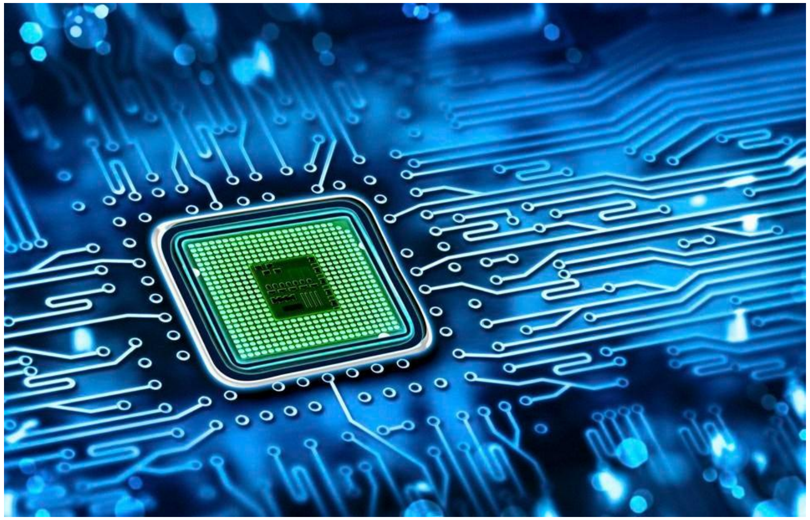
SNS COLLEGE OF ENGINEERING

(Autonomous)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

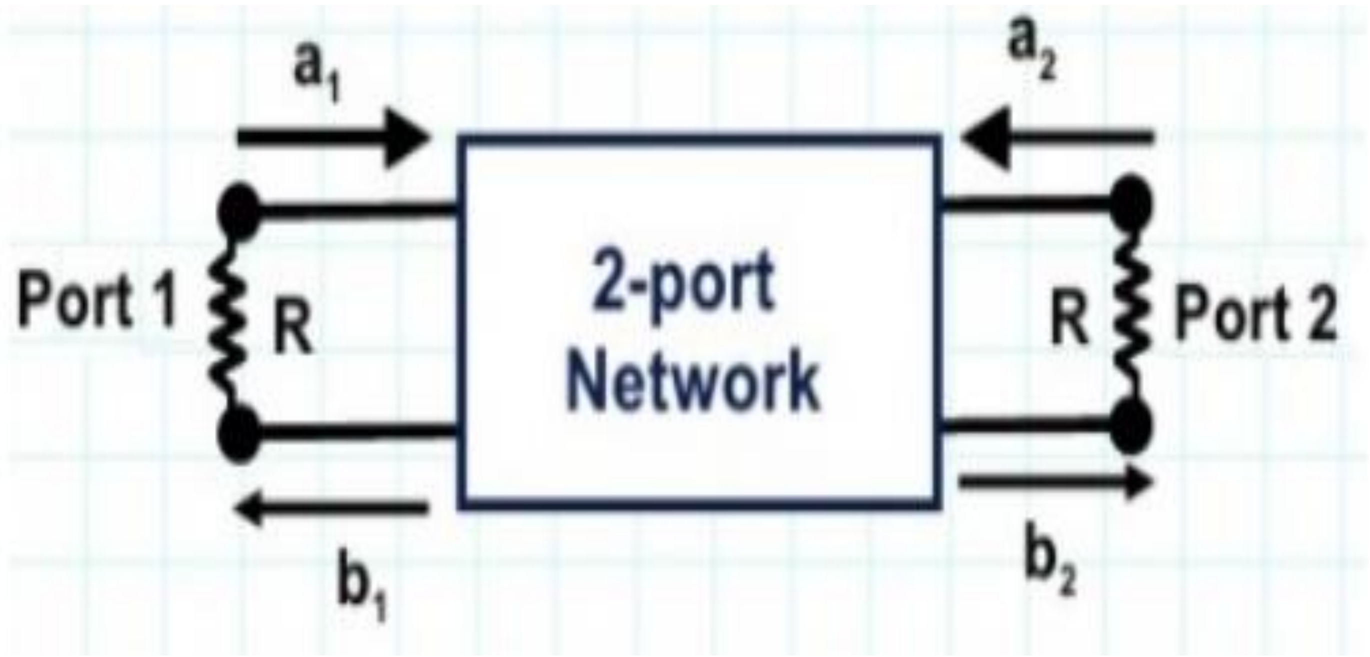
CONVERSION OF ABCD AND S-PARAMETER



CONVERSION OF ABCD AND S-PARAMETER

- S-matrix is composed of S-parameters or scattering parameters.
- It is known as scattering matrix.
- It describes electrical behaviour of linear electrical networks when subjected to steady state stimuli with the help of electrical signals.
- They do not use open circuit and short circuit conditions.
- They use matched loads to characterize linear electrical network due to ease at higher frequencies compare to short/open circuit terminations. Following figure depicts 2-port network with s-parameters. A set of linear equations are written to describe network in terms of injected and transmitted waves.

CONVERSION OF ABCD AND S-PARAMETER



CONVERSION OF ABCD AND S-PARAMETER

S-Parameters:

$$b_1 = S_{11}a_1 + s_{12}a_2$$
$$b_2 = S_{21}a_1 + S_{22}a_2$$

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

CONVERSION OF ABCD AND S-PARAMETER

➡ $S_{ij} = b_i/a_j = [(\text{Power measured at port-i})/(\text{Power injected at port-j})]^{0.5}$

Where,

Sii = ratio of reflected power to injected power at port-i

Sij = ratio of power measured at port-j to power injected at port-i

CONVERSION OF ABCD AND S-PARAMETER

- Electrical circuit or network is composed of inductors, capacitors or resistors in its basic form. Some of their parameters such as return loss, insertion loss, gain, VSWR, reflection coefficients are represented by S-parameters.
- S-parameters are similar to other parameters such as Z-parameters, Y-parameters, H-parameters, T-parameters, abcd-parameters etc.
- Following equations are used to derive various S-parameters such as S11, S12, S21 and S22.

CONVERSION OF ABCD AND S-PARAMETER

$$S_{11} = \frac{b_1}{a_1}\Big|_{a_2=0}$$ = Input reflection coefficient Γin for case of $Z_L = Z_0$

