

# R.V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Date \_\_\_\_\_

Name Lakhman Singh - H

Dept./Lab ECE / MSCOR

Class VIII B

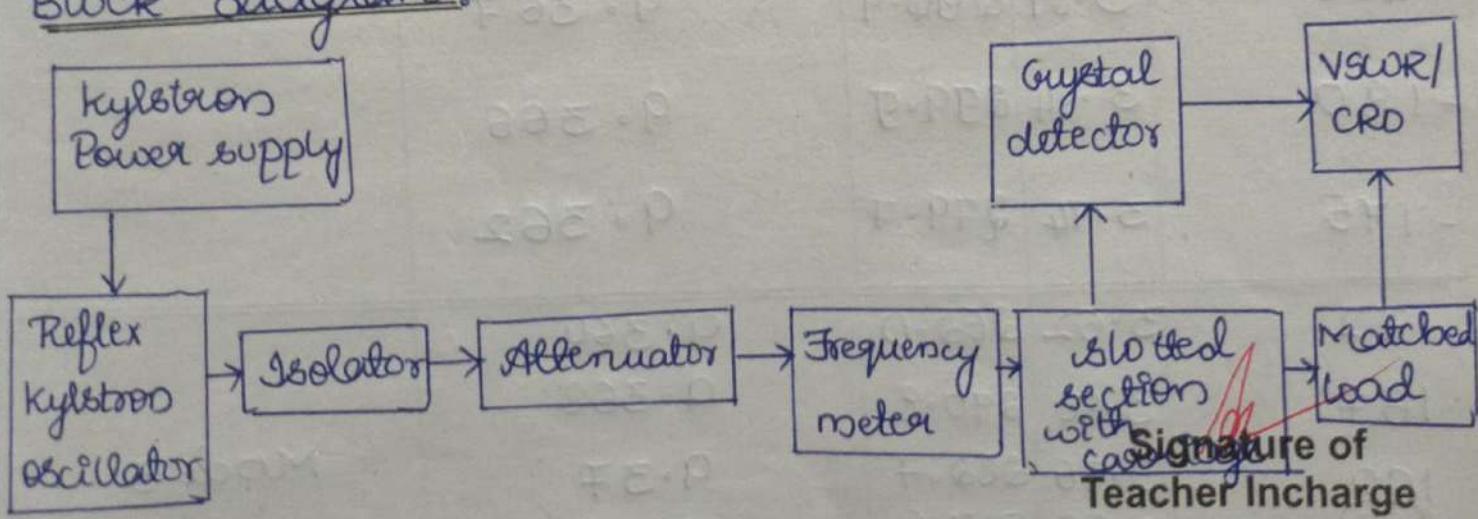
Expt./No. 1

Title Study of Mode curves of Reflex klystron source.

Aim: To conduct a suitable experiment on reflex klystrons to plot its mode curves and determine its transit time, electronic tuning range, sensitivity, Peak o/p power for different modes and frequency variation for any one mode.

Equipment Required: klystron power supply, isolator, frequency meter, variable attenuator x-band detector, wave guide to BNC adaptor and CRO/ VSWR meter.

Block diagram:



Tabular Columns:

Repeller v <sub>tg</sub>	V <sub>P-P</sub> (V)	Power (mw)	frequency (GHz)	R
-245	2.12	89.88	9.5233	
-240	2.28	103.96	9.5232.	
-235	2.32	107.64	9.53	Mode 1
-230	2.28	103.96	9.53	
-225	1.96	76.83	9.529	
-220	1.40	39.2	9.528	
-215	0.45	4.05	9.528	
-210	0.08	1.56	9.528	
-205	0.5	5	9.5285	
-200	0.9	16.2	9.5285	
-195	1.28	32.76	9.5282	
-190	1.48	43.80	9.5282	
-185	1.72	59.16	9.528	mode 2
-180	1.68	56.44	9.528	
-175	1.60	51.2	9.527	
-170	1.56	48.6	9.527	
-165	1.40	39.2	9.526	
-160	1.2	28.8	9.526	
-155	1.04	21.63	9.526	
-150	1.04	21.63	9.526	
-145	1.25	31.25	9.528	
-140	1.3	33.8	9.524	mode 3
-135	1.25	31.25	9.523	
-130	0.6	7.2.	9.523	

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## OBSERVATION / DATA SHEET

Date

Name Dakshay Singh H

Dept./Lab EE - MWRS

Class VII B

Expt./No. 1

Title Kyletron

$$V_1 = -185$$

$$f_1 = 9.528 \text{ GHz}$$

$$V_2 = -140$$

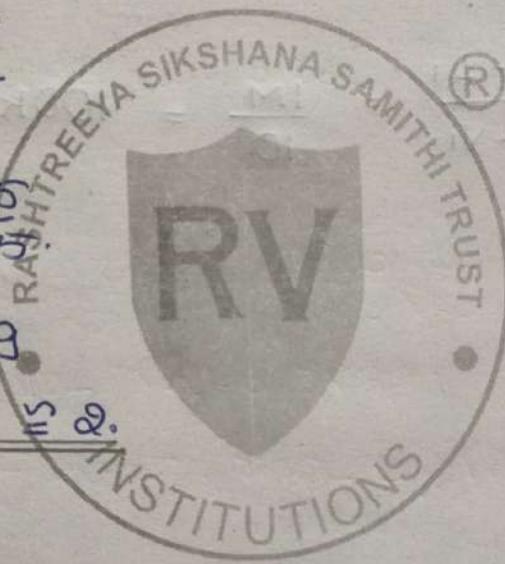
$$f_2 = 9.524 \text{ GHz}$$

$$\frac{V_1}{V_2} = \frac{D + 1.75}{D + 0.75}$$

$$\frac{185}{140} = \frac{D + 1.75}{D + 0.75}$$

$$0.3210 = 0.7589$$

$$\therefore D = 2.36 \approx 2.$$



Transit time :

$$t_1 = \frac{D + 0.75}{f_1} = \frac{0.75}{9.528 \times 10^9} = 0.2886 \text{ nsec.}$$

$$t_2 = \frac{D + 1.75}{f_2} = \frac{3.75}{9.524 \times 10^9} = 0.393 \text{ nsec.}$$

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Teacher Incharge

3. Electronic timing range,

$$\text{for } t_1 = (f_2 - f_1) = 9.528 - 9.526 = 0 \text{ MHz}$$

$$t_2 = (f_2 - f_1) = 9.524 - 9.523 = 1 \text{ MHz}$$

4. Electronic timing sensitivity,

$$t_1 = \frac{f_2 - f_1}{V_2 - V_1} = \frac{2M}{30} = 66.66 \text{ kHz}$$

$$t_2 = \frac{f_2 - f_1}{V_2 - V_1} = \frac{1M}{10} = 100 \text{ kHz.}$$

$$D_1 = 16.5$$

$$D_2 = 14.8$$

$$D_3 = 12.5$$

$$\therefore \Delta g = \omega (14.8 - 12.5)$$

$$\therefore \Delta g = 4.6 \text{ cm}$$

$x e$ ,

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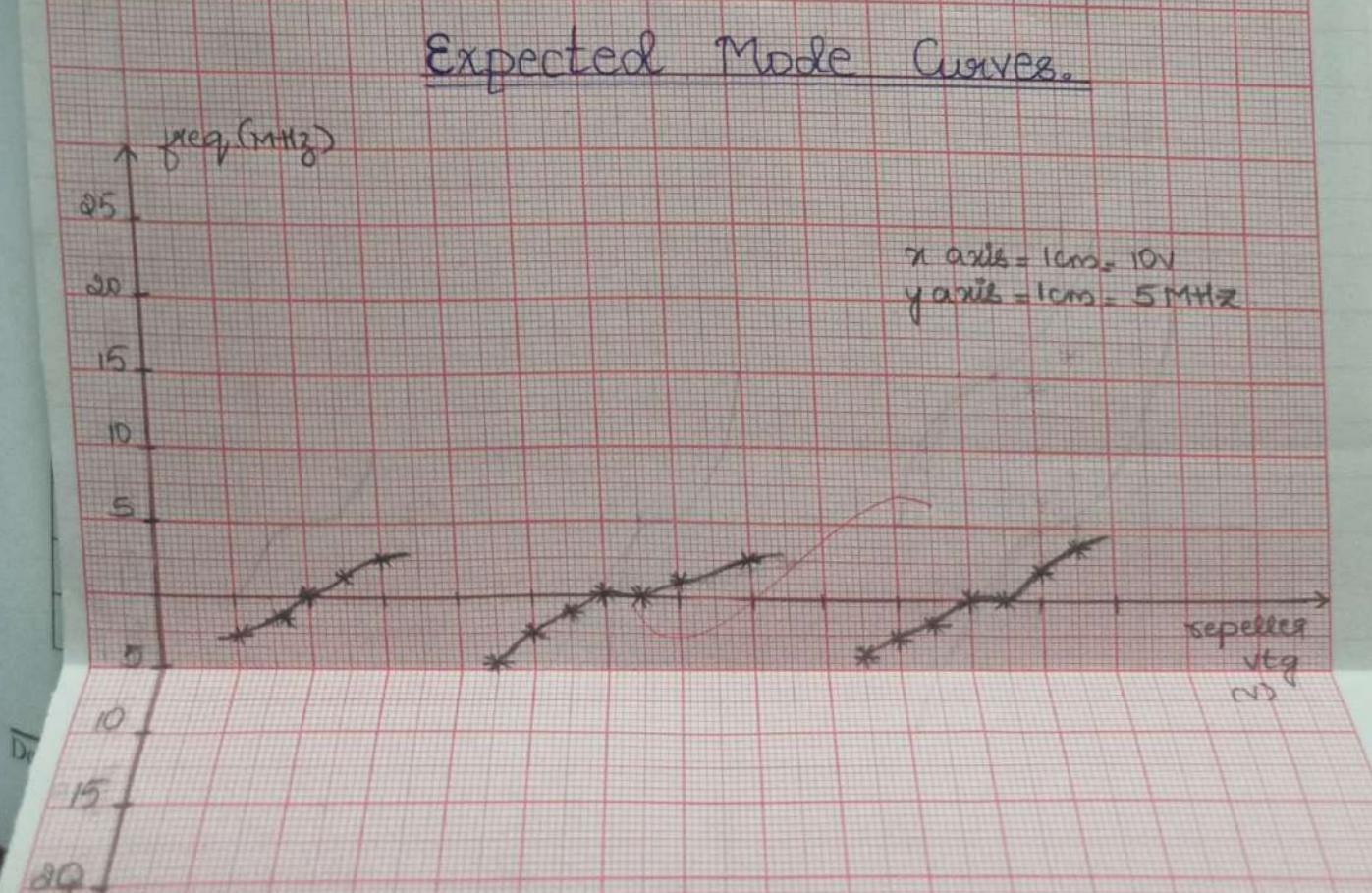
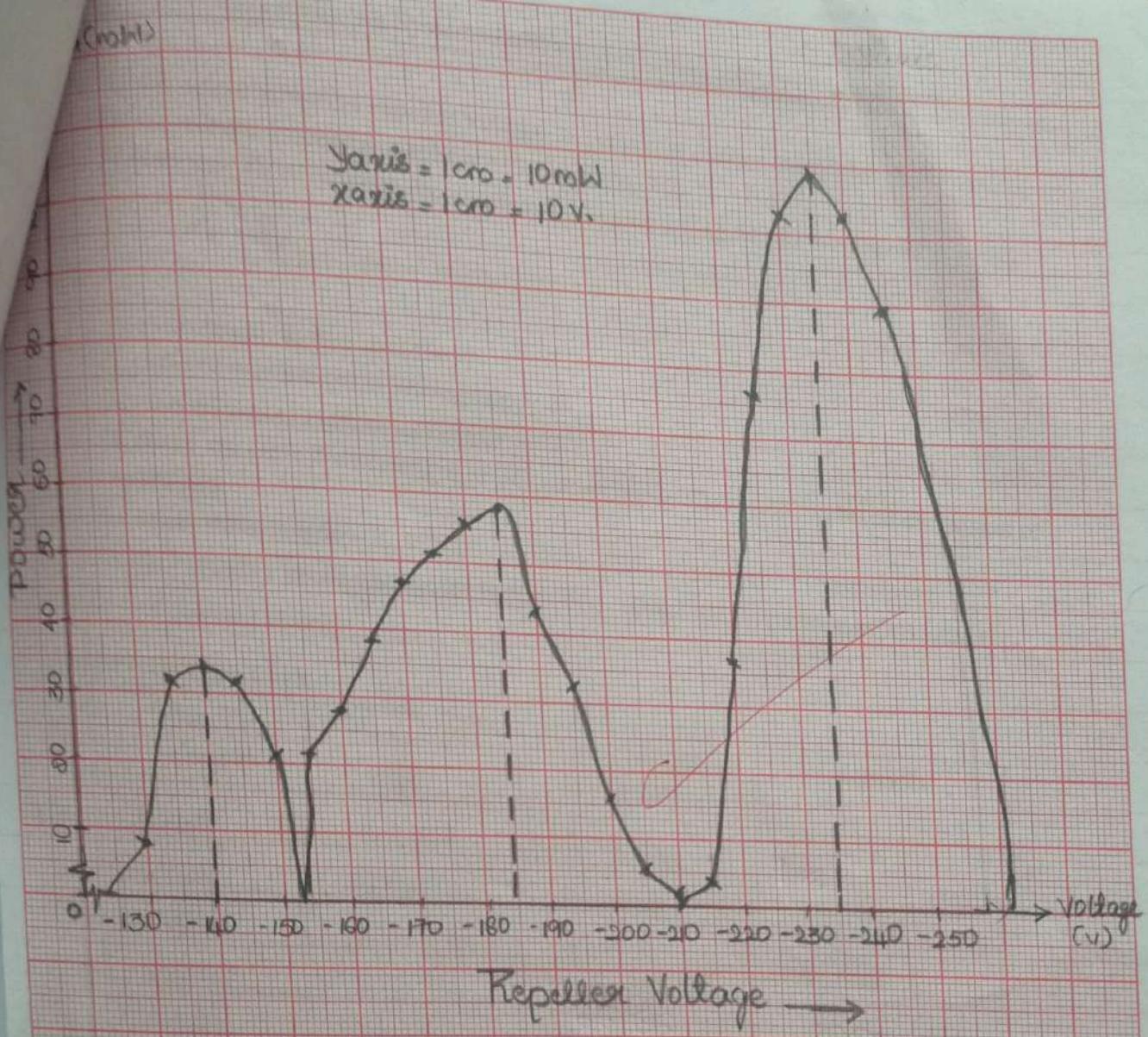
## OBSERVATION / DATA SHEET

Date \_\_\_\_\_ Name Lakhan Singh. H  
 Dept./Lab ECE / MWSR Class VII B Expt./No. 1  
 Title Kyletron

### Result :

Mode	Case 1	Case 2.
Transit time	0.1836 msec	0.2887 msec
Electronic tuning range	2MHz	1.4 MHz.
Electronic tuning sensitivity.	kHz/V 66.66	100 . kHz/V.

