Unit-1 → 2 port

8

1/8/23

→ high freq. ckt.

Introduction to RF communication

Low freq parameter: ABCD, H, Y, Z
→ ckt: electronic ckts.
High freq parameters: S parameter.
Formulation S matrix for 2 & 4 port network.
^ port network
4 properties for S matrix
components @ high freq: lumped components & types
3 port device : E, H plane T.
4 port " : Magic T,
Microwave transistors - operates @ high freq
diodes - Shotkey barrier diode, Gunn diode, Impa diode.
FET, MMIC (6 steps for fab)
1- basic 2,3 - (components + device) 4 - measurements / MW Tubes.
5-
Tubes - for connecting components + devices.

5
- T, π matching network
- Microstrip line matching network
- Amplifier design.

Spectrum: band of freqs
band: Range of freqs

$\lambda = c/f \Rightarrow \boxed{\lambda f = c}$

$freq \propto \frac{1}{size\ of\ device}$.

Unit-1 → 2 port network theory.

divider s / combiner → Unit-2

2, 3, 4 way.

↳ 1 i/p will be divided into 2 parts.

MW filters → high freq. filters

low freq. power amplifiers: Class A, B, AB, C.

Jammer → Blocks mobile signal → EM waves.

Signal enhancer / Repeater → in high freq.

↳ amplifies weak signal

GPS → location identification

GSM → 2G communication -

RF Transceivers → Receiver + Transmitters

RFID — Tags, Readers.

GPR → Gnd Penetrating Radar

↳ TO find obstacles

send waves via water & the reflected wave is received & analyzed.

Radar for automobile.

MW — equipments — Network, spectrum analyser
MW generator.

MW Imaging

MW — for (cancer treatment) (Hypothermia)

Ultra high freq → 300MHz to 300GHz.

4 to 8 GHz → C band for satellite comm.

19/8/23

3) Unitary proper. for any lossless network.

Problem. (*) → conjugate

$S_1 S_{11}^* = |S_{11}|^2$

↳ Complex no.

(*) Lossless, reciprocal network

4) Phase shift property:

$S = \frac{V^-}{V^+}$ → for each incident & reflected wave voltage there is a phase shift.

16 (8m) Components @ high frequency → loss component.

Low freq — High freq.

lumped components — distributed component.

2m) Skin effect.

Skin depth → delta param.

FAQ) Draw equivalent ckt of inductor / capacitor @ HF. (2m)

FAQ) Sparam properties.

22/8/23 The Sparameter of a 2 port network is given 2x2.

$$S = \begin{bmatrix} 0.2+j0.4 & 0.8-j0.4 \\ 0.8-j0.4 & 0.2+j0.4 \end{bmatrix}$$

Find whether the given network is reciprocal & lossless.

Ans:

(2m) Reciprocal Network $S = S^T$

$$\underbrace{\begin{bmatrix} 0.2+j0.4 & 0.8-j0.4 \\ 0.8-j0.4 & 0.2+j0.4 \end{bmatrix}}_{S} = \underbrace{\begin{bmatrix} 0.2+j0.4 & 0.8-j0.4 \\ 0.8-j0.4 & 0.2+j0.4 \end{bmatrix}}_{S^T}$$

Hence it is a reciprocal network

Lossless network / lossy : 2m

$\sum_k S_{ki} S_{kj}^* = 1$ for $(i = j)$

(or) $[S]^T [S]^* = [U]$ → unitary / identity matrix.

$$\begin{bmatrix} 0.2 + j0.4 & 0.8 - j0.4 \\ 0.8 - j0.4 & 0.2 + j0.4 \end{bmatrix} \begin{bmatrix} 0.2 - j0.4 & 0.8 + j0.4 \\ 0.8 + j0.4 & 0.2 - j0.4 \end{bmatrix}$$

$$= \begin{bmatrix} (0.2)^2 - j^2(0.4)^2 + (0.8)^2 - j^2(0.4)^2 & 0.16 + j^2(0.4)^2 + 0.16 + j^2(0.4)^2 \\ 0.16 + j^2(0.4)^2 + 0.16 + j^2(0.4)^2 & 0.64 - j^2(0.4)^2 + 0.04 - j^2(0.4)^2 \end{bmatrix}$$

