5.2 ABCD parameter

Module:5 Microwave Passive components

Course: BECE305L – Antenna and Microwave Engineering

-Dr Richards Joe Stanislaus

Assistant Professor - SENSE

Email: richards.stanislaus@vit.ac.in

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

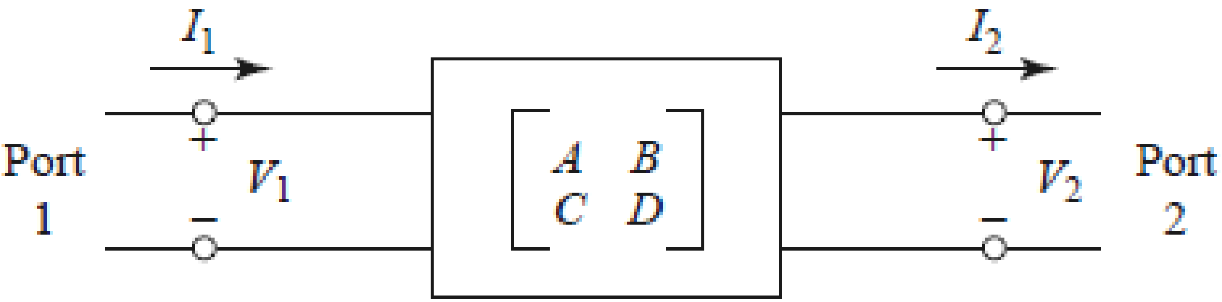
CHENNAI

Module:5 Microwave Passive components 6 hours

- Microwave Networks - ABCD, ‘S’ parameter and its properties. E-Plane Tee, H-Plane Tee, Magic Tee and Multi-hole directional coupler. Principle of Faraday rotation, isolator, circulator and phase shifter.

- Source of the contents: Pozar

1. ABCD Parameters



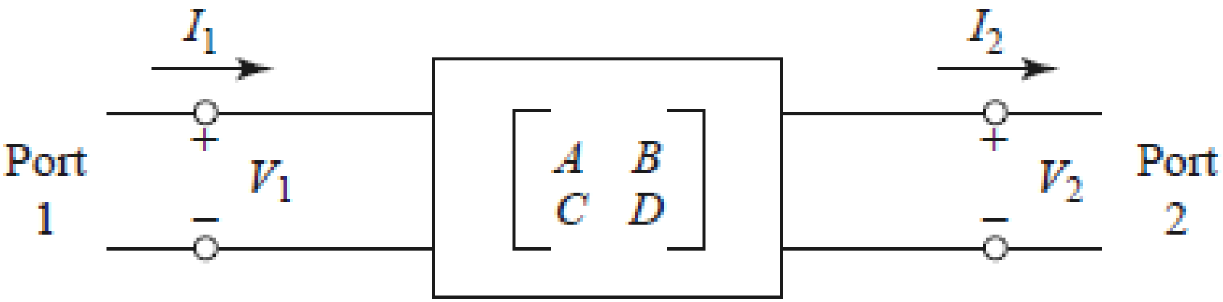
- The Z, Y , and S parameter representations can be used to characterize a microwave network with an arbitrary number of ports, but in practice many microwave networks consist of a cascade connection of two or more two-port networks
- define a 2 × 2 *transmission*, or *ABCD*, *matrix*, for each two-port network
- multiply the *ABCD* matrices of the individual two-ports
- *ABCD* matrix is defined for a two-port network in terms of the total voltages and currents (Note: I_2 is current flowing outward, and for inward current, $-I_2$)

$$V_1 = AV_2 + BI_2,$$

$$I_1 = CV_2 + DI_2,$$

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

1. ABCD Parameters



$$V_1 = AV_2 + BI_2,$$

$$I_1 = CV_2 + DI_2,$$

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

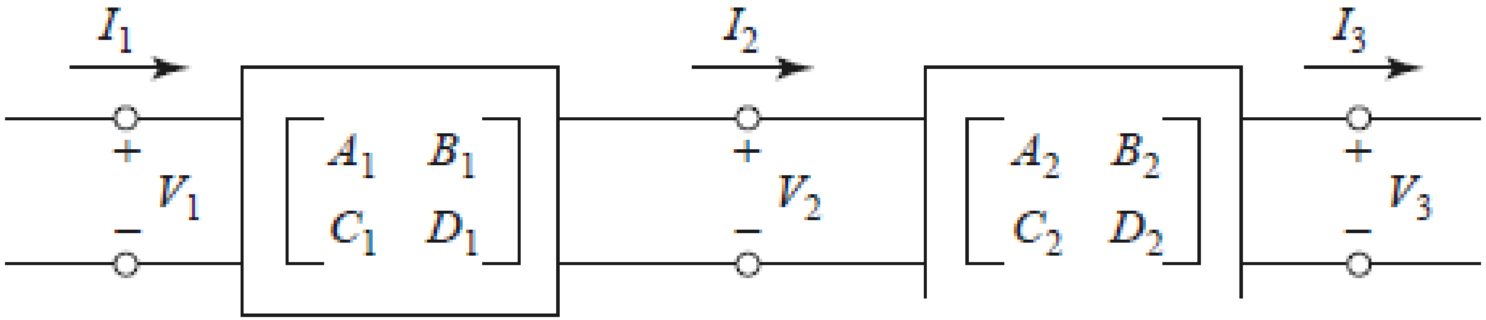
$$A = \left.\frac{V_1}{V_2}\right|_{I_2=0},$$

