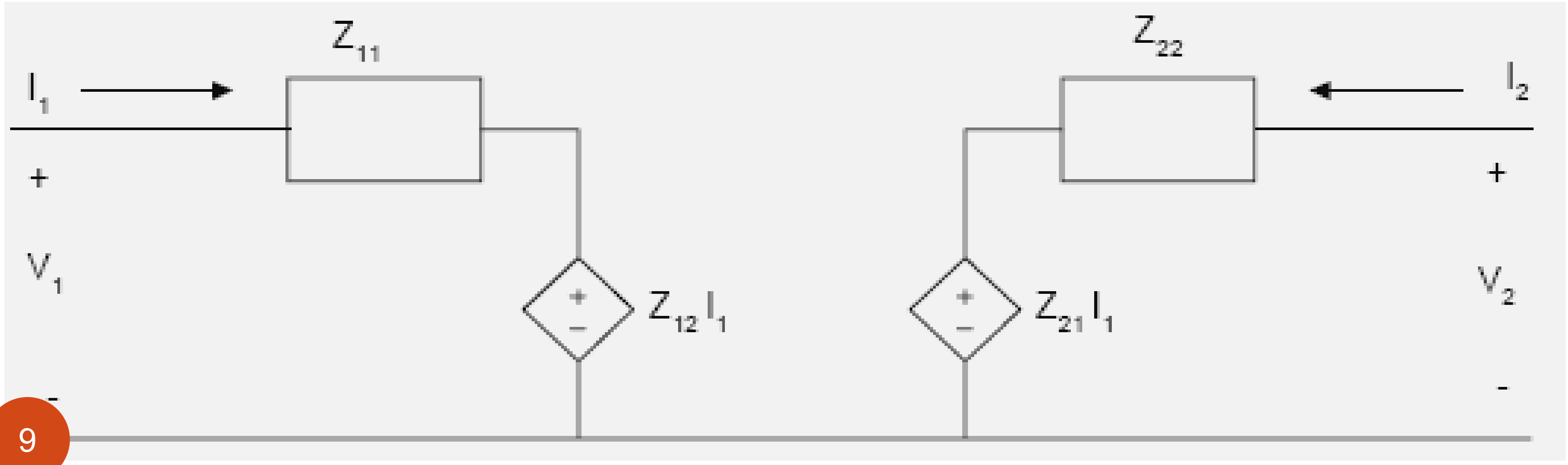
- Useful in designing impedance matching and power distribution system.
- Two port network can either be voltage or current driven.
- The input and output terminal voltage can be presented as follows:

$$(V_1, V_2) = f(I_1, I_2)$$

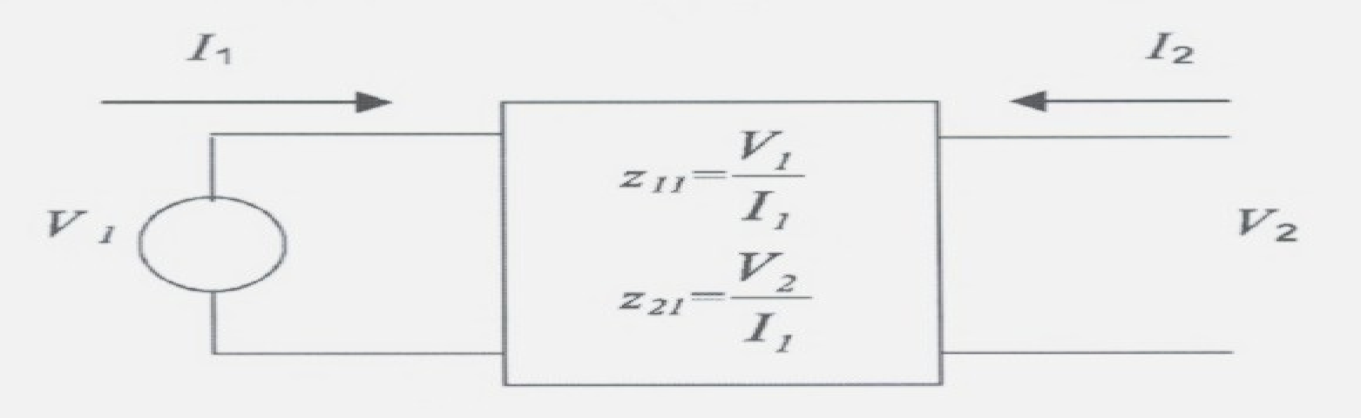
$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$[V] = [Z][I]$$