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Plot the output power vs repeller voltage to get mode curves. Also plot the frequency vs repeller voltage. Expected graphs are shown in fig 1.2.  
 For dominant TE<sub>10</sub> mode in rectangular waveguide  $\lambda_0$ ,  $\lambda_g$  and  $\lambda_c$  are related as below

$$\frac{1}{\lambda^2_0} = \frac{1}{\lambda^2_g} + \frac{1}{\lambda^2_c} \quad (1.1)$$

$\lambda_0$ : wavelength in free space in m

$\lambda_g$ : guided wavelength in waveguide in m

$\lambda_c$ : cut-off wavelength in waveguide in m

Measure the cut-off wavelength of TE<sub>10</sub> mode by  $\lambda_c = 2a$  where a is broad dimension of waveguide

The guide wave length is  $\lambda_g = 2(d_1 - d_2)$  in m, From eqn 1, the  $\lambda_0$  is calculated.  
 operating frequency inside waveguide is  $f_0 = c / \lambda_0$  which can be verified by measured

#### TABULAR COLUMN:

No.	Repeller voltage (V)	Power (dB) mW	Frequency meter reading (GHz).	Remarks
1	-245	89.88	9.533	
2	-240	103.96	9.532	
3	-235	107.64	9.53	Mode 1
4	-230	103.96	9.53	
5	-225	78.83	9.529	
6	-220	39.2	9.528	
7	-215	4.05	9.528	
8	-210	1.56	9.5285	
9	-205	5	9.5285	
10	-200	16.2	9.5285	
11	-195	32.76	9.5282	
12	-190	43.8	9.5282	
13	-185	59.16	9.528	Mode 2
14	-180	56.44	9.528	
15	-175	51.2	9.527	
16	-170	48.6	9.527	
17	-165	39.2	9.527	

18	-160	28.8	9.526	
19	-155	21.63	9.526	
20	-150	21.63	9.526	
21	-145	31.25	9.525	
22	-140	33.8	9.524	Mode 3
23	-135	31.85	9.523	
24	-130.	4.2	9.523	

### CAUTION

Even though there should be little danger from microwave radiation hazards in the lab, the following work habits are recommended whenever working with RF or microwave equipment:

- Never look into the open end of a waveguide or transmission line that is connected to other equipment.
- Do not place any part of your body against the open end of a waveguide or transmission line.
- Turn off the microwave power source when assembling or disassembling components.

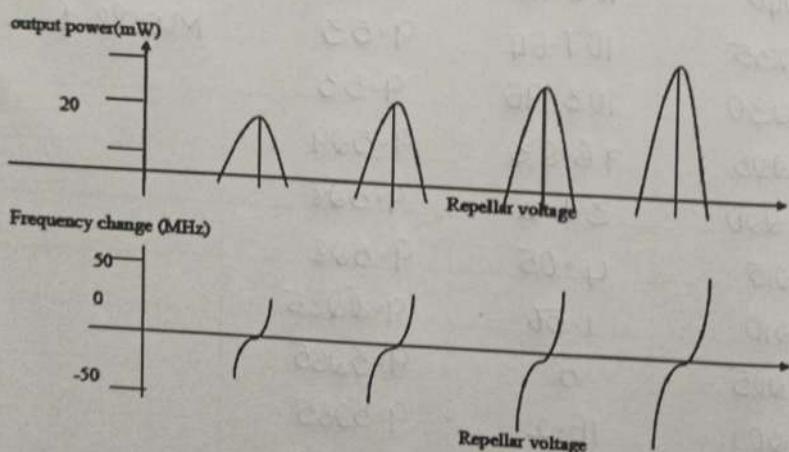


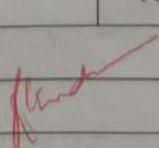
Fig 1.2: Expected Mode curves of a klystron

### 7. RESULT

Mode No.	Case(1)	Case(2)
Transit time	$0.10886 \times 10^{-9}$ s	$0.288 \times 10^{-9}$ s
Electronic tuning Range	2 MHz	1 MHz
Electronic tuning sensitivity	66.6 kHz/V	100 kHz/V

## Observations:

- As no. of mode increase the transit time increases and peak o/p power decreases.
- Electronic timing range decreases but sensitivity increases with mode number
- Half power frequencies are separated by large distance with increase in mode no.
- Variation in o/p power at different modes is observed similarly frequency variation is also observed and each pot is made for mode 1, 2, 3.

Data sheet			
1	Problem statement	10	10
2	Design & specifications	10	10
3	Expected output	10	10
Record			
4	Simulation/ Conduction of the experiment	15	15
5	Analysis of the result	15	15
6	Viva	40	35
7	Total	100	95
Scale down to 10 marks			
Staff Signature: 			

# R.V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

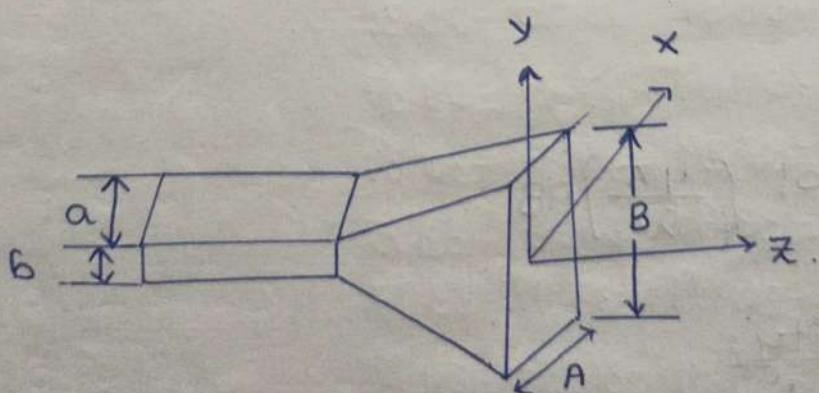
Date \_\_\_\_\_ Name Sakhan Singh +e

Dept./Lab ECE I MCUSR. Class VII B. Expt./No. 2

Title Radiation characteristic of pyramidal horn antenna and microstrip Patch (X-band)

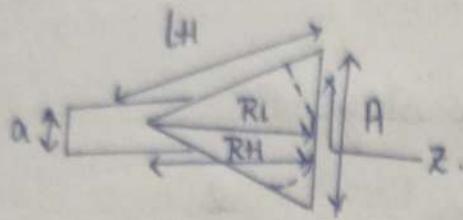
Aim: To measure the antenna parameter, radiation pattern, determine half power beamwidth and directivity of horn antenna and carry out Gain measurement using method of comparison.

Equipment required: Klystron power supply, isolator, frequency meter, variable attenuator, X-Band detector, horn antenna (2), waveguide to BNC adaptor and oscilloscope, power meter.

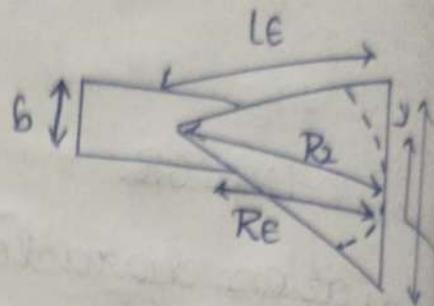


Overall geometry of pyramidal horn antenna.

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Teacher Incharge



Cross section through XY plane (H plane)



Cross section through YZ plane (E plane)

\* The normalized radiation patterns of horn

$$F_{H(\theta)} = \frac{1 + \cos\theta}{2} f_{H(\theta)} \text{ where, } f_{H(\theta)} \propto \int_{-A/2}^{A/2} \cos \frac{\pi x'}{A} e^{-jBx'} e^{j\beta} dx'$$

$\hookrightarrow$  H-plane

$$F_{E(\theta)} = \frac{1 + \cos\theta}{2} f_{E(\theta)} \text{ where, } f_{E(\theta)} \propto \int_{-B/2}^{B/2} e^{-jBx'} \sqrt{R_2^2 + y'^2} e^{j\beta} dy'$$

$\hookrightarrow$  E plane.

\* Half power beamwidth :

$$\theta_E = 54 \frac{\lambda}{B}$$

$$\theta_H = 78 \frac{\lambda}{A}$$

\* Gain:

$$G = 0.51 \left( \frac{4\pi}{\lambda^2} \right) AB$$

\* Directivity:

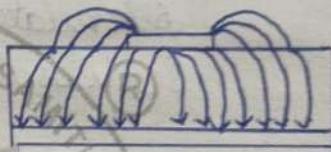
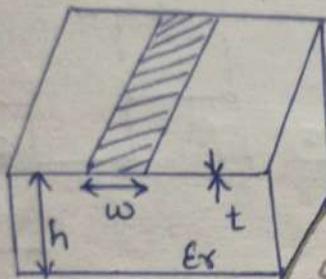
$$D = \frac{41253}{\theta_E \theta_H}$$

# V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Date \_\_\_\_\_ Name Sakhan Singh + e  
 Dept./Lab ECCL MUOSR Class VII B Expt./No. 2

Title Microstrip Patch antenna.



Electric field lines across plane for microchip use.

The normalised radiation pattern of microstrip patch antenna:

for  $E$  :  $-90^\circ \leq \phi \leq 90^\circ ; \theta = 90^\circ$

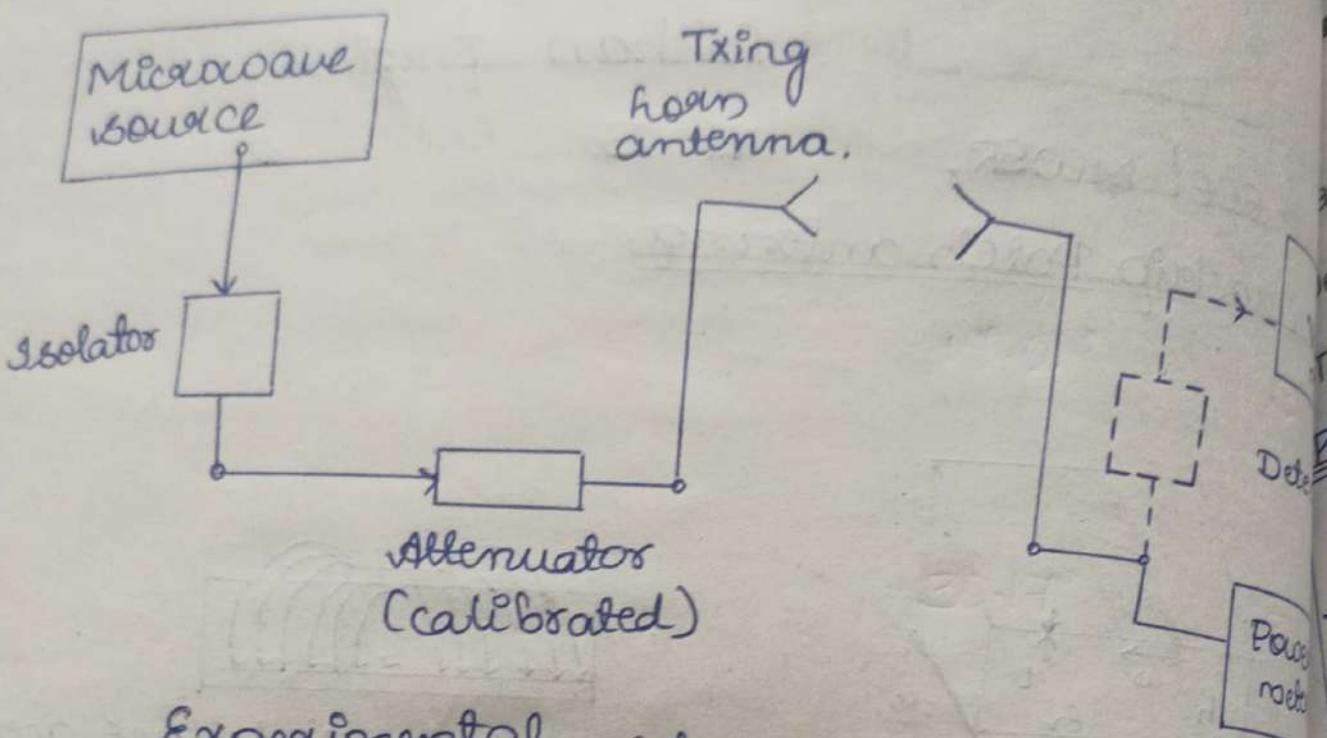
$$E(\phi) = \frac{\sin \left[ koh/2 \cos \phi \right]}{koh/2 \cos \phi} \sin \phi$$

for  $H$  :  $0 \leq \theta \leq 180^\circ ; \phi = 0^\circ$

$$E(\theta) = \sin \theta \quad \frac{\sin \left[ koh/2 \sin \theta \right]}{koh/2 \sin \theta} \quad \frac{\sin \left[ kow/2 \sin \theta \right]}{kow/2 \sin \theta}$$

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Teacher Incharge

## Block diagrams:



Experimental setup for radiation measurement.

## Jabular columns:

Angle	HORN antenna				Patch Antenna			
	Power in +E Plane (mW)		Power in -E Plane		+e plane		-e plane	
	left	Right	left	Right	left	Right	left	Right
0	-25.67	-26.02	-22.85	-23.34				
5	-26.37	-28.87	-25.03	-25.35				
10	-27.13	-29.89	-27.95	-29.37				
15	-30.45	-32.39	-29.37	-32.39				
20	-31.70	-33.97	-33.15	-33.15				
25	-33.15	-34.89	-33.97	-33.97				
30	-34.89	-35.91	-34.89	-34.89				
35	-34.89	-37.07	-35.91	-35.19				
40	-35.91	-38.41	-37.07	-37.07				

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## OBSERVATION / DATA SHEET

Name Lakhman Singh

Dept./Lab EEC / MSOE Class VII B Expt./No. 8

Result:

Parameter.