(0.04, 0.16, 0.64, 0.16)

$= 0.68 + 2(0.16)$

$$= \begin{bmatrix} 0.68 + 0.32 & 0.32 - 2(0.16) \\ 0.32 - 0.32 & 0.68 + 2(0.16) \end{bmatrix}$$

$$= \begin{bmatrix} 1.00 & 0 \\ 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

Hence lossless network

$\sum_{k} S_{ki} S_{kj}^* = 1$ (for $i = j$) — k → row, i → 1st element, j → col

$S_{11} S_{11}^* + S_{12} S_{12}^* = |S_{11}|^2 + |S_{12}|^2 = 1$

$(0.2 + j0.4)(0.2 - j0.4) + (0.8 - j0.4)(0.8 + j0.4)$

$= (0.04 + 0.16) + (0.64 + 0.16)$

Q) $S = \begin{bmatrix} 0.2\angle 0^\circ & 0.6\angle 90^\circ \\ 0.6\angle 90^\circ & 0.1\angle 0^\circ \end{bmatrix}$

Reciprocal network:

$\therefore S = S^T$

Lossy / lossless network:

$$\sum_k S_{ki} S_{kj}^* = 1 \quad (\text{for } i = j)$$

$$S_{11} S_{11}^* + S_{12} S_{12}^* = 1$$

$$|S_{11}|^2 + |S_{12}|^2 = 1$$

$$(0.2)^2 + (0.6)^2 = 1$$

$$0.04 + 0.36 = 1$$

$$0.40 \neq 1 \longrightarrow \text{Hence lossy network}$$

Problems:

1. Losses
2. S param properties.

23/8/23

Unit-2

Microwave passive components.

* E plane Tee, H plane Tee, Magic Tee
  - 3 ports (E plane Tee, H plane Tee)
  - 4 ports (Magic Tee) — combination

port = arm.

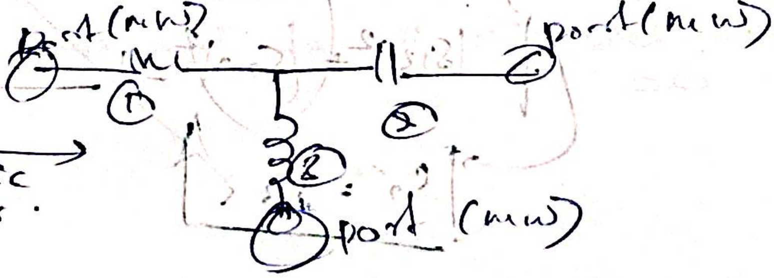
* Directional coupler – 4 ports.
* Circulator – circular form – 3/4 ports.
* isolator, phase shifter, attenuator → MW Active components.
  - phase shift – (-ve) sign.
  - attenuator → To avoid losses.
* Corners, bends, & twists.

MW Tee junction → meeting pt of intersection – ports/components/devices.

↓

junction of MW devices

Tee junction: → electronic ckts.



↓

MW Tee junction – 3 MW devices.

3 port Network (T-junction):

Reciprocal network: $S = S^T$

$S_{ij} = S_{ji}$

$$\begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{21} & S_{22} & S_{23} \\ S_{31} & S_{32} & S_{33} \end{bmatrix} \quad \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{22} & S_{23} \\ S_{13} & S_{23} & S_{33} \end{bmatrix}$$

Perfect matched condition: All diagonal elements = 0.

Lossless Network:

$$\sum_{k=1}^{N} S_{ki} S_{kj}^{*} = 1 \quad \text{for } i=j$$

$$\sum_{k=1}^{N} S_{ki} S_{kj}^{*} = 0 \quad \text{for } i \neq j$$

$S_{11} S_{11}^{*} = 1 \quad S_{12} S_{12}^{*} = 1$

$$\left.\begin{aligned} |S_{12}|^2 + |S_{13}|^2 &= 1 \\ |S_{12}|^2 + |S_{23}|^2 &= 1 \\ |S_{13}|^2 + |S_{23}|^2 &= 1 \end{aligned}\right\} \quad (3)$$

$$\left.\begin{aligned} |S_{12}|^2 + |S_{13}|^2 &= 1 \\ |S_{12}|^2 + |S_{23}|^2 &= 1 \end{aligned}\right\} \longrightarrow S_{13} = S_{23}$$

$$\left.\begin{aligned} |S_{12}|^2 + |S_{23}|^2 &= 1 \\ |S_{13}|^2 + |S_{23}|^2 &= 1 \end{aligned}\right\} \longrightarrow S_{13} = S_{12} = S_{23}$$