- where impedance parameters of the system is z = $\begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix}$
- $V_1 = z_{11}I_1 + z_{12}I_2$
- $V_2 = z_{21}I_1 + z_{22}I_2$



- Case –I Assuming the output of the two port to be open circuit, $I_2 = 0$



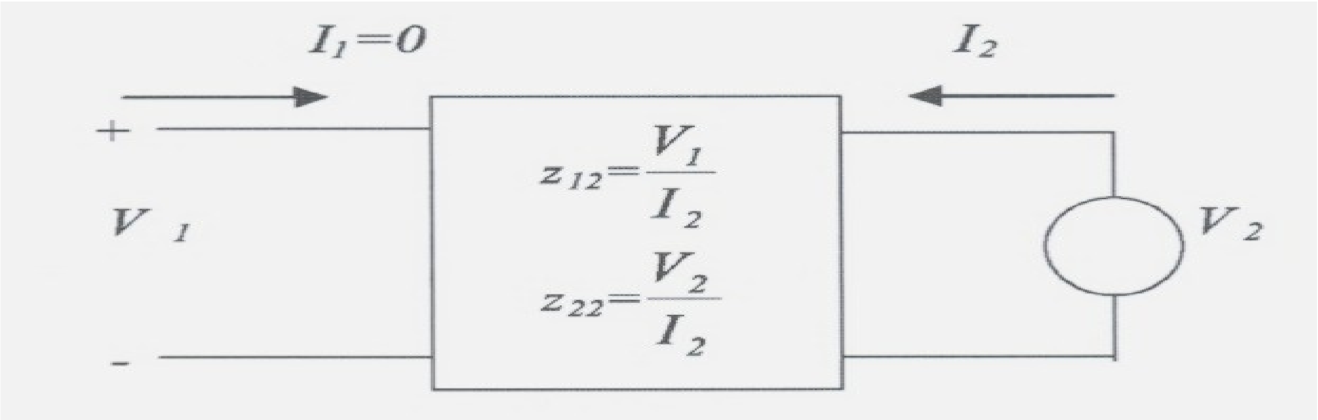
$$z_{11} = \frac{V_1}{I_1} \Big|_{I_2=0}$$