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

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

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

1. ABCD Parame



- the left-hand side represents the voltage and current at port 1 of the network, while the column on the right-hand side represents the voltage and current at port 2

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

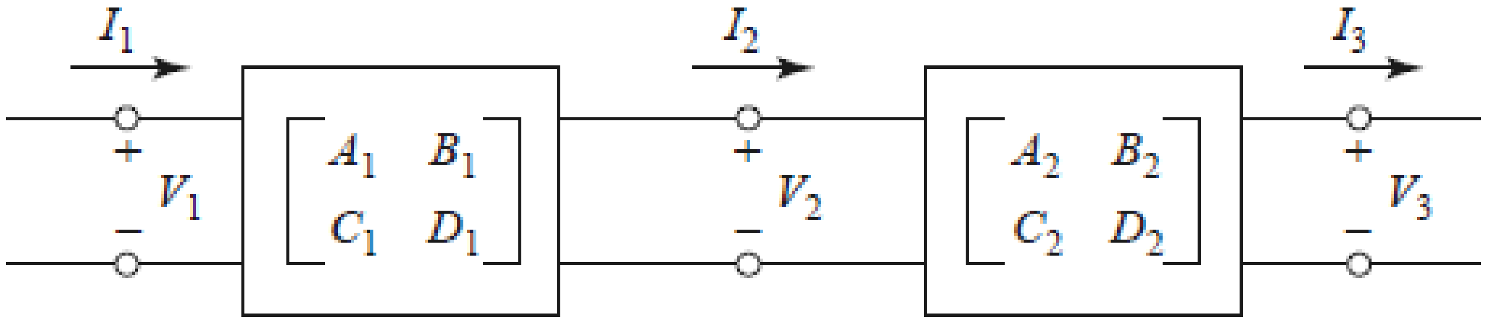
- the cascade connection of two two-port networks

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix}, \qquad \begin{bmatrix} V_2 \\ I_2 \end{bmatrix} = \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} V_3 \\ I_3 \end{bmatrix}.$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & C_1 \end{bmatrix} \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} V_3 \\ I_3 \end{bmatrix},$$

- *ABCD* matrix of the cascade connection of the two networks is equal
- to the product of the *ABCD* matrices representing the individual two-ports

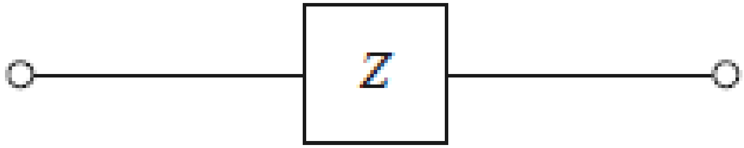
1. ABCD Parame



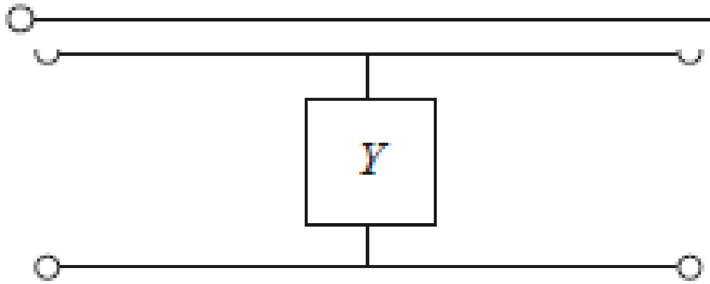
- order of multiplication of the matrix must be the same as the order in which the networks are arranged

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & C_1 \end{bmatrix} \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} V_3 \\ I_3 \end{bmatrix},$$

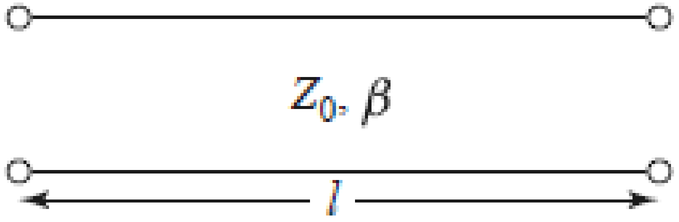
2. Circuits and its ABCD parameters



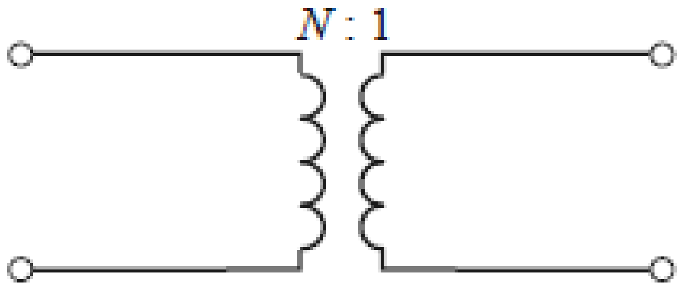
$$A = 1 \qquad B = Z$$
$$C = 0 \qquad D = 1$$



