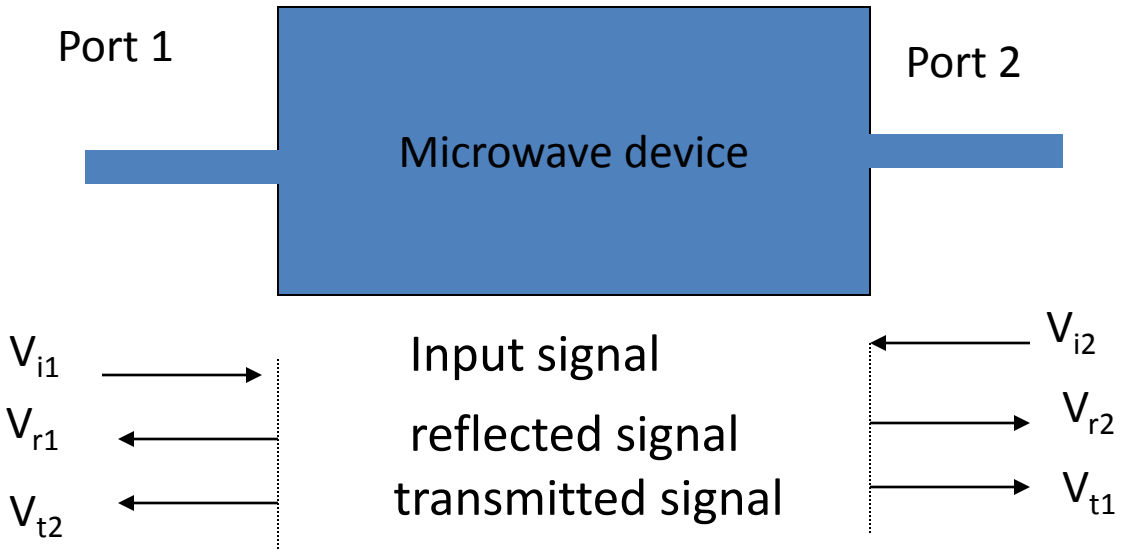
UNIT-2

Microwave Engineering

S-parameters



Transmission and reflection coefficients

$$\tau = \frac{V_t}{V_i} \qquad \rho = \frac{V_r}{V_i}$$

S-parameters

Voltage of traveling wave away from port 1 is

$$V_{b1} = \frac{V_{r1}}{V_{i1}} V_{i1} + \frac{V_{t2}}{V_{i2}} V_{i2}$$

Voltage of Reflected wave From port 1

Voltage of Transmitted wave From port 2

Voltage of transmitted wave away from port 2 is

$$V_{b2} = \frac{V_{t1}}{V_{i1}} V_{i1} + \frac{V_{r2}}{V_{i2}} V_{i2}$$

Let $V_{b1}= b_1$, $V_{i1}=a_1$, $V_{i2}=a_2$, $\rho_1 = \frac{V_{r1}}{V_{i1}}$, $\tau_{12} = \frac{V_{t2}}{V_{i2}}$, $\tau_{21} = \frac{V_{t1}}{V_{i1}}$

and $\rho_2 = \frac{V_{r2}}{V_{i2}}$

Then we can rewrite

S-parameters

Hence

$$b_1 = \rho_1 a_1 + \tau_{12} a_2$$

$$b_2 = \tau_{21} a_1 + \rho_2 a_2$$

In matrix form

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} \rho_1 & \tau_{12} \\ \tau_{21} & \rho_2 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

- S_{11} and S_{22} are a measure of reflected signal at port 1 and port 2 respectively
- S_{21} is a measure of gain or loss of a signal from port 1 to port 2.
- S12 ia a measure of gain or loss of a signal from port 2 to port 1.

S-matrix

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

Logarithmic form

$S_{11}=20 \log(\rho_1)$

$S_{22}=20 \log(\rho_2)$

$S_{12}=20 \log(\tau_{12})$

$S_{21}=20 \log(\tau_{21})$

S-parameters

$$S_{11} = \left.\frac{V_{r1}}{V_{i1}}\right|_{V_{r2}=0}$$

$$S_{12} = \left.\frac{V_{t2}}{V_{i2}}\right|_{V_{r2}=0}$$

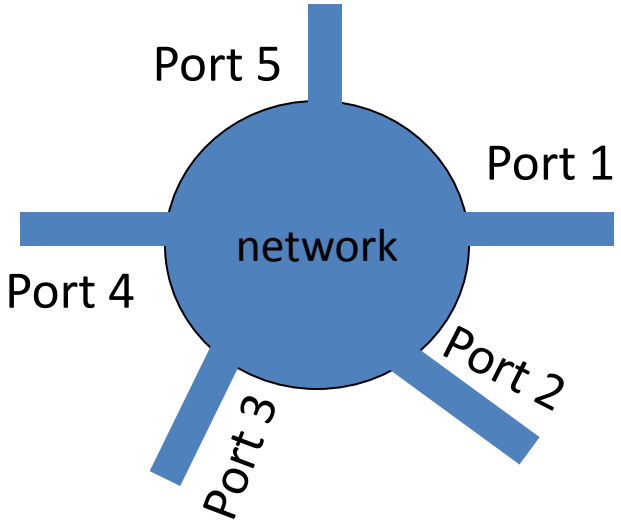
V_{r2}=0 means port 2 is matched

$$S_{21} = \left.\frac{V_{t1}}{V_{i1}}\right|_{V_{r1}=0}$$

$$S_{22} = \left.\frac{V_{r2}}{V_{i2}}\right|_{V_{r1}=0}$$

V_{r1}=0 means port 1 is matched

Multi-port network



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

Passive Microwave Devices

Phase and group velocity Phase velocity of a wave is the rate at which phase of wave propagates in space. This is the velocity at which phase of any one frequency component of the wave will propagate. In mathematical terms, be the angular frequency and is the phase constant. Then phase velocity p v is defined as vp=/. The group velocity of a wave is the velocity with which the overall shape of wave amplitude (known as the envelope of the wave) propagates through space. The group velocity is the velocity with which energy propagates and is defined by β ω ∂ ∂ vg = . The phase velocity is also given by the slope of a line from origin to a point on dispersion curve, while the group velocity is given by slope of a tangent to the dispersion curve.