



SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
An Autonomous Institution



Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A+' Grade
Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

OPTICAL AND MICROWAVE ENGINEERING

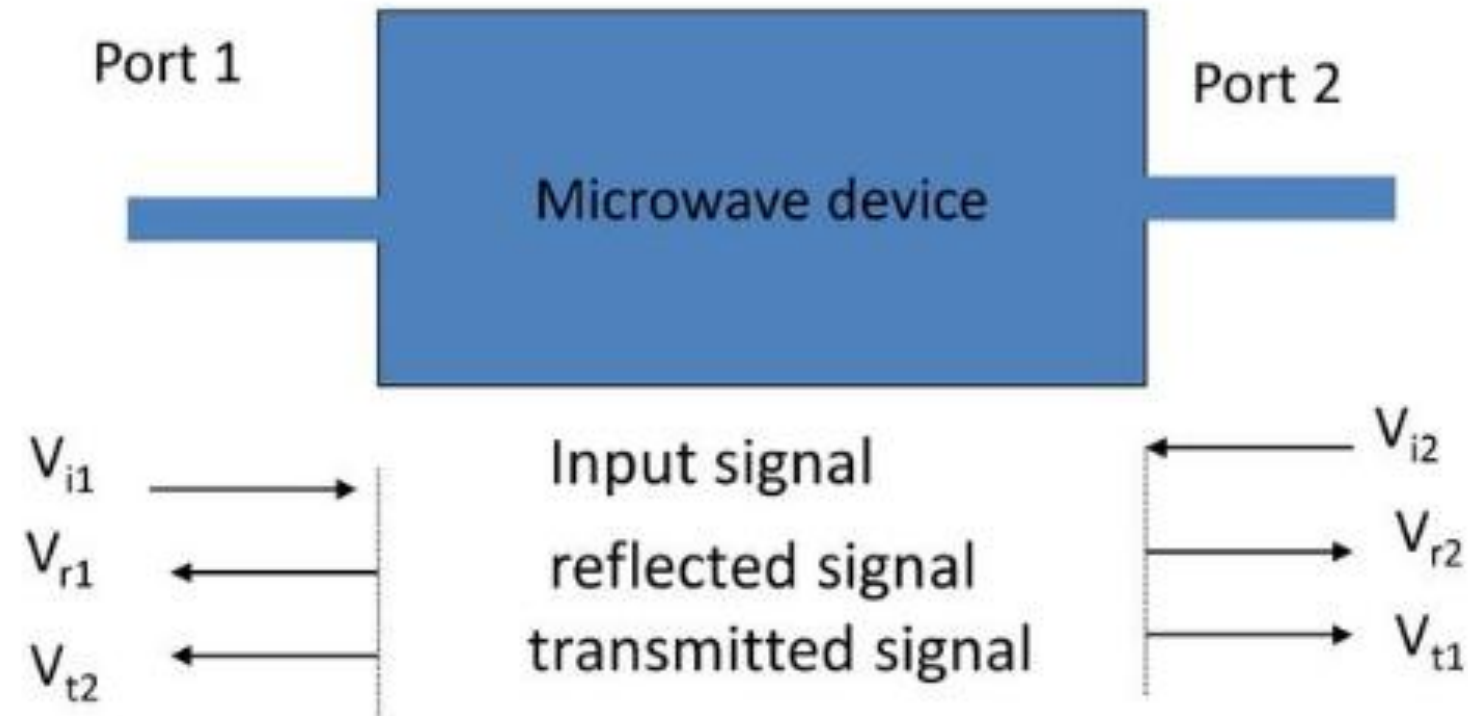
III YEAR/ VI SEMESTER

UNIT 1 – MICROWAVE PASSIVE DEVICES

S PARAMETERS



S PARAMETERS