$$S_{21} = \frac{b_2}{a_1}\Big|_{a_2=0}$$ = Forward transmission (insertion) gain for case of $Z_L = Z_0$

$$S_{12} = \frac{b_1}{a_2}\Big|_{a_1=0}$$ = Reverse transmission (insertion) gain for case of $Z_s = Z_0$

$$S_{22} = \frac{b_2}{a_2}\Big|_{a_1=0}$$ = Output reflection coefficient Γout for case of $Z_s = Z_0$

CONVERSION OF ABCD AND S-PARAMETER

abcd matrix

- It describes network in terms of both voltage and current waves as shown below.
- It is also known as transmission matrix.
- It is suitable to cascade elements since it represents ports in terms of currents and voltages. The matrices are cascaded by multiplication operation.

$$V_1 = AV_2 + BI_2$$

$$I_1 = CV_2 + DI_2$$

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

CONVERSION OF ABCD AND S-PARAMETER

- Coefficients are defined using superposition as follows.
- ABCD parameters are expressed as follows.

$$A = \left.\frac{V_1}{V_2}\right|_{I_2=0} \quad B = \left.\frac{V_1}{I_2}\right|_{V_2=0} \quad C = \left.\frac{I_1}{V_2}\right|_{I_2=0} \quad D = \left.\frac{I_1}{I_2}\right|_{V_2=0}$$

S-parameters are measured using VNA. Later they are converted to ABCD matrix. ABCD matrix can also be converted to S-matrix.

CONVERSION OF ABCD AND S-PARAMETER

Convert abcd matrix to S-matrix

Following equations are used to **convert abcd matrix to S-matrix**.

$$S_{11} = \frac{A + B/Z_o - CZ_o - D}{A + B/Z_o + CZ_o + D}$$

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

$$S_{21} = \frac{2}{A + B/Z_o + CZ_o + D}$$

$$S_{11} = \frac{-A + B/Z_o - CZ_o + D}{A + B/Z_o + CZ_o + D}$$

CONVERSION OF ABCD AND S-PARAMETER

Convert S-matrix to ABCD matrix:

Following equations are used to **convert S-matrix to ABCD matrix**.

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

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

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

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


Thank you