The transmitted power ( $P_t$ )

The operating frequency

The operating wavelength

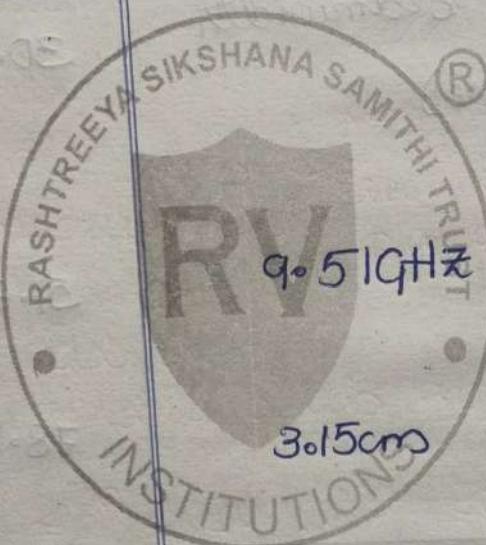
distance b/w

$T_x$  &  $R_x$  (R)

The received power ( $P_r$ )

TOPN  
Antenna

Patch  
Antenna.



• 6989m

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Antenna  
Parameter

half power beamwidth  
( $\theta_E$ )

half power Beamwidth  
( $\theta_{+e}$ )

Gains

Directivity.

Theoretical

17.01°

13°

30.17°

30°

51.67

26.02

78.97

105.

# N. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Name Dakhan Singhote

Dept./Lab ECE - MWRS Class VII B Expt./No. 2

Title Horn antenna.

$$freq = 9.51 \text{ GHz}$$

$$\lambda = c/f = \frac{3 \times 10^8}{9.51 \times 10^9} = 0.0315 \text{ m} = 3.15 \text{ cm}$$

$$A = 8 \text{ cm}$$

$$B = 10 \text{ cm}$$

$$\theta_e = 54 \frac{\lambda}{B} = 17.01^\circ$$

$$\theta_t = 78 \frac{\lambda}{A} = 30.71^\circ$$

$$G = 0.51 \left( \frac{4\pi}{\lambda^2} \right) AB = 51.67$$

$$D = \frac{41253}{\theta_e \theta_t} = 78.97$$

$$R = \frac{\theta d^2}{\lambda} = 0.6989$$

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H plane

dB 50

E plane

30°  
40°  
50°  
60°  
70°  
80°  
90°  
100°  
110°  
120°  
130°  
140°  
150°  
160°  
170°  
180°  
190°  
200°  
210°  
220°  
230°  
240°  
250°  
260°  
270°  
280°  
290°  
300°  
310°  
320°  
330°

0°  
10°  
20°  
30°  
40°  
50°  
60°  
70°  
80°  
90°  
100°  
110°  
120°  
130°  
140°  
150°  
160°  
170°  
180°  
190°  
200°  
210°  
220°  
230°  
240°  
250°  
260°  
270°  
280°  
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300°  
310°  
320°  
330°

0°  
10°  
20°  
30°  
40°  
50°  
60°  
70°  
80°  
90°  
100°  
110°  
120°  
130°  
140°  
150°  
160°  
170°  
180°  
190°  
200°  
210°  
220°  
230°  
240°  
250°  
260°  
270°  
280°  
290°  
300°  
310°  
320°  
330°

## 6. Tabular column:

	HORN antenna					PATCH Antenna			
	Power in E plane		Power in H plane		Power in E plane		Power in H plane		
Angle (degrees)	Left	Right	Left	Right	Left	Right	Left	Right	
0	-28.85	-23.34	-25.67	-26.02					
5	-25.03	-25.85	-26.37	-28.87					
10	-27.95	-29.37	-27.13	-29.89					
15	-29.37	-32.39	-30.45	-32.39					
20	-33.15	-33.15	-31.07	-33.39					
25	-33.97	-33.97	-33.15	-34.89					
30	-34.89	-34.89	-34.89	-35.91					
35	-35.07	-35.19	-34.89	-37.07					

## RESULT

Parameters	HORN Antenna	PATCH Antenna
The transmitted power (Pt)	0.023 W.	
The Operating frequency	9.51 GHz	
The Operating wavelength	3.15 cm	
The separating distance between transmitter and receiver (R)	6.989 m	
The received power (Pr)	0.512 mW	
Antenna Parameters	Theoretical	Practical
Half power Beamwidth( $\theta_E$ )	17.01	13 $\uparrow$
Half power Beamwidth( $\theta_H$ )	30.17	30 $\theta_E > \theta_H$
Gain	51.67	26.02
Directivity	78.97	105.

### Basic precautions to be taken:

1. Power flowing out of horn antenna may damage the retina of the eye, do not see directly inside the horn antenna.
2. Materials present in the vicinity of the experimental setup may be absorbing ones. Keep reflecting objects away from the experimental setup.

### Observations:

- \* Distance b/w  $T_x$  and  $R_x$  is kept sufficiently large for far-field radiation.
- \* Value of beamwidth is taken for every  $5^\circ$  toward left and right.
- \* It is observed if both antenna faces each other, the power received is max i.e  $0^\circ$ .
- \* If rotate the  $T_x$   $5^\circ$  everytime, the power  $R_x$  decreases.
- \* The radiation pattern the is observed is plotted on polar graph.
- \* The theoretical values and practical values are compared in the tabular form.

Sl.No	Criteria	Max Marks	Marks obtained
<b>Data sheet</b>			
1	Problem statement	10	10
2	Design & specifications	10	10
3	Expected output	10	10
<b>Record</b>			
4	Simulation/ Conduction of the experiment	15	15
5	Analysis of the result	15	14
6	Viva	40	32
7	Total	100	91
Scale down to 10 marks			
Staff Signature:			

# R.V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Date 1/1/2023 Name Cakhar Singh + 8

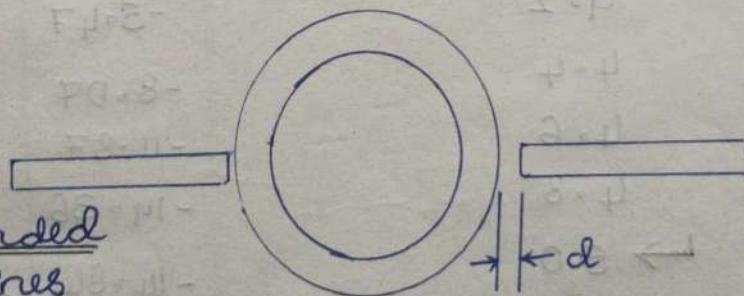
Dept./Lab ECE / MWRS Class VII B Expt./No. 3

Title Characterisation of Ring Resonator, Power divider, directional coupler and Hybrid Ring (stipline type - C band).

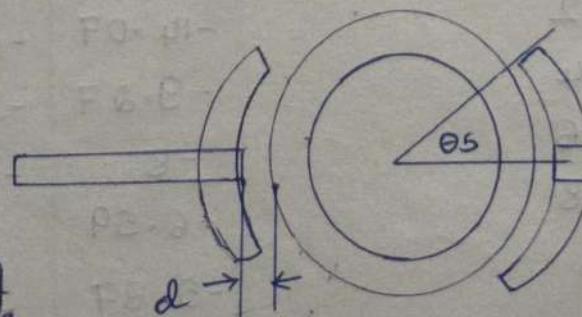
Aim: To characterise the microwave passive components @ 'C' band range of frequencies

Apparatus: RF signal source, Power meter / VSWR meter ring resonator, power divider, directional coupler and hybrid coupler.

\*1. Ring resonator coupled with open ended lines and coupling arcs:



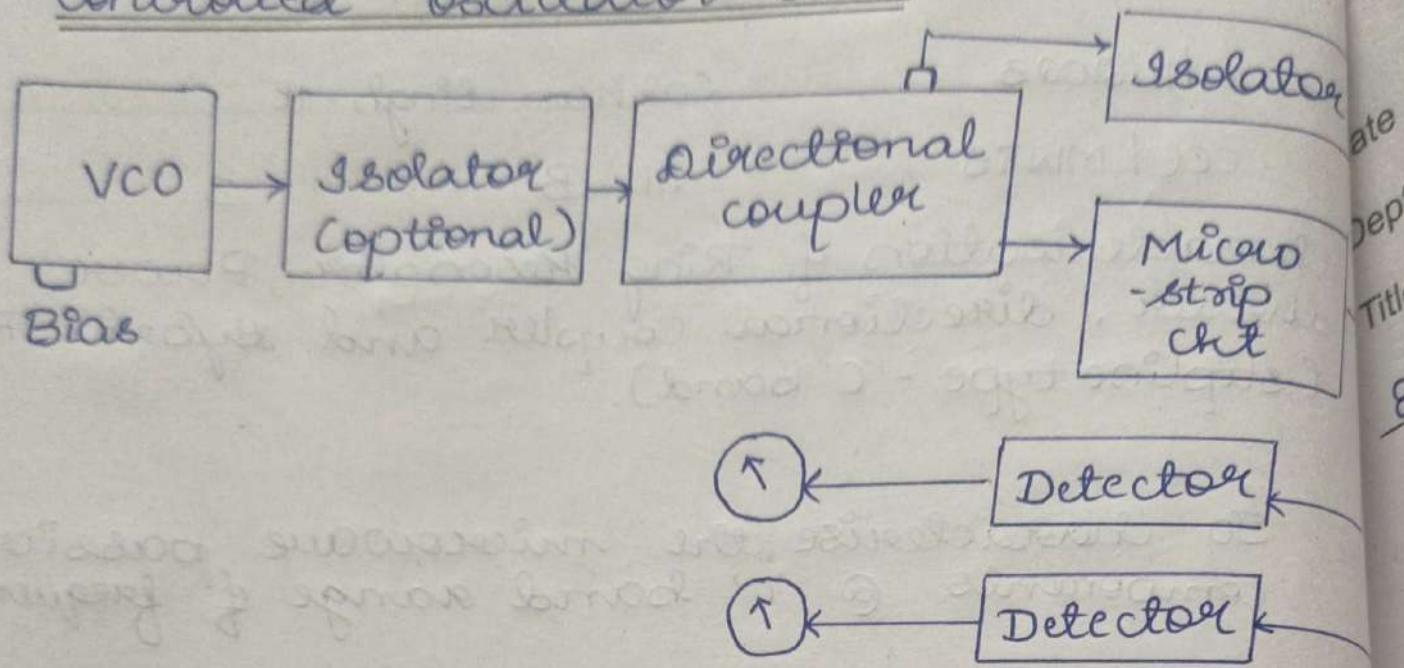
a. open ended lines



b. coupling arcs.

  
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Teacher Incharge

Measurement setup based on voltage controlled oscillator (VCO).



VSWR / power  
meter.

Tabular columns:

Sl.no	Frequency (GHz)	Received Power (dB)	P <sub>i</sub>	P <sub>o</sub>	P <sub>o</sub> -P <sub>i</sub>
1	3.8	-5.9	-5.9	-40	34.21
2	4.0	-5.47	-5.47	-40	34.53
3	4.2	-5.47	-5.47	-40	34.53
4	4.4	-8.07	-8.07	-40	31.93
5	4.6	-11.87	-11.87	-40	28.13
6	4.8	-14.36	-14.36	-37.87	23.51
7	5.0	-14.84	-14.84	-23.43	8.59
8	5.2	-14.07	-14.07	-26.72	12.65
9	5.4	-9.27	-9.27	-34.59	28.96
10	5.6	-8	-8	-37.96	29.96
11	5.8	-6.59	-6.59	-40	33.41
12	6	-5.87	-5.87	-38.15	34.13

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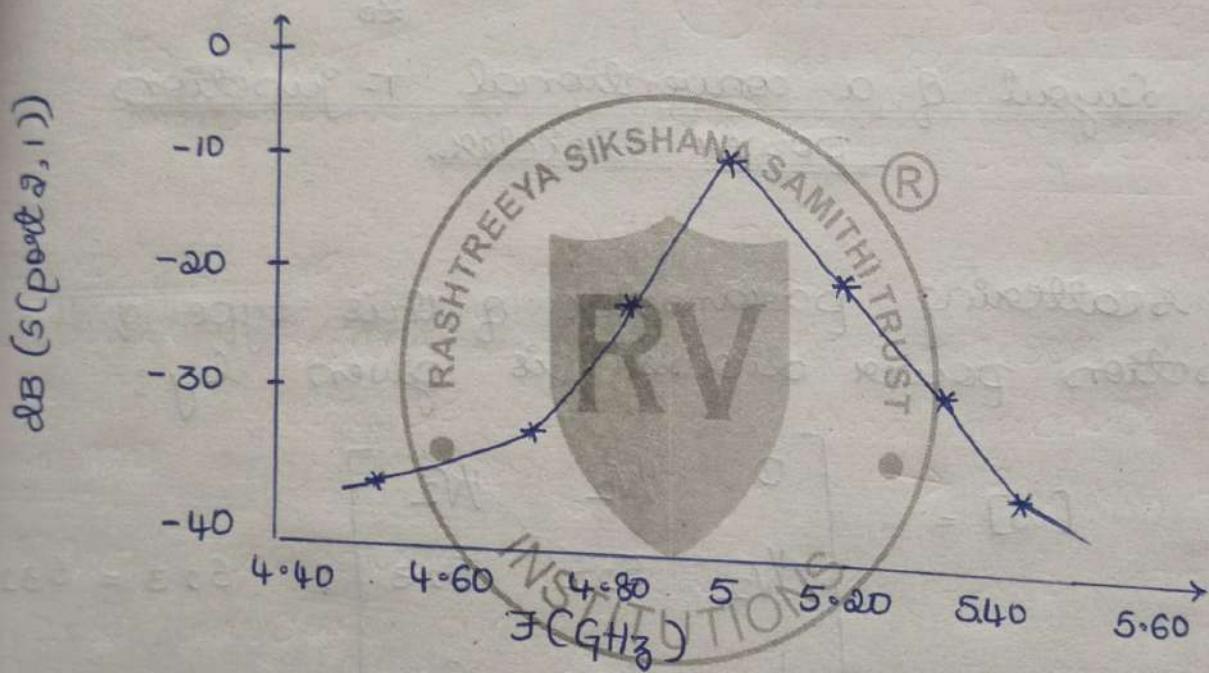
## OBSERVATION / DATA SHEET