Transmission and reflection coefficients

$$\tau = \frac{V_t}{V_i}$$

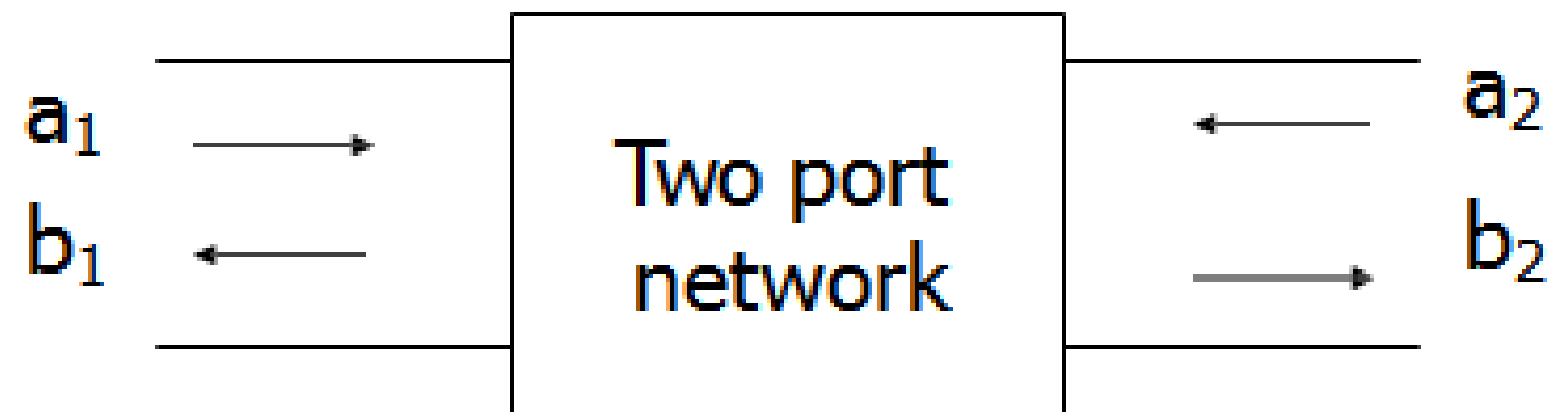
$$\rho = \frac{V_r}{V_i}$$



S PARAMETERS

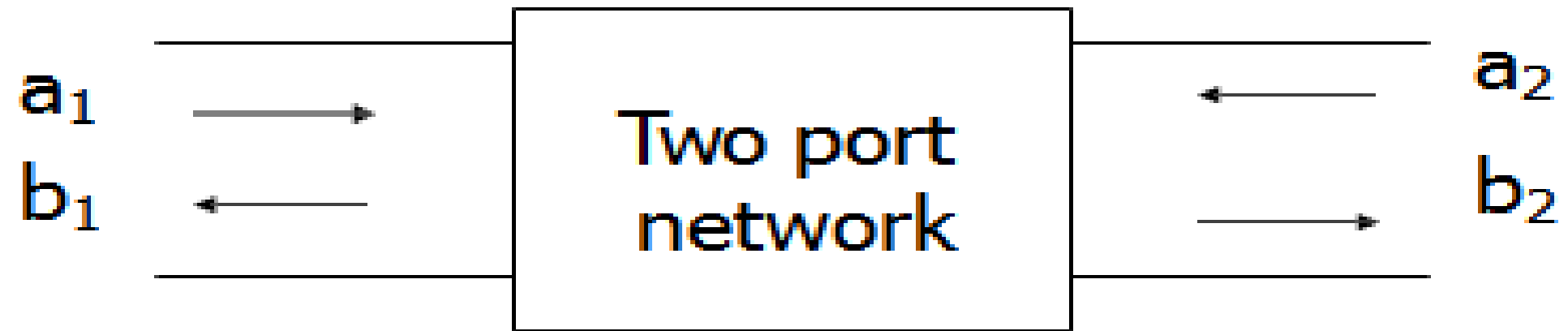


- Incident and reflected waves are being monitored instead.
- Resistive termination is employed.
- Active devices are normally quite stable under resistive termination.