$$A = 1 \qquad B = 0$$
$$C = Y \qquad D = 1$$

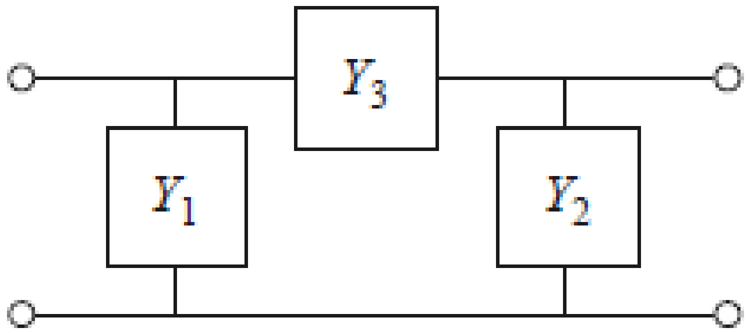


$$A = \cos \beta\ell \qquad B = jZ_0 \sin \beta\ell$$
$$C = jY_0 \sin \beta\ell \qquad D = \cos \beta\ell$$



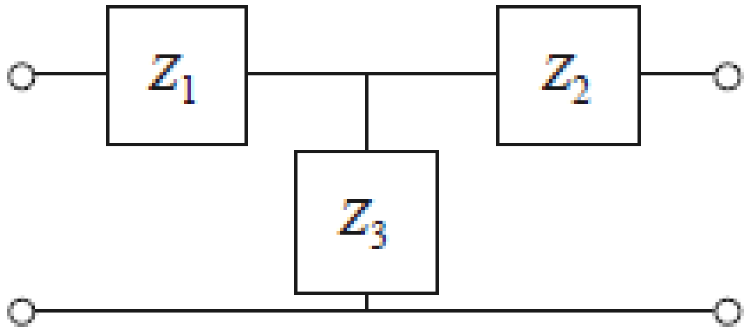
$$A = N \qquad B = 0$$
$$C = 0 \qquad D = \frac{1}{N}$$

2. Circuits and its ABCD parameters



$$A = 1 + \frac{Y_2}{Y_3} \qquad B = \frac{1}{Y_3}$$

$$C = Y_1 + Y_2 + \frac{Y_1 Y_2}{Y_3} \qquad D = 1 + \frac{Y_1}{Y_3}$$



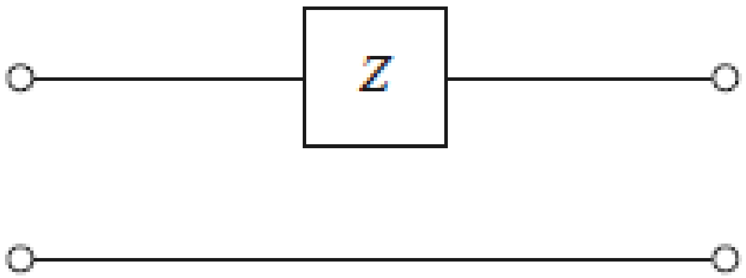
$$A = 1 + \frac{Z_1}{Z_3} \qquad B = Z_1 + Z_2 + \frac{Z_1 Z_2}{Z_3}$$

$$C = \frac{1}{Z_3} \qquad D = 1 + \frac{Z_2}{Z_3}$$

3. Evaluation of ABCD Parameters

- Find the *ABCD* parameters of a two-port network consisting of a series impedance *Z* between ports 1 and 2
- *A* is found by applying a voltage *V*1 at port 1, and measuring
- the open-circuit voltage *V*2 at port 2. Thus, *A* = 1.

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



$$A = 1 \qquad B = Z$$

$$C = 0 \qquad D = 1$$

$$B = \left.\frac{V_1}{I_2}\right|_{V_2=0} = \frac{V_1}{V_1/Z} = Z,$$

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

$$D = \left.\frac{I_1}{I_2}\right|_{V_2=0} = \frac{I_1}{I_1} = 1.$$

4. Relation between S parameters and ABCD parameters

$$S_{11} = \frac{A + B/Z_0 - CZ_0 - D}{A + B/Z_0 + CZ_0 + D}$$

$$S_{12} = \frac{2(AD - BC)}{A + B/Z_0 + CZ_0 + D}$$

$$S_{21} = \frac{2}{A + B/Z_0 + CZ_0 + D}$$

$$S_{22} = \frac{-A + B/Z_0 - CZ_0 + D}{A + B/Z_0 + CZ_0 + D}$$

$$A = \frac{(1 + S_{11})(1 - S_{22}) + S_{12}S_{21}}{2S_{21}}$$

$$B = Z_0 \frac{(1 + S_{11})(1 + S_{22}) - S_{12}S_{21}}{2S_{21}}$$

$$C = \frac{1}{Z_0} \frac{(1 - S_{11})(1 - S_{22}) - S_{12}S_{21}}{2S_{21}}$$

$$D = \frac{(1 - S_{11})(1 + S_{22}) + S_{12}S_{21}}{2S_{21}}$$