Date 11/1/2023 Name Lakhman Singh

Dept./Lab ECE / MCOSR Class VII B Expt./No. 3

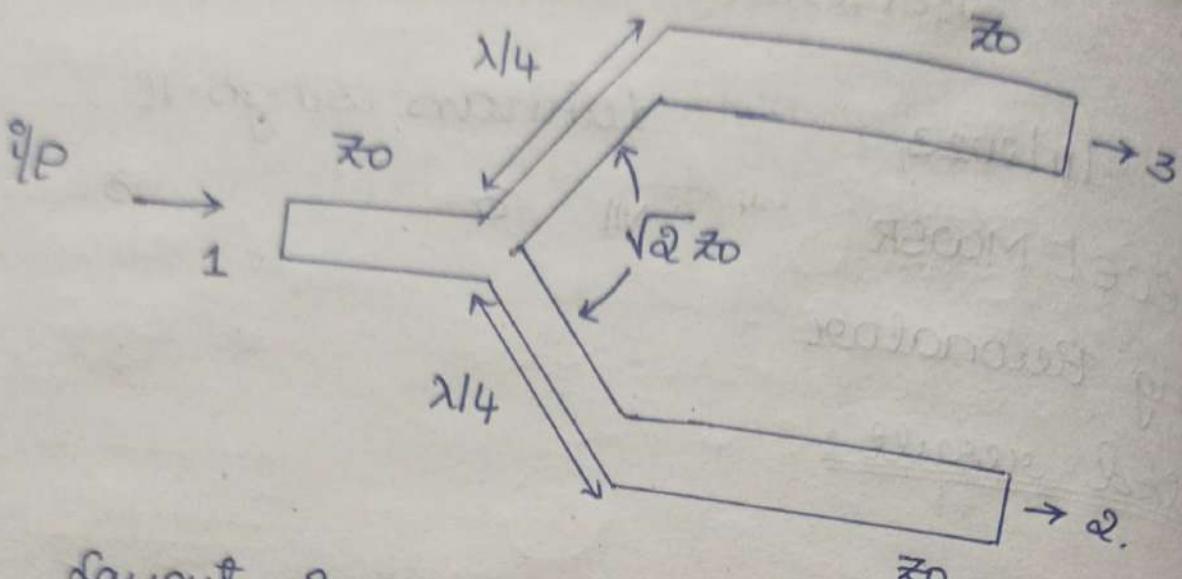
Title Ring Resonator

Expected result:



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## 2. Power divider.



Layout of a conventional T-junction power divider.

The scattering parameter of this type of T-junction power divider is given by:

$$[S] = \begin{bmatrix} 0 & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & S_{22} & S_{23} \\ \frac{1}{\sqrt{2}} & S_{32} & S_{33} \end{bmatrix}; \quad S_{23} = S_{31}$$

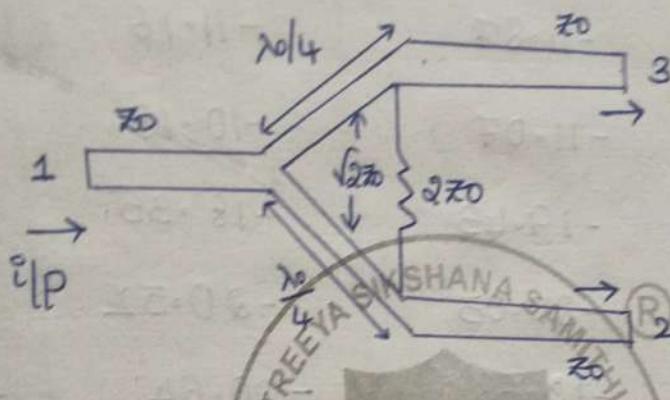
Unitary condition,

$$S_{22} = -S_{23}$$

$$|S_{22}| = |S_{23}| = -|S_{23}| = y_2.$$

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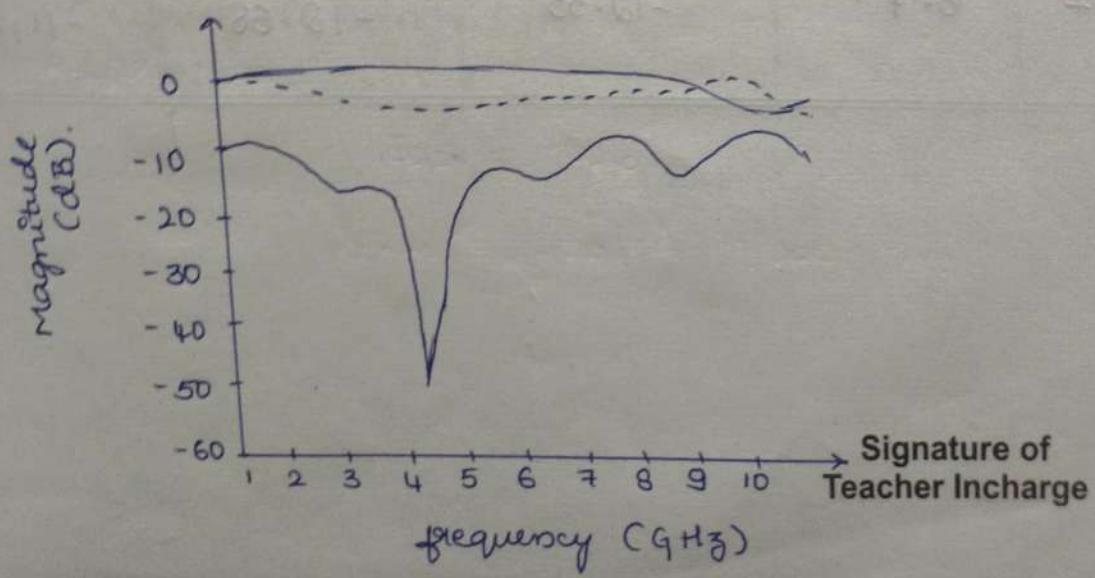
## OBSERVATION / DATA SHEET

Date 11/1/2023Name Dakhan Singh +PDept/Lab ECE / MWOSR Class VII B Expt./No. 30Title Power divider

layout of the modified T-junction power divider

$$[S] = \frac{1}{\sqrt{2}} \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}$$

Expected output:



Tabular column:

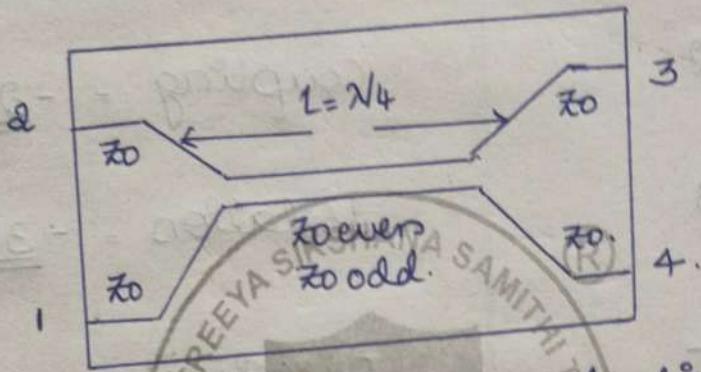
SL no.	frequency (GHz)	Rx power (dB) in P <sub>2</sub> , Match P <sub>3</sub> $P_1 = i/P$	Rx power (dB) in P <sub>3</sub> , Match P <sub>2</sub> $P_1 = i/P$	Rx power (dB) in P <sub>3</sub> , Match P <sub>2</sub> $P_1 = i/P$
1	3.8	-11.87	-11.36	-14.48
2	4	-11.87	-11.16	-13.95
3	4.3	-11.07	-10.16	-13.07
4	4.6	-19.43	-18.35	-23.23
5	4.9	-20.03	-20.52	-24.51
6	5	-20.68	-20.64	-23.32
7	5.2	-20.07	-13.16	-23.12
8	5.5	-13.68	-11.75	-16.36
9	5.8	-12.07	-11.20	-14.68
10	6.1	-10.87	-10.75	-12.95
11	6.4	-11.75	-11.36	-13.07
12	6.7	-12.55	-12.68	-14.75

# V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Date 11/12/2023 Name Lakhan Singh + 1  
 pt./Lab ECE | MCWSR Class VII B Expt./No. 3

Parallel coupled directional coupler.



Layout of a parallel coupled directional coupler.

parameters:

$$\text{Return loss} = -20 \log_{10} |S_{11}|$$

$$\text{Insertion loss} = -20 \log_{10} |S_{21}|$$

$$\text{coupling} = -20 \log_{10} |S_{21}|$$

$$\text{Isolation} = -20 \log_{10} |S_{31}|$$

$$\text{Directivity} = \text{Isolation} - \text{coupling}.$$

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Teacher Incharge

Results:

Sl.no	Parameter (dB)
1	Insertion loss = <u>-24.79</u>
2	Coupling = <u>-29.7</u>
3	Isolation = <u>-31.49</u>
4	Directivity = <u>-1.79</u>

$$S_{21} = -30.87 \text{ dB}$$

$$S_{31} = -37.55 \text{ dB}$$

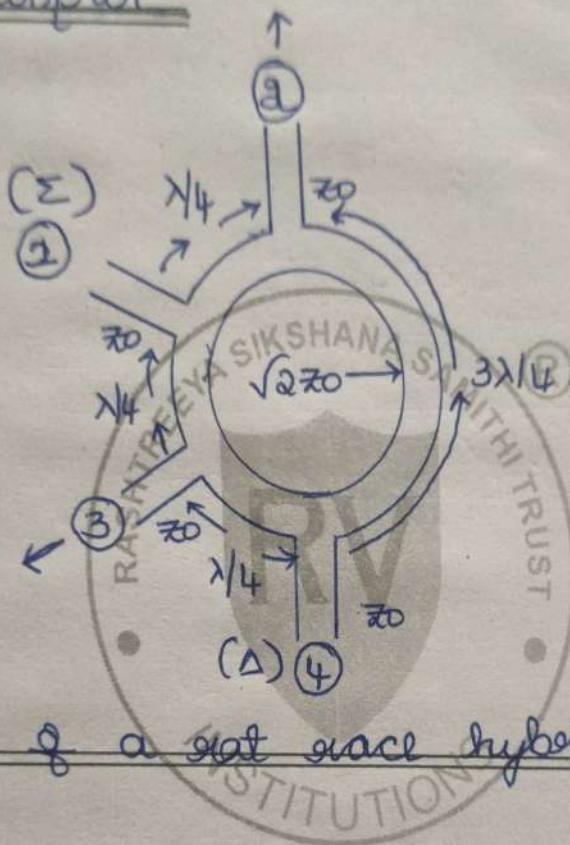
$$S_{41} = -17.36 \text{ dB}$$

# V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Date 11/12/2023 Name Sakhan Singh + te  
 pt./Lab ECE1 MSWOR Class VII B Expt./No. 3

ie Hybrid coupler



layout of a rat race hybrid coupler.

Result:

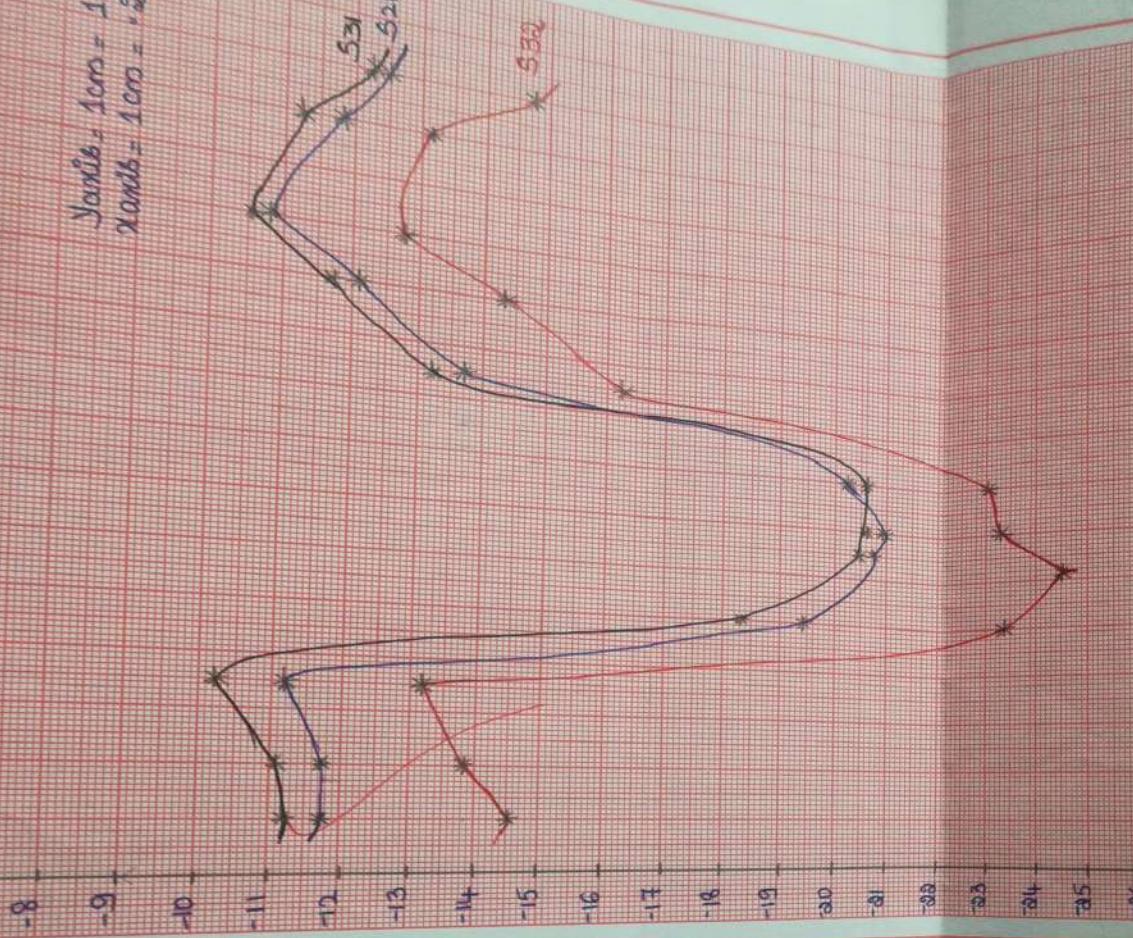
Sl. no	Parameter (dB)
1	Insertion loss : <u>-25.58</u>
2	Coupling : <u>-25.67</u>
3	Isolation : <u>-28.48</u>
4	Directivity :- <u>-2.79</u>