Scattering Parameters



$$a_1 = \frac{v_{i,1}}{\sqrt{Z_o}}$$

$$a_2 = \frac{v_{i,2}}{\sqrt{Z_o}}$$

$$b_1 = \frac{v_{r,1}}{\sqrt{Z_o}}$$

$$b_2 = \frac{v_{r,2}}{\sqrt{Z_o}}$$



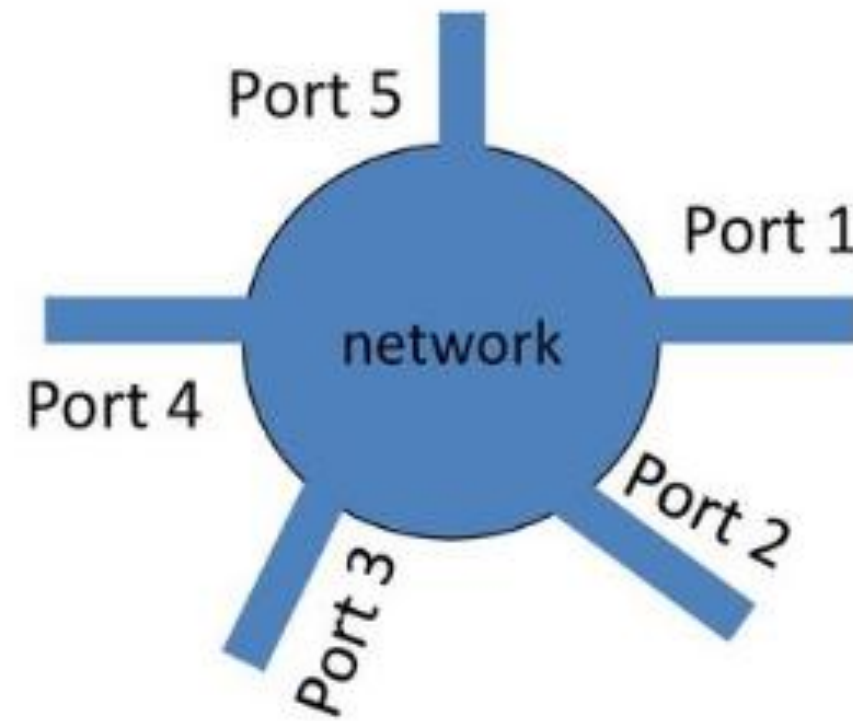
Scattering parameters



$$\begin{aligned} b_1 &= S_{11}a_1 + S_{12}a_2 \\ b_2 &= S_{21}a_1 + S_{22}a_2 \end{aligned} \quad \longrightarrow \quad \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$



Multiport Network



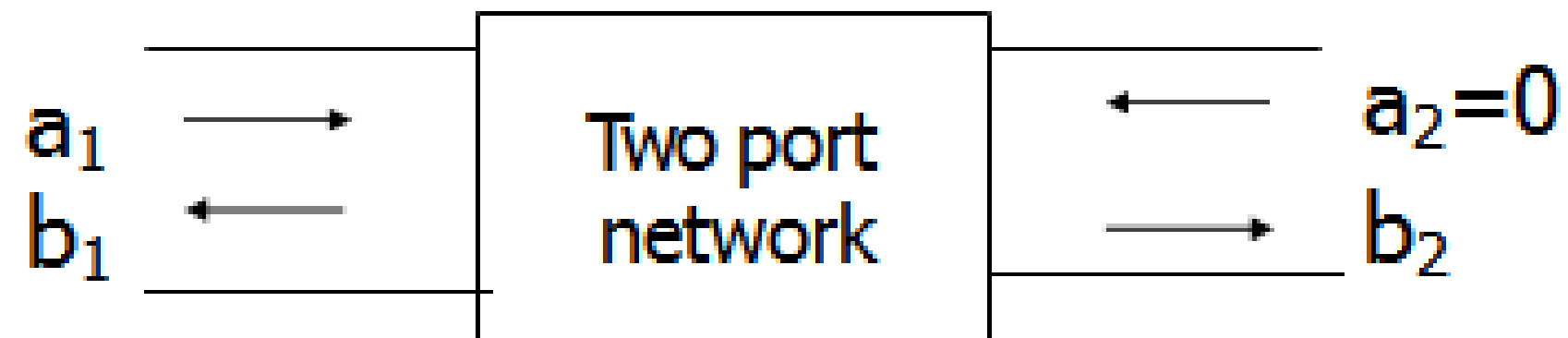
$$\begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \\ b_5 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} & S_{15} \\ S_{21} & S_{22} & S_{23} & S_{24} & S_{25} \\ S_{31} & S_{32} & S_{33} & S_{34} & S_{35} \\ S_{41} & S_{42} & S_{43} & S_{44} & S_{45} \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \\ a_5 \end{bmatrix}$$