Input driving point impedance with the output port open circuit

$$z_{21} = \frac{V_2}{I_1} \Big|_{I_2=0}$$

Forword transfer impedance with the output port open circuit

- Case –II Assuming the input of the same two port to be open circuit, $I_1 = 0$



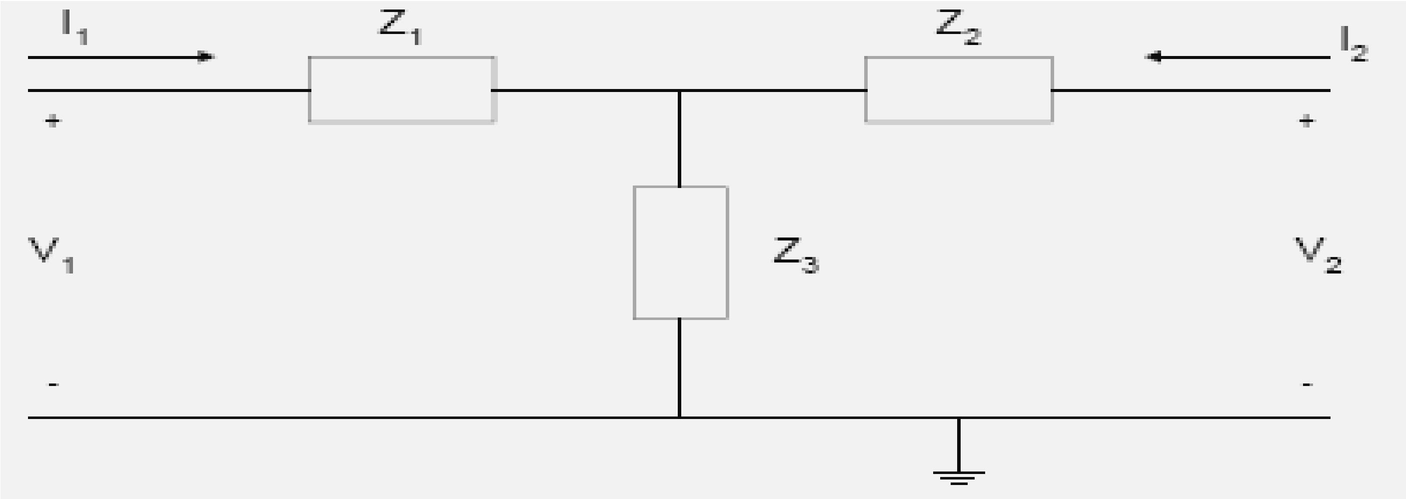
$$z_{12} = \frac{V_1}{I_2} \Big|_{I_1 = 0}$$

Reverse Transfer impedance with the input port open circuit

$$z_{22} = \frac{V_2}{I_2} \Big|_{I_1 = 0}$$

output driving point impedance with the input port open circuit

For the T-network shown in Figure, find the z-parameters.



- Using KVL

$$V_1 = Z_1 I_1 + Z_3 (I_1 + I_2) = (Z_1 + Z_3) I_1 + Z_3 I_2$$

$$V_2 = Z_2 I_2 + Z_3 (I_1 + I_2) = (Z_3) I_1 + (Z_2 + Z_3) I_2$$

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_1 + Z_3 & Z_3 \\ Z_3 & Z_2 + Z_3 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

and the z-parameters are

$$[Z] = \begin{bmatrix} Z_1 + Z_3 & Z_3 \\ Z_3 & Z_2 + Z_3 \end{bmatrix}$$

Short Circuit Admittance (y) parameter

- Useful for describing the network when impedance parameters may not be existed.
- This is solved by finding the second set of parameters by expressing the terminal current in term of the voltage.
- The input and output terminal current can be presented as follows:

$$(I_1, I_2) = f(V_1, V_2)$$

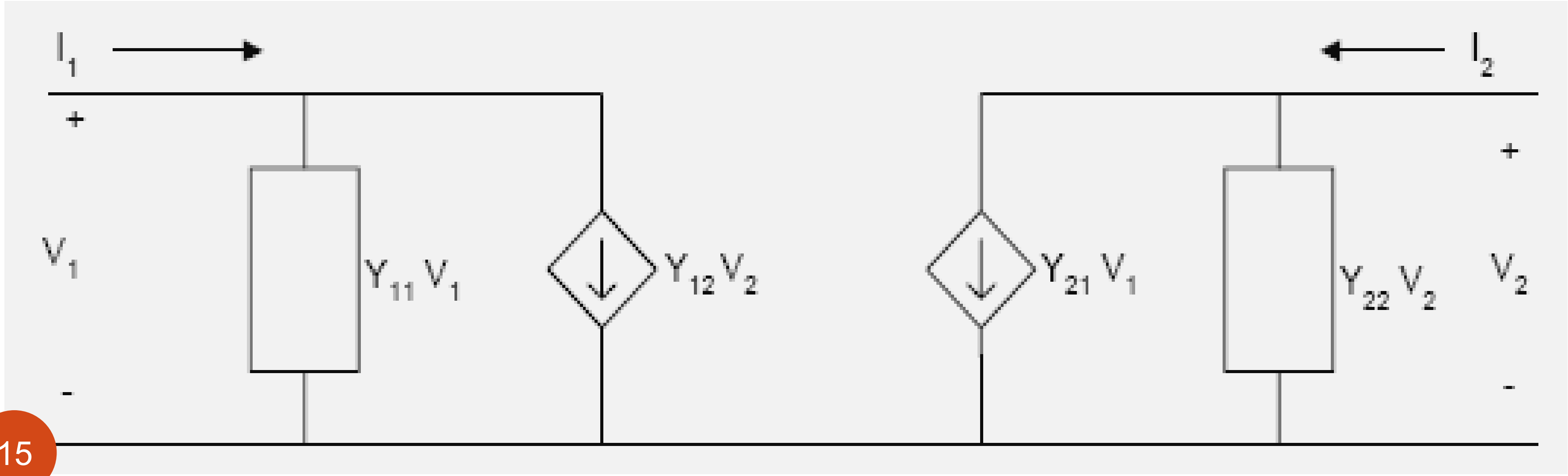
$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