Signature of  
Teacher Incharge

Magnitude (dB)

Power division

$$Y_{AB} = 10 \text{ m} = 10 \text{ dB}$$
$$X_{AB} = 1 \text{ m} = 2 \text{ GHz}$$



freq (GHz)

3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0	6.2	6.4	6.6	6.8
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Power (dB)

0

-2

-4

-6

-8

-10

-12

-14

-16

-18

-20

-22

-24

-26

-28

-30

-32

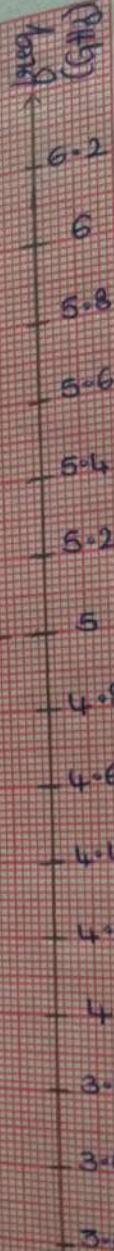
-34

-36

Ring Resonance:

$$Y_{AB} = 1 \text{ cm} = -2 \text{ dB}$$

$$Z_{AB} = 1 \text{ cm} = 39 \text{ Hz}$$



## PROCEDURE:

To measure return and insertion loss characteristics of the microstrip resonator frequency and insertion loss at the resonant frequency. Pick up the Microstrip Ring Resonator circuit board from the AMTK and mount the substrate in the test jig as shown in Fig 3.2. Here we use only the center pair of input/output SMA connectors. The circuit is now ready for testing.

1. Set up the system as shown in Fig 3.3.
2. Measure the input power fed to the Microstrip ring resonator circuit at a selected VCO frequency.
3. Measure the reflected power by noting the reading of the detector connected to the directional coupler and the forward power by noting the reading of the detector connected to the Microstrip ring resonator circuit (DUT) at the same frequency settings of the VCO.
4. Repeat the above two steps at 5-10 different frequencies by tuning the VCO.
5. Plot the transmission loss of the microstrip ring resonator.
6. From the plot, determine the resonant frequency of the microstrip ring resonator. From this knowing that ring length =  $\lambda_g$ , calculate the effective dielectric constant and the permittivity of the substrate used. This should be 3.2.

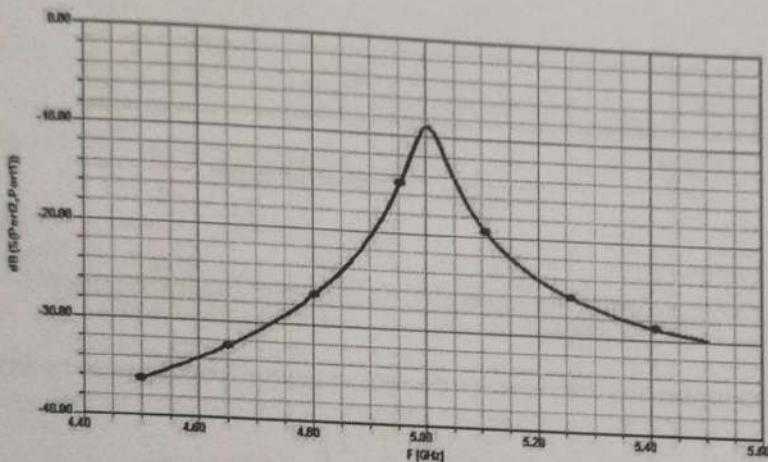
Tabular column:

Sl No	Frequency (GHz)	$P_i$	$P_o$	Received power (dB)
1	3.8	-5.79	-40	34.21
2	4	-5.47	-40	34.53
3	4.2	-5.47	-40	34.53
4	4.4	-8.07	-40	31.93

5	$4^{\circ} 6$	-11.87	-40	28.13
6	$4^{\circ} 8$	-14.36	-37.87	23.51
7	5	-14.84	-23.43	8.59
8	$5^{\circ} 2$	-9.87	-56.72	10.65
9	$5^{\circ} 4$	-8	-34.59	28.96
10	$5^{\circ} 6$	-6.59	-37.96	29.96

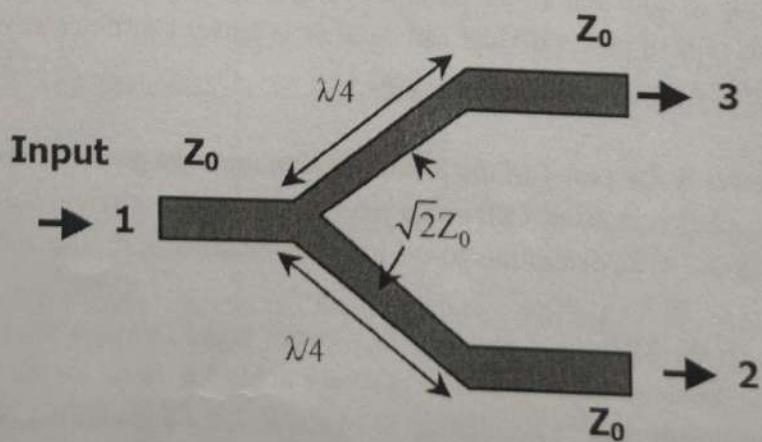
51

Expected result:



### Power divider:

The layout of a conventional T-junction power divider in microstrip configuration with input port



matched is shown in Fig 3.4.

Fig. 3.4 Layout of a conventional T-junction Power Divider

The scattering parameters of this type of T-junction power divider is given by:

$$[S] = \begin{bmatrix} 0 & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & S_{22} & S_{23} \\ \frac{1}{\sqrt{2}} & S_{32} & S_{33} \end{bmatrix}; S_{23} = S_{32}$$

- Using the same procedure, plot power coupled to port 3 (Match terminate port 2).  
 Terminate port 1 and feed power to port 2 and measure power available at port 3.  
 Now terminate port 1 with matched load and measure isolation between ports 2 and 3.  
 Determine the power split and isolation at the centre frequency.

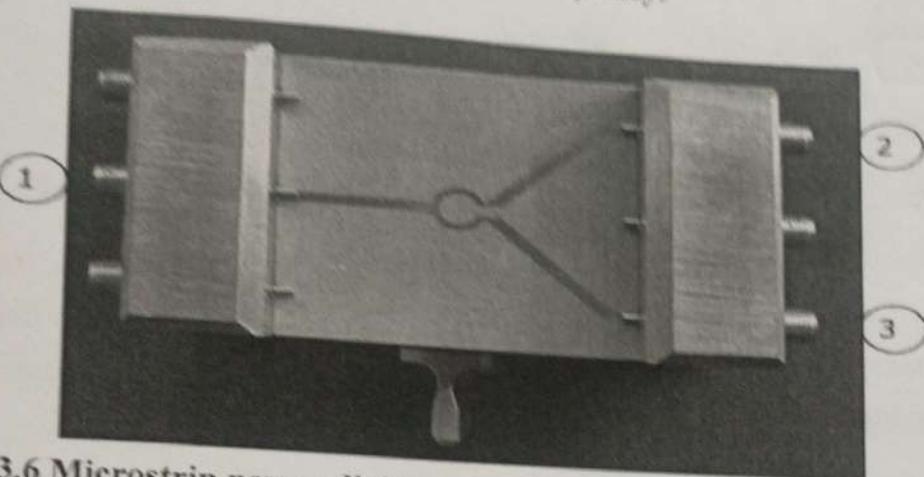
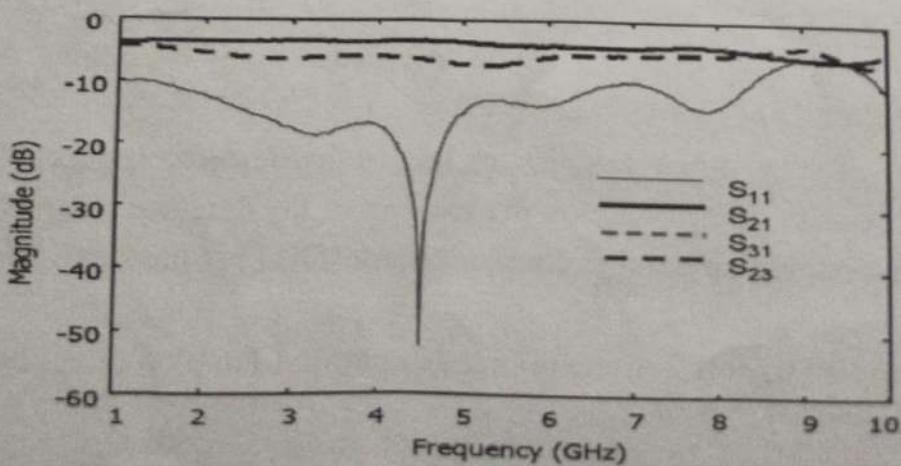


Fig. 3.6 Microstrip power divider circuit without resistor in the test jig

Tabular column:

Sl No	Frequency (GHz)	Received power (dB) in P2, Match P3, P1=input	Received power (dB) in P3, Match P2, P1=input	Received power (dB) in P3, Match P1, P2=input
1	3.8	-11.87	-11.36	-14.48
2	4	-11.87	-11.16	-13.95
3	4.3	-11.07	-10.16	-13.07
4	4.6	-19.43	-18.35	-23.23
5	4.9	-20.03	-20.52	-24.51
6	5	-20.68	-20.64	-23.32
7	5.2	-20.07	-13.16	-23.12

Expected result:



7. Using the same procedure, find power coupled to port 3 (Matched terminate ports 2 and 4) and port 4 (matched terminate ports 2 and 3)
  8. Determine insertion loss, coupling and isolation at the centre frequency.

Various parameters of the coupling are given by:

$$\text{Return loss} = -20 \log_{10} |S_{11}|, \quad \text{Insertion Loss} = -20 \log_{10} |S_{41}|,$$

**coupling**= $-20\log|S_{21}|$ , **Isolation**= $-20\log|S_{31}|$

and Directivity=Isolation-Coupling.

and Directivity=Isolation-Coupling.

### Result:

Sl No	Parameter(dB)
1	Insertion loss = -24.79 $S_{41} = -17.36$ .
2	Coupling = -29.7 $S_{21} = -30.87$
3	Isolation = -31.49 $S_{31} = -37.55$
4	Directivity = -1.79

### Hybrid Coupler:

Theory: The layout of a rat race hybrid coupler in microstrip configuration is shown in Fig 3.9.

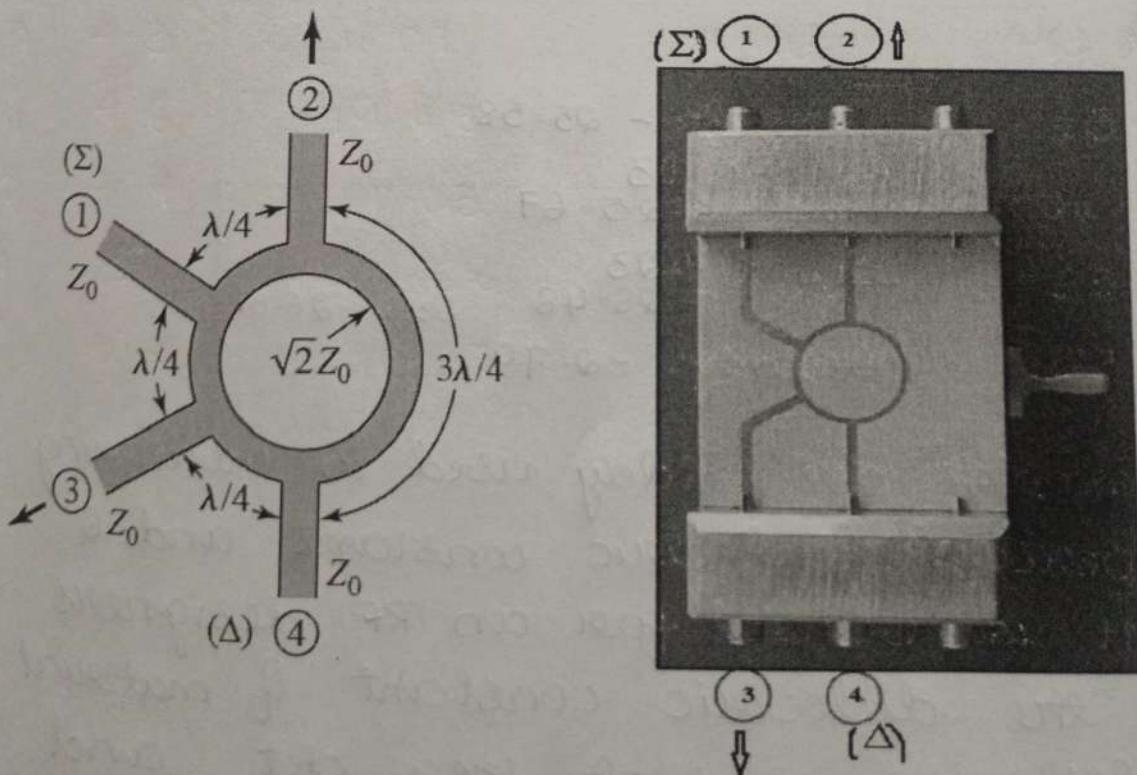


Fig. 3.9: a) Layout of a rat race hybrid coupler b) Microstrip Rat Race Hybrid Coupler Circuit

from ports 2 and 3 and port 4 is isolated. With port 1 as the input port, signals of equal amplitude signals enter the coupler. At the output port, signals from ports 2 and 3 and port 4 is isolated. These signals have  $180^\circ$  phase shift. When used as a power combiner, signals are fed to ports 2 and 3. Difference signal is available at port 4 ( $\Delta$ -port) and the sum signal is available at port 1 ( $\Sigma$ -port).