Scattering parameters



$$S_{11} = \left. \frac{b_1}{a_1} \right|_{a_2=0} = \text{reflection coefficient at port 1 with } a_2=0$$

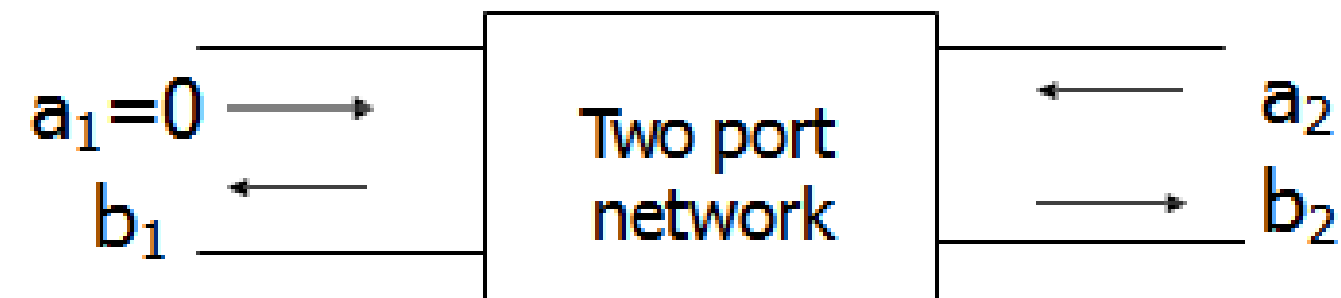


$$S_{21} = \left. \frac{b_2}{a_1} \right|_{a_2=0} = \text{forward transmission coefficient from port 1 to 2 with } a_2=0$$



2-port network (new terms)

$$S_{12} = \left. \frac{b_1}{a_2} \right|_{a_1=0} = \text{reverse transmission coefficient from port 2 to 1 with } a_1=0$$



$$S_{22} = \left. \frac{b_2}{a_2} \right|_{a_1=0} = \text{reflection coefficient at port 2 with } a_1=0$$



Properties of S Matrix



Properties of S matrix

For m-port network, it is always square matrix with order $m \times m$

$$\begin{bmatrix} b_1 \\ b_2 \\ \cdot \\ \cdot \\ b_{m-1} \\ b_m \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} & \dots & \dots & S_{1(m-1)} & S_{1m} \\ S_{21} & S_{22} & \dots & \dots & S_{2(m-1)} & S_{2m} \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ S_{(m-1)1} & S_{(m-1)2} & \cdot & \cdot & S_{(m-1)(m-1)} & S_{(m-1)m} \\ S_{m1} & S_{m2} & \cdot & \cdot & S_{m(m-1)} & S_{mm} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ \cdot \\ \cdot \\ a_{m-1} \\ a_m \end{bmatrix}$$



Properties of S Matrix

Properties of S matrix

For lossless network, [S] matrix is unitary

$$[S][S]^* = I$$

$$\rightarrow \begin{bmatrix} S_{ii} & S_{ij} \\ S_{ji} & S_{jj} \end{bmatrix} \begin{bmatrix} S_{ii} & S_{ij} \\ S_{ji} & S_{jj} \end{bmatrix}^* = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Properties of S matrix

[S] is symmetric for all reciprocal networks

$$[S] = [S]^T$$

$$\rightarrow \begin{bmatrix} S_{ii} & S_{ij} \\ S_{ji} & S_{jj} \end{bmatrix} = \begin{bmatrix} S_{ii} & S_{ji} \\ S_{ij} & S_{jj} \end{bmatrix}$$

$$\rightarrow S_{ij} = S_{ji}$$



Properties of S Matrix



Properties of S matrix

Under this condition

$$\sum_{i=1}^N S_{ij} S_{ij}^* = 1 \quad \sum_{i=1}^N S_{ij} S_{ik}^* = 0$$



THANK YOU