$$[I] = [Y][V]$$

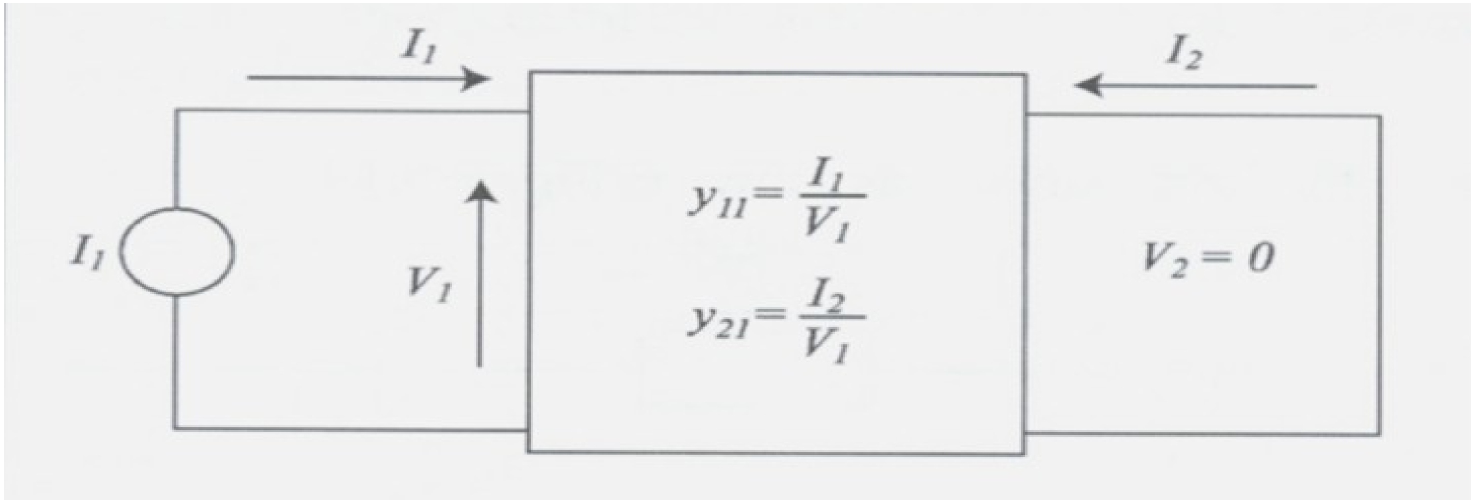
where admittance parameters of the system is y = $\begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix}$