### Procedure:

Pick up the Microstrip Rat Race Hybrid Coupler circuit board from the AMTK and mount the subminiature connectors in the test jig as shown in Fig 3.10. Here we use top two pairs of input/output SMA connectors. The circuit is now ready for testing.

1. Set up the system as shown in Fig 3.3.
2. Terminate ports 3 and 4 in 50-ohm matched loads.
3. Measure the input power fed to port 1 of the Microstrip rat race hybrid coupler circuit at selected VCO frequency.
4. Measure the reflected power by noting the reading of the detector connected to the directional coupler and the forward power by noting the reading of the detector connected to port 2 of the Microstrip rat race hybrid coupler circuit (DUT) at the same frequency settings of the VCO.
5. Determine the power coupled to port 2 of the microstrip rat race hybrid coupler circuit.
6. Using the same procedure, find the power coupled to port 3 (Match terminate ports 2 and 4) and port 4 (match terminate ports 2 and 3).

### RESULT:

Sl No	Parameter(dB)
1	Insertion loss = $-25.58$ $S_{41} = -19.03$
2	Coupling = $-25.67$ $S_{21} = -19.23$
3	Isolation = $-28.48$ $S_{31} = -26.51$
4	Directivity = $-2.79$

### Observations:

The ring resonator are widely used in measuring for dispersion, dielectric constant and Q factor. It is crucial for an RF designer to know the dielectric constant of material when designing at high freq ckt and one reliable method is using a ring resonator.

# R.V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Date \_\_\_\_\_ Name Sakhan Singh • H \_\_\_\_\_

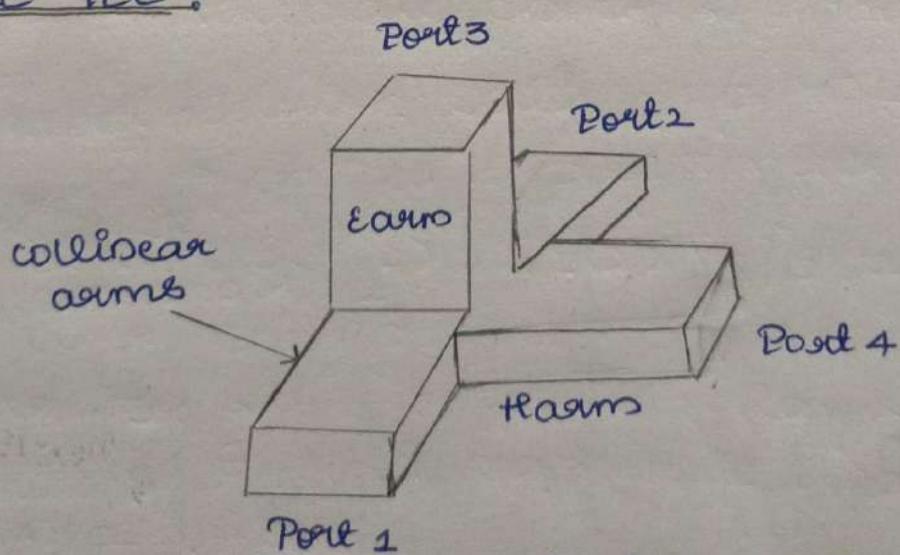
Dept./Lab ECE - MWRS Class VII B Expt./No. 4

Title Characterization of microwave Magic Tee , Directional coupler, circulator, variable attenuator and isolator.

Aim: To determine S parameter and plot S-matrix for passive microwave devices such as waveguide e plane, t<sub>e</sub> plane, Magic Tee, Circulator, Directional coupler, Attenuators.

Equipment required: kylstron power supply, Oscillator, Isolator, attenuator, freq meter, all above devices, CRO and match load.

### Magic Tee:



A magic tee is combination of e plane and t<sub>e</sub> plane Tee.

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$S$  matrix:

$$\begin{bmatrix} 0 & 0 & S_{13} & S_{14} \\ 0 & 0 & S_{23} & S_{24} \\ S_{31} & S_{32} & 0 & 0 \\ S_{41} & S_{42} & 0 & 0 \end{bmatrix}$$

Sl.no	Parameter	Value (dB)
1	$S_{31} = S_{32}$	-19.13
2	$S_{41} = S_{42}$	-45
3	$S_{34} = S_{43}$	0

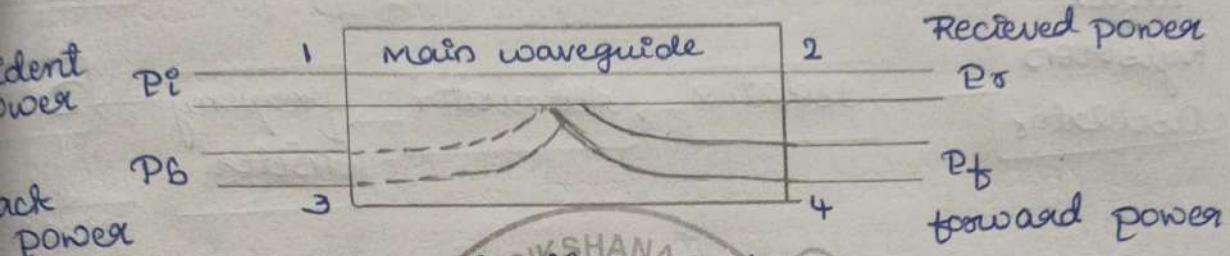
# V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Name Lakhan Singh Expt. No. 4

Dept./Lab ECE - MCORS Class VII B Expt./No. 4

Topic Directional coupler.



$$\text{coupling factor (C)} = 10 \log_{10} \left( \frac{P_s}{P_f} \right) \text{ dB}$$

$$\text{Directivity (D)} = 10 \log_{10} \left( \frac{P_s}{P_b} \right) \text{ dB}$$

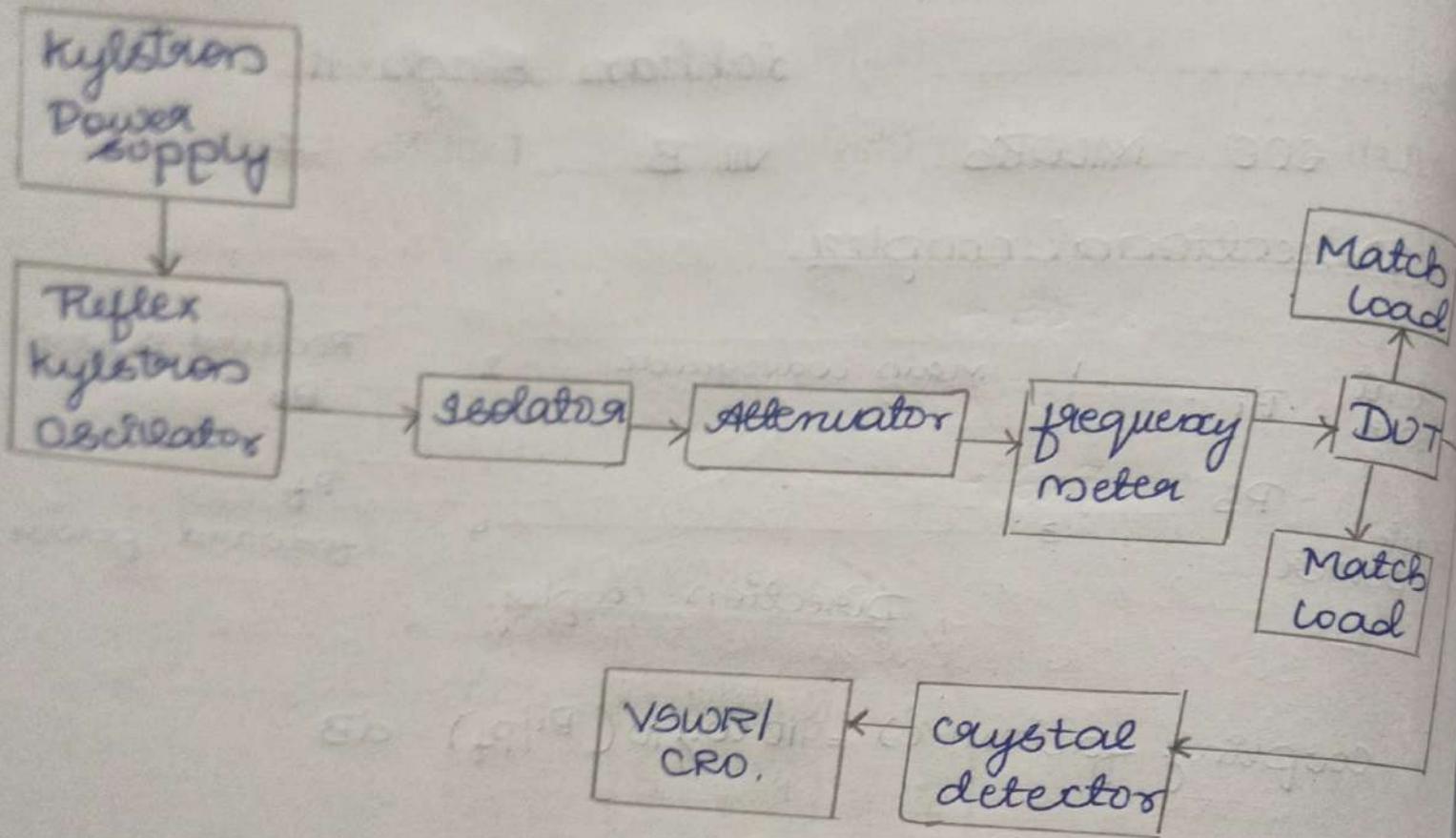
$$\text{Isolation (I)} = 10 \log_{10} \left( \frac{P_i}{P_b} \right) \text{ dB}$$

$$\text{Isolation in dB} = \text{coupling factor} + \text{directivity.}$$

S matrix:

Sl.no	Parameter	Value (dB)	Signature of Teacher Incharge
1	S <sub>12</sub>	-17.8	
2	S <sub>21</sub>	-17.7	
3	S <sub>32</sub>	0	

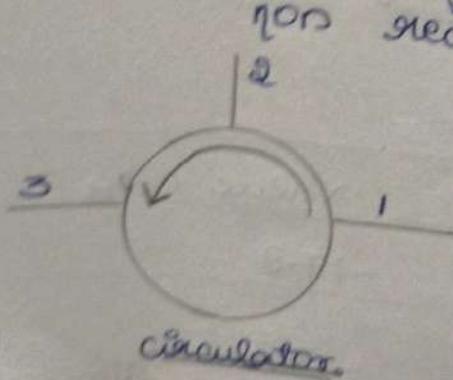
# Block diagram



S matrix determination setup  
for passive devices.

## Circulator:

Three port circulator are non reciprocal devices.



ideal S matrix:

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

# V. COLLEGE OF ENGINEERING

## OBSERVATION / DATA SHEET

Name Dakhan Singh : H

Dept./Lab ECE - MWRS Class VII B Expt./No. 4

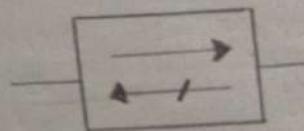
Title circulator & isolator.

S matrix circulator.

SL no	Parameter	value (dB)
1	$S_{13}$	16.2
2	$S_{21}$	-16.2
3	$S_{32}$	-16.2

$S_{12} = S_{23} = S_{31} = 0$

Isolator: two port non symmetric scattering matrix and non reciprocal device.



Isolator.

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

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S matrix of isolator.

Sl no	Parameter	Value (ohm)
1	$S_{12}$	- 35.8
2	$S_{21}$	- 16.9.

- Magic Tee**
- Equipment's are connected as shown in the Fig 4.3.
  - Keep the repeller voltage at maximum, beam voltage at minimum before switching on power supply and also switch on the fan.
  - Switch on klystron power supply and increase the beam voltage to 250V. Note down beam current.
  - Adjust the repeller voltage and detector knob to get maximum output ( $P_1$ ) on CRO/SWR meter keeping frequency meter detuned.
  - Feed the microwave power at the given port and measure the output power at the required port using the CRO while terminating the other ports with matched loads.
  - The readings are noted and the parameters like insertion loss, isolation and power division are calculated using necessary equations.
  - The input power to any given can be measured by removing the magic tee and connecting the crystal detector and CRO.

### Directional Coupler

- The experimental set up is as shown in Fig 4.3.
- Energize the microwave source for particular frequency of operation.
- Set any reference level of power on CRO/SWR meter, and note the reading (reference level let  $P_1$ ).
- Measure the power in different ports and calculate coupling, directivity and isolation.

### RESULTS:

S-matrix of a magic tee:

Sl No	Parameter	Value (dB)
1	$S_{31}=S_{32}$	-19.13
2	$S_{41}=S_{42}$	-45
3	$S_{34}=S_{43}$	0

S-matrix of a Directional Coupler

Sl No	Parameter	Value (dB)
1	$S_{12}$	-17.8
2	$S_{21}$	-17.7
3	$S_{32}$	0

## CIRCULATOR AND ISOLATOR

**THEORY:** A circulator is a ferrite device (ferrite is a class of materials with strange magnetic properties) with usually three ports circulators are non-reciprocal devices, that is, energy into port 1 predominantly exits port 2, energy into port 2 exits port 3, and energy into port 3 exits port 1. In a reciprocal device the same fraction of energy that flows from port 1 to port 2 would occur to energy flowing in the opposite direction, from port 2 to port 1. The scattering matrix for an ideal three-port circulator is

$$[S] = \begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$

S-Matrix of Circulator

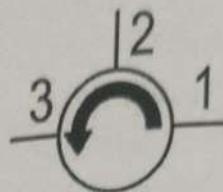


Fig 4.4: Circulator

An isolator is a two-port device that transmits microwave or radio frequency power in one direction only. It is used to shield equipment on its input side, from the effects of conditions on its output side, for example, to prevent a microwave source being detuned by a mismatched load. An isolator is a non-reciprocal device, with a non-symmetric scattering matrix. An ideal isolator transmits all the power entering port 1 to port 2, while absorbing all the power entering port 2, its S-matrix is

$$[S] = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix}$$

S-Matrix

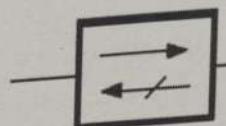


Fig 4.5: Isolator

## PROCEDURE:

1. Connect the components as shown in experimental set up Fig 4.3.
2. Structure of a circulator and isolator are shown in the Fig 4.4 and Fig 4.5 respectively.
3. Energize the microwave source for particular frequency of operation.
4. With the help of variable attenuator and gain control knob of VSWR meter set any power level in the CRO/SWR meter.
5. Verify the s-matrix for both circulator, isolator and attenuator.