$S_{11} = S_{13}$

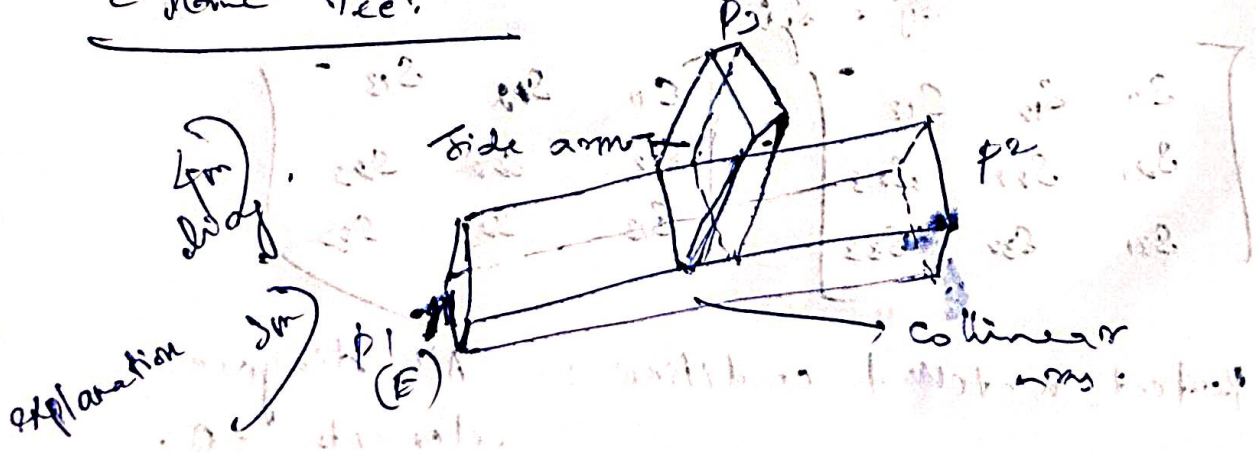
(6)

$S_{13}^{*} S_{13} = 0 \longrightarrow k = 3$

$S_{23}^{*} S_{12} = 0 \longrightarrow k = 2$

$S_{12}^{*} S_{13} = 0$

E plane Tee:

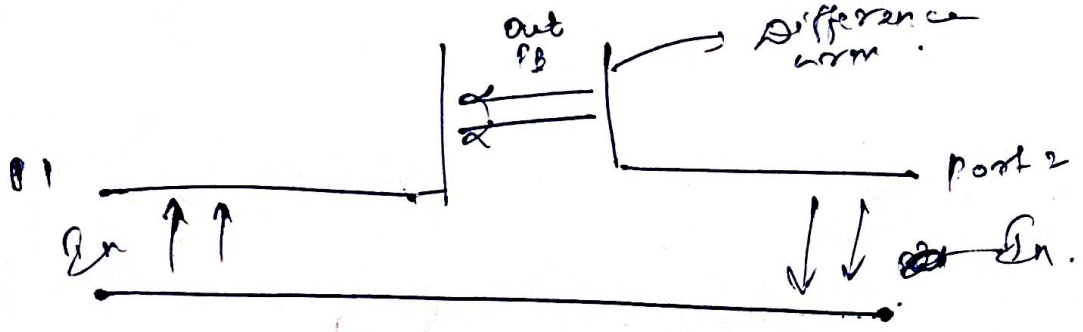


explanation

direction of E field.

E ⊥ to P1 & P2.

|| to P3 axis.



P1 + P2 → opposite phase @ port 3

i/p ports

o/p port

P3 = difference b/w P1 & P2.

if P3 — i/p → o/p: P2 & P1.

opposite phase same magnitude.

$S_{13} = -S_{23}$

* if port 3 matched → $S_{33} = 0$.
* if all ports matched → all diagonal elements = 0.
  → impossible