$$I_1 = y_{11}V_1 + y_{12}V_2$$

$$I_2 = y_{21}V_1 + y_{22}V_2$$



- Case –I Assuming the output of the two port to be short circuit, $V_2 = 0$



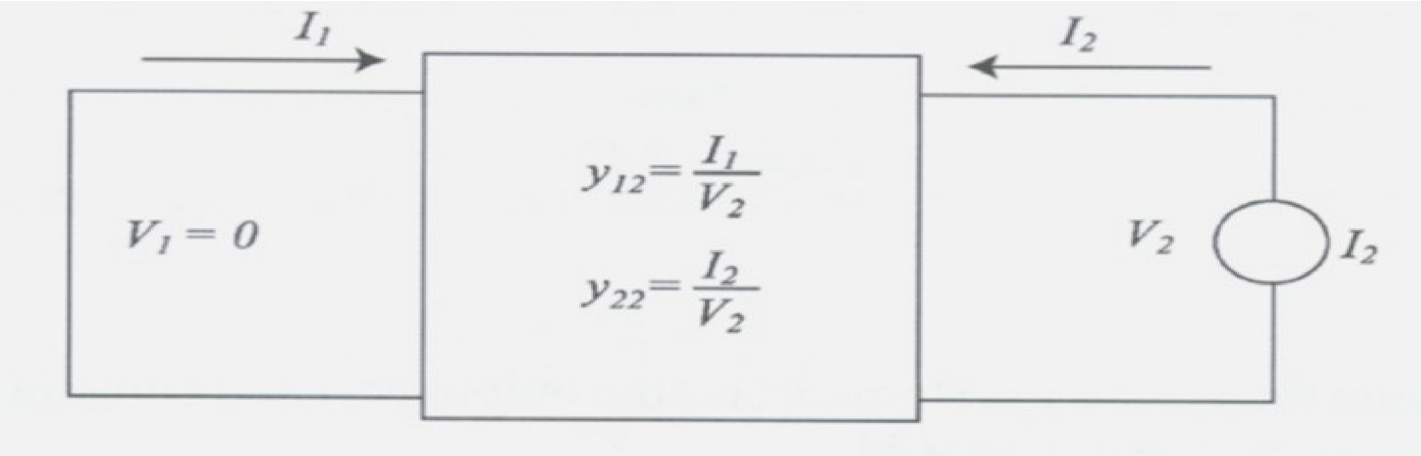
$$y_{11} = \frac{I_1}{V_1}\Big|_{V_2=0}$$

Input driving point admittance when port 2 is shorted.

$$y_{21} = \frac{I_2}{V_1}\Big|_{V_2=0}$$

Forward transfer admittance when port 2 is shorted.