## RESULT

### S-matrix of a Circulator:

SI No	Parameter	Value (dB)
1	S13	-16.12
2	S21	-16.12
3	S32	-16.12

S12=S23=S31=0 (To verify)

**S-matrix of a Isolator:**

Sl No	Parameter	Value (dB)
1	S12	-35.8
2	S21	-16.9

**S-matrix of a Attenuator:**

Sl No	Parameter	Value (dB)
1	S12	-
2	S21	-

**Observations:**

→ Magic Tee, due to symmetric property we get  $S_{ij} = S_{ji}$   
 Also because of zero property and unitary property  
 $S_{31} = S_{32}$  and  $S_{41} = S_{42}$ .

→ For circulator we observe that power is only available at the port which is circularly next to I/P port.

→ For isolator we find power is only made available on particular direction

→ If the direction of power flow is in comparison to allowed direction a high isolation is provided.

Sl.No	Criteria	Max Marks	Marks obtained
<b>Data sheet</b>			
1	Problem statement	10	
2	Design & specifications	10	
3	Expected output	10	
<b>Record</b>			
4	Simulation/ Conduction of the experiment	15	
5	Analysis of the result	15	
6	Viva	40	
7	Total	100	
<b>Scale down to 10 marks</b>			
<b>Staff Signature:</b>			

# R.V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Date \_\_\_\_\_ Name Lakhan Singh + E

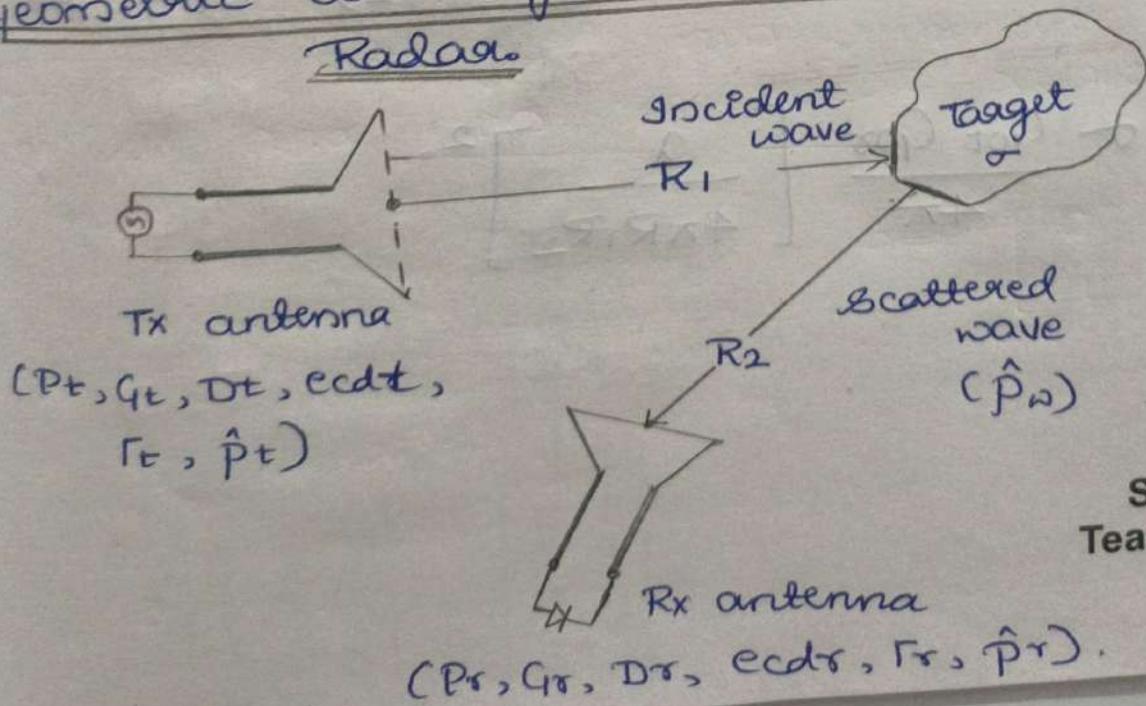
Dept./Lab ECE - MWRS Class VII B Expt./No. 5

Title Illustrations of Radar Range.

Aim: To compute the range and objection detection using x-band horn antenna Tx and Rx with different Radar Cross section (RCS).

Equipment Required: Kybstons power supply, Isolator, Freq meter, Variable attenuator, x-band detector, horn antenna, metal plate, waveguide-to-BNC adapter, Oscilloscope, Power meter.

Geometric arrangement of Tx, target, Rx for Radar.



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$$\rightarrow P_t = \pi R^2 \omega s = \epsilon c d t e c d r \sigma \frac{P_t D_t(\theta_t, \phi_t) D_r(\theta_r, \phi_r)}{4\pi}$$

$$* \left( \frac{\lambda}{4\pi R} \right)^2$$

→ Rx power to i/p power

$$\frac{P_r}{P_t} = \epsilon c d t e c d r \sigma \frac{D_t(\theta_t, \phi_t) D_r(\theta_r, \phi_r)}{4\pi}$$

→ losses included.

$$\frac{P_r}{P_t} = \epsilon c d t e c d r [1 - |T_t|^2] [1 - |T_r|^2] \sigma \frac{D_t D_r}{4\pi} \times \left( \frac{\lambda}{4\pi R_1 R_2} \right)^2 |P_i^w \cdot P_r^w|$$

$$\rightarrow \frac{P_r}{P_t} = \sigma \frac{G_{ot} G_{or}}{4\pi} \left[ \frac{\lambda}{4\pi R_1 R_2} \right]^2$$

# V. COLLEGE OF ENGINEERING®

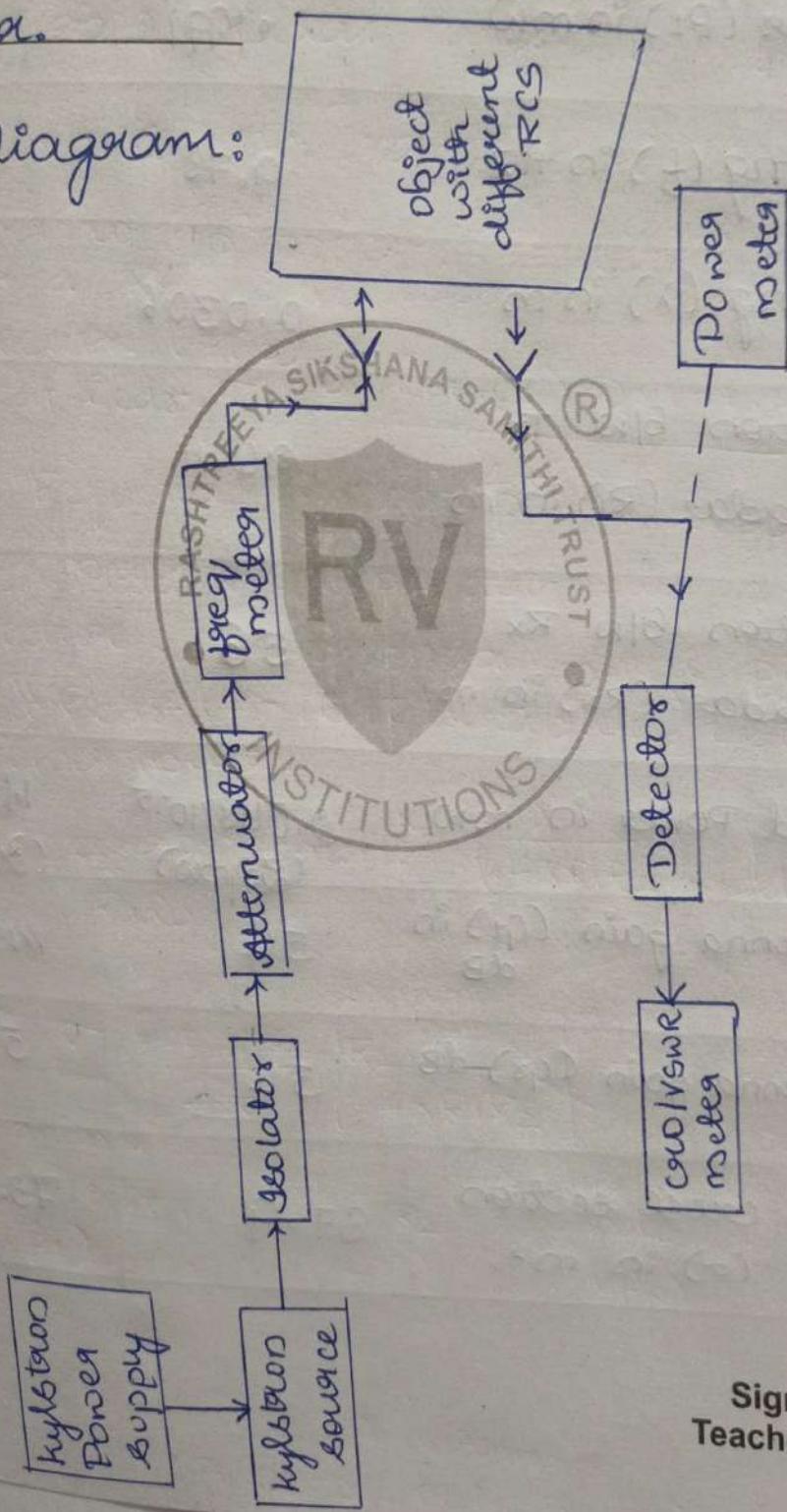
## OBSERVATION / DATA SHEET

Name Dakhan Singh . te

Dept/Lab ECE - MWRS Class VII B Expt./No. 5

Radar.

Block diagram:



Signature of  
Teacher Incharge

## Tabular columns

Parameter	Target 1	Target 2
Tx power ( $P_t$ ) in mW	1971	1971
Operating ( $f$ ) in Hz	9.78	9.78
Operating ( $\lambda$ ) in m	0.0306	0.0306
Separation b/w Tx and Radar ( $R_1$ ) in m	94.11	65.35
Separation b/w Rx and Radar ( $R_2$ ) in m	56	54
Received Power in mW	$2.048 \times 10^{-5}$ (2.04mW)	$1.15 \times 10^{-5}$ (1.15mW)
Tx antenna gain ( $G_t$ ) in dB	54	16454X
Rx antenna gain ( $G_r$ ) dB	54	54
Radar cross section ( $\sigma$ ) in $m^2$	87.9	73.01

8. Find the receiver power ( $P_r$ ) of the antenna. Find the radar cross section( $\sigma$ ) of the target by using radar range equation  $\frac{P_r}{P_t} = \sigma \frac{G_t G_r}{4\pi} \left[ \frac{\lambda}{4\pi R_1 R_2} \right]^2$ . Here  $G_t$  and  $G_r$  is practical transmitter and receiver antenna gain.
9. Repeat the step 6 to 8 for the different target object.

### TABULAR COLUMN

RESULTS

Parameters	Target 1	Target 2
transmitted power ( $P_t$ ) in mW	0.1971	0.1971
Operating frequency (f) in Hz	9.78	9.78
Operating wavelength ( $\lambda$ ) in meter	0.0306	0.0306
separating distance between transmitter and target ( $R_1$ ) in meter	94.11	85.35
separating distance between target and receiver antenna ( $R_2$ ) in meter	54	54
received power ( $P_r$ ) in mW	8.8mW	$1.15 \times 10^{-5}$ (34mW)
transmitter antenna gain ( $G_t$ ) in dB	54	54
receiver antenna gain ( $G_r$ ) in dB	54	54
Radar cross section ( $\sigma$ ) in $\text{cm}^2$	87.9	73.01

Observations:

Specific precautions to be taken:

1. Power flowing out of horn antenna may damage the retina of the eye, **do not see directly inside the horn antenna.**
2. Materials present in the vicinity of the experimental setup may be absorbing ones. Keep reflecting objects away from the experimental setup.

# R.V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Date \_\_\_\_\_

Name Dakhan Singh-te

Dept./Lab ECE / MOORS

Class VII B Expt./No. 05

Title Design simulation of microstrip line and hybrid ring using HFSS.

Aim: To design, simulate and analyse the parameter of  $50\Omega$  microstrip line and printed hybrid ring @ given frequency band.

Apparatus: 64 bit PC / Laptop. Ansys HFSS design kit

$$\text{Equation: } V_p = C/V_0$$

$$\beta = k \sqrt{\epsilon_r}$$

$$\epsilon_r = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \frac{1}{\sqrt{1 + 1.2d/\lambda}}$$

$$\frac{\omega}{d} = \begin{cases} \frac{8e^4}{\epsilon^2 \cdot A - 2} & \text{for } \omega/d < 2 \\ \frac{2}{\pi} [B - 1 - \ln(2B - 1) + \frac{\epsilon_r - 1}{2\epsilon_r} \{ \ln(B - 1) + 0.39 - \frac{0.11}{\epsilon_r} \}] & \text{for } \omega/d > 2. \end{cases}$$

$$A = \frac{Z_0}{60} \sqrt{\frac{\epsilon_r + 1}{2}} + \frac{\epsilon_r - 1}{2\epsilon_r} \left[ 0.23 + \frac{0.11}{\epsilon_r} \right]$$

$$B = \frac{377\pi}{2Z_0\sqrt{\epsilon_r}} \quad [S] = -\frac{j}{2} \begin{bmatrix} 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & -1 \\ 1 & 0 & 0 & 1 \\ 0 & -1 & 1 & 0 \end{bmatrix}$$

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## Steps:

1. Insert Hfss design.
  - a. Project → Insert Hfss design.
2. Creating ground plane for microchip line.
3. Draw → Rectangle → mouse pointer in aligns C.
4. Draw rectangle with arbitrary x & y size.
5. Rename the ground plane with ground.
6. Go to Model windows → Rectangle1 → Attribute  
Name → ground.
7. color → orange → Ok.
8. Select the ground plane dimension
9. Model → ground → create rect → x size = 20mm,  
y size = 40mm
10. Design substrate box.  
Draw → Box → position → using mouse → origin (0,0,0)  
x size = 20mm, y size = 40mm → Ok.
11. Rename the box width substrate & choose substrate material solid → vacuum → Name → substrate → material → edit → search by name → "fr4" → select FR4-epoxy → Ok.
12. change the thickness of substrate  
model → solids → FR4 epoxy → substrate → create Box  
→ z size = 1.6mm → Ok.
13. streets → unassigned → Rect1 → Double click → Name =  
"line", colour → orange → Ok.
14. change dimension & position.  
streets → line → create Rect.

# V. COLLEGE OF ENGINEERING<sup>2</sup>®

## OBSERVATION / DATA SHEET

Date \_\_\_\_\_ Name Dakhan Singh. K \_\_\_\_\_

Dept./Lab ECE I MWRS. Class VII B Expt./No. 6

Title Microstrip & Hybrid Ring.

16. using del command select both ground & line  
→ Right mouse click → Assign boundary → Perfect e.
17. Assign excitation for port1 and port2.
18. Draw → Rect → with mouse pointer select face of microstrip line.
19. Adjust port 1 to accurate dimensions.  
model → sheets → unassigned → Port 1 → create Rect position → 8.5, 0, 1.6.
20. X size → 3.
21. Create Radiation Box,  
model → solids → air → radiations, Right click on mouse → Assign Boundary → Radiation → OK.
22. In project manager explorer.  
hfss design → Analysis → Right click → Add solution setup → solution frequency → 5GHz → OK.
23. Distribution → linear step → 1GHz - 20GHz  
step size = 0.1GHz, sweep type → fast click on preview to check the no. of iterations execution.
25. hfss → validate check if error is displayed then

Signature of  
Teacher Incharge

- check the boundary, dimensions & excitations
25. If yes  $\rightarrow$  validation check if error is less than check the boundary, dimensions & excitations.
26. After validation  $\rightarrow$  execute Analyse all.

HFSS procedure for hybrid Ring

26. for post line:

$$f = 2.4 \text{ GHz}, \epsilon_r = 4.4, H = 1.6 \text{ mm}, Z_0 = 50 \Omega, L = 90^\circ \text{ Post width } 3 \text{ mm.}$$

for inner radius:

$$f = 2.4 \text{ GHz}, \epsilon_r = 4.4, H = 1.6 \text{ mm}, Z_0 = 70.7 \Omega, L = 540^\circ, \text{Radius width} = 1.62 \text{ mm, length} = 105 \text{ mm.}$$

27. Design Parameters:

$$\text{width } (70.7 \Omega) = 1.62 \text{ mm}$$

$$\text{length } (70.7 \Omega) = 10.5 \text{ mm}$$

$$R = 15.9 \text{ mm}$$

$$\tau = 17.52 \text{ mm.}$$

28. Rectangle designs:

$$x \text{ size} = 3 \text{ mm}$$

$$y \text{ size} = 24 \text{ mm}$$

$$\text{position} = -1.5, -30, 0$$

# L.V. COLLEGE OF ENGINEERING

## OBSERVATION / DATA SHEET

Date \_\_\_\_\_

Name Lakhan Singh + H

Dept./Lab ECE - MURS

Class VII B Expt./No. 5

Title Microstrip & Hybrid ring

31. Draw substrate & ground plane beneath hybrid ring.

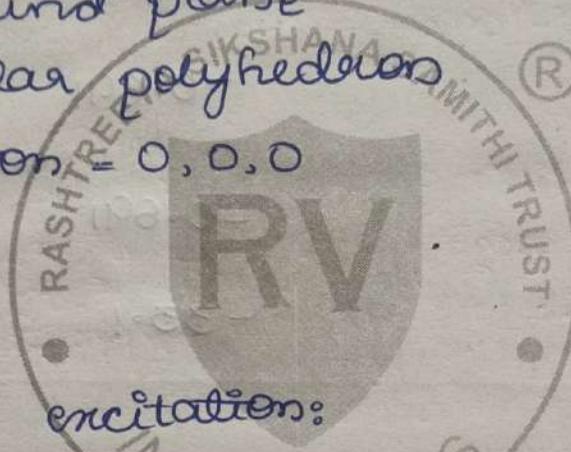
→ Route → Axis → Z → Angle 30° → OK

→ creating ground plane

→ Draw regular polyhedrons  
centre position = 0, 0, 0

Axis = Z

height = 0mm



32. Assign port excitation:

→ lumped port → name → 1/2/3/4

Assign excitation for renaming ports

33. Draw box (-50, -50, -50)

x = 100, y = 100, z = 100.

34. Draw material as air to Box.

35. Increase transparency of box.

36. Assign Boundary as Radiation Box.

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Results:

construct a table of s parameters for microstrip line & plot s parameter

parameter

$S_{11}$

dB

-112.3

$S_{12}$

-0.691

$S_{21}$

-0.691

$S_{22}$

-33.1

$$[S] = -j/\sqrt{2} \begin{bmatrix} 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & -1 \\ 1 & 0 & 0 & 1 \\ 0 & -1 & 1 & 0 \end{bmatrix}$$

hybrid ring.

### Observations

- \* we get  $S_{11}$  and  $S_{22}$  (i.e (reflection coefficient) is less than  $-20\text{dB}$  showing not much reflection on designed freq. Hence micro strip wire typically can operate B/w 1 to  $20\text{GHz}$ .
- \* The  $S_{12}$  or  $S_{21}$  (Transmission coefficient) is around 0 to  $-30\text{dB}$ , which suggest that transmission happens around 1 to  $20\text{GHz}$ .  $S_{12}$  and  $S_{21}$  gradually decrease with increase in frequency which suggest less or gradually increasing to higher frequency.

Sl.No	Criteria	Max Marks	Marks obtained
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# R.V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Date \_\_\_\_\_ Name Lakhan Singhote

Dept./Lab ECE - MCORS Class VII B Expt./No. 7

Title Design and Simulation of Rectangular Waveguide and Magic See using HFSS.

Aim: To design , simulate and analyze the Rectangular waveguide and magic see.

Equipment required: 64 bit personal computer with HFSS.

### Procedure:

- HFSS → validation check
- HFSS → Analyze all
- Tools → Options → General options
- Expand HFSS branch
- left mouse click boundary assignment
- use wizard for data i/p when creating new boundaries checked
- Duplicate boundaries/mesh operations with geometry checked.

### Setting tool options

- Expand the 3D modeler branch
- Drawing: edit properties of new primitives: checked.

Signature of  
Teacher Incharge

Expand the display branch

Rendering set default transparency to 0.  
History tree: Select last command on object checked.

- Start HFSS and define geometry
- Select → HFSS → Solution type → model
- Select → Modeler → units → mm
- Define geometry: Draw Box → click three times in main area
- In box properties tab → define position  
Position:  $-a/2, -b/2, 0$ .
- Define parameter used.
  - Unit type: length
  - Unit: mm
  - value for  $a = 22.86$
  - value for  $b = 10.16$
- Reset the value.
  - X size:  $a$
  - Y size:  $b$
  - Z size:  $l$
- click OK.
- Define 'L', length of waveguide along Z axis.
  - unit type = length
  - unit: mm
  - value of  $L = 60$ . OK.

# V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Name Lakhans Singh

Dept./Lab ECE - MWRS Class VII B Expt./No. 7

Title Rectangular wave guide

- copy the inner wall definition and then modify it to give waveguide thickness.
- click on box object Box1 and  $ctrl+C$  and  $ctrl+V$  in same plane. Box2 is created.
- Double click on Box2,  
Name : metal  
Material : copper
- Open command tab for this airbox by double click create box under copper solid , change properties.

Position:  $-a/2 + th, -b/2 - th, 0$ .

- Define th value.

Unit type : length

Unit : mm

Value for th : 0.2

X size :  $a + 2 * th$

Y size :  $b + 2 * th$

click OK,

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Teacher Incharge

- modeler → Boolean → Subtract.
- In modeler tree, select Box1 and copy with Not assigned solid, apply Name: air  
Material: air  
Transparent: 1
- In modeler tree, select air and copy with new air1 solid, apply Name: Radiation  
Material: air  
Transparent: 1  
Position:  $-a/2 - 5\text{mm}$ ,  $-b/2 - 5\text{mm}$ , 0  
X size:  $a + 10\text{mm}$   
Y size:  $b + 10\text{mm}$   
Z size: L
- New assigns this box as radiation boundary modeler tree, RC on radiation solid → Assigns Boundary → radiation ok.
- Press F to enter face selection mode.  
Select x-y plane  
face → Assigns excitation → wave part.
- Integration line → new line → 3<sup>rd</sup> modeler editor.

# V. COLLEGE OF ENGINEERING

## OBSERVATION / DATA SHEET

Date

Name: Lakhans Singh, 1E

Dept/Lab: ECE - MWRS

Class: VII B

Expt./No.: 7

Title: Waveguide & Magic Tee.

→ Project manager → analysis → add solution  
setup → advance.

Freq: 10GHz

Num of pass: 10

OK.

→ setup → Add freq sweep

sweep type: Discrete

Distribution: Linear step

Start: 5 GHz

End: 17 GHz

Step: 0.1 GHz

Save field: All frequencies checked.

Simulation:

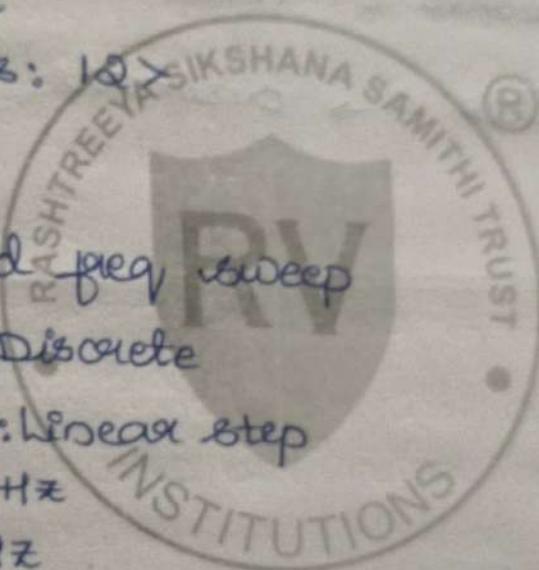
→ HFSS → validation check → analyze all

→ Project manager → part field display → mode

→ model tree, R click on Air solid:

Plot field → E → mag E.

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Teacher Incharge



- ~~Hfield~~ → Field → Edit sources → mode 2 and view result and observe the change in  $E$  field.
- Remove plot visibility for Mag-E.
- model tree, R click on Air solid:  
Plot field  $\rightarrow E \rightarrow$  vector-E.
- field → edit sources → activate first mode and observe  $E$ -vector.  
R click vector  $E \rightarrow$  animate.

# V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Name Dakhan Singh - H  
Dept./Lab ECE - MWRS Class VII B Expt./No. 7  
Title Magic Tee

→ draw the box and its dimension

Draw → Box → Use mouse pointer → select origin  
(0, 0, 0)

→ model → vacuum → box → Create box

Position → (1143; 0, -5.08)

x → 22.86

y, → 100

z → 10.16

→ Duplicate the box.

\* Port 2

Axis: z

Angle: 90°

Total no.: 2

\* Port 1

Axis: z

Angle: -90°

Total number: 2

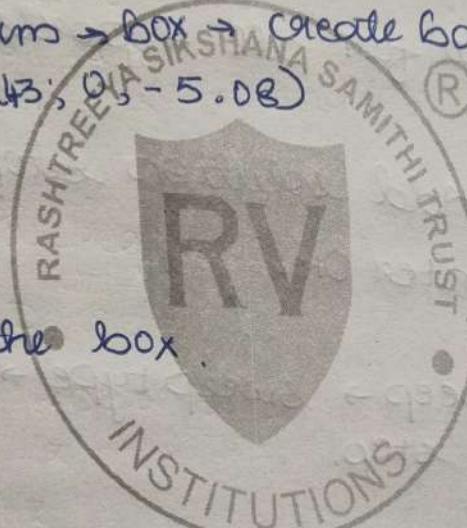
\* Port 3

Axis: y

Angle: -90°

Total no.: 2

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Teacher Incharge



- Edit → select all
- modeler → Booleans → unfile.
- select ctrl + select all arms except face
- Right click mouse → Assign Boundary → Perfect E → Name → PerfectE.
- Assign excitation → waveport → Name → 3. Integration line → new line
- Similarly do for all 4 ports.
- Analysis → Add solution setup → Solution freq → 10GHz → Enter Ok.
- Add freq sweep → Sweep type → Interpolation,  
Type → linear step.
- Start : 6GHz ; Stop : 15GHz, Step size: 0.1GHz.
- Hfield → validate check → Analyze all.
- Model solution data report → Rectangular  
Port → choose S parameter → quantity →  
 $S_{1,1}$ ,  $S_{1,2}$ ,  $S_{2,1}$ ,  $S_{2,2}$ , click new report.
- magic tee → create field overlay → Plot →  $E \rightarrow$  vector-E.
- Similarly E field magnitude (mag-E) can be seen. plot

PARAMETERS	(dB) @ 6GHz.
S11	0.00098 = -60.17
S22	0.00098 = -71.05
S33	0.00093 = -60.63
S44	0.0012 = -58.41
S12=S21	3.7656. = 11.51
S13=S31	0.00055 = -65.19
S14=S41	0.000555 = -65.19
S23=S32	1.673 = 4.46
S24=S42	1.7389 = 4.805
S34=S43	0.00046. = -66.74.

## Observations:

The designed magic tee gives high isolation loss about -60dB for designed frequency.

The observed value of magic tee is in accordance with theoretical expected value of magic Tee.

At given freq 10GHz, magic Tee is designed and S-parameter plot was calculated and analysed.

Sl.No	Criteria	Max Marks	Marks obtained
Data sheet			
1	Problem statement	10	
2	Design & specifications	10	
3	Expected output	10	
Record			
4	Simulation/ Conduction of the experiment	15	
5	Analysis of the result	15	
6	Viva	40	
7	Total	100	
Scale down to 10 marks			

# R.V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Name Lakhan Singh +e