- Case –I Assuming the input of the same two port to be short circuit, $V_1 = 0$



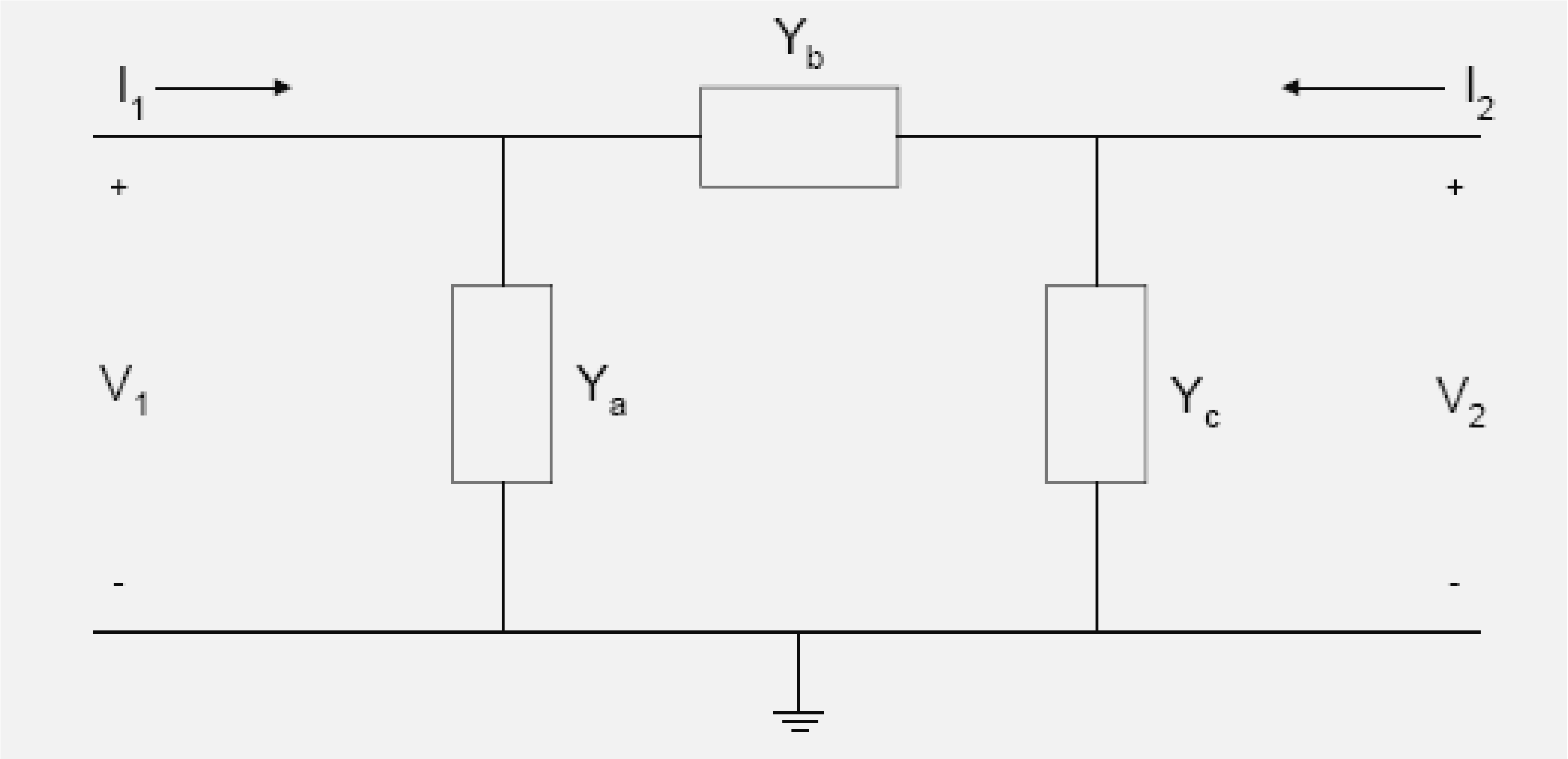
$$y_{12}=\frac{I_1}{V_2}\Bigg|_{V_1=0}$$

Reverse transfer admittance when port 1 is shorted.

$$y_{22}=\frac{I_2}{V_2}\Bigg|_{V_1=0}$$

output driving point admittance when port 1 is shorted.

Find the y-parameters of the pi (π) network shown in Figure



Using KCL, we have

$$I_1 = V_1 Y_a + (V_1 - V_2) Y_b = V_1 (Y_a + Y_b) - V_2 Y_b$$

$$I_2 = V_2 Y_c + (V_2 - V_1) Y_b = -V_1 Y_b + V_2 (Y_b + Y_c)$$

$$[Y] = \begin{bmatrix} Y_a + Y_b & -Y_b \\ -Y_b & Y_b + Y_c \end{bmatrix}$$

Transmission (T)or Chain or ABCD Parameter

- Used in Analysis of power transmission line.
- The input and output terminal current and voltage can be presented as follow:

$$(V_1, I_1) = f(V_2, -I_2)$$

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

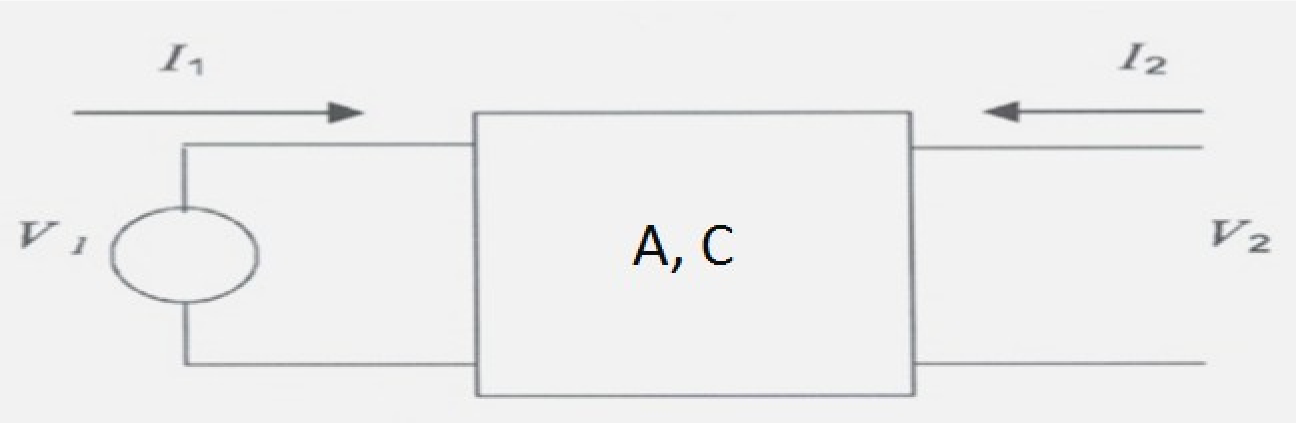
- where Transmission parameters of the system is T= $\begin{bmatrix} A & B \\ C & D \end{bmatrix}$

$$V_1 = AV_2 - BI_2$$

$$I_1 = CV_2 - DI_2$$

- Equivalent circuit for this parameter is not possible.

- Case –I Assuming the output of the two port to be open circuit, $I_2 = 0$



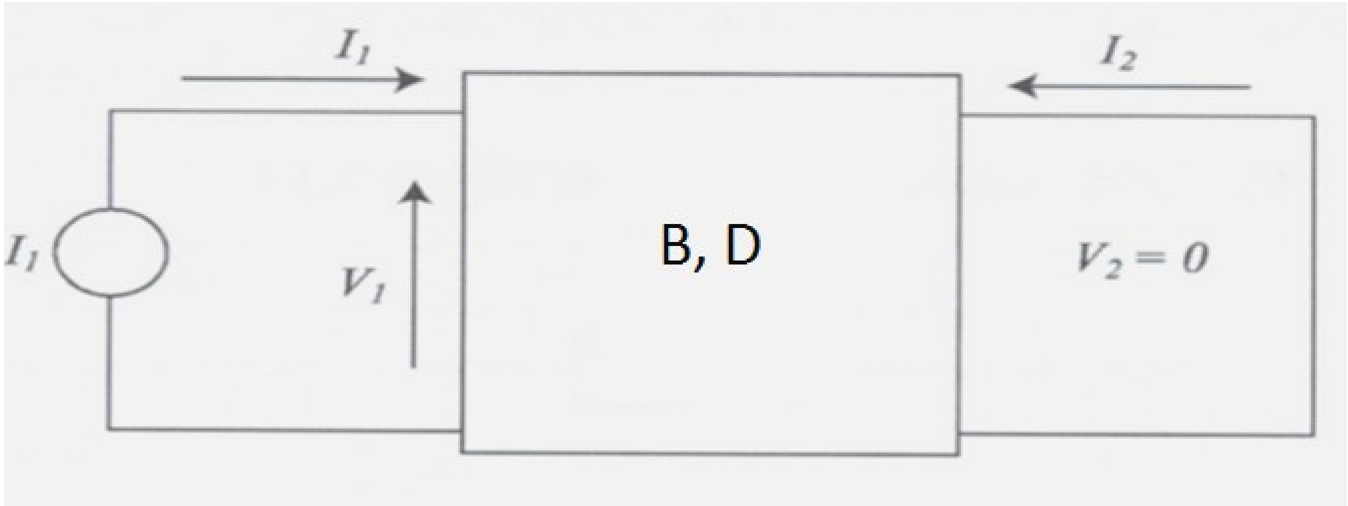
$$A = \frac{V_1}{V_2}\Bigg|_{I_2 = 0}$$

Open circuit Voltage ratio

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

Open circuit transfer admittance

- Case –II Assuming the output of the two port to be short circuit, V_2 =0



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

Negative short circuit transfer impedanc

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

Negative short circuit current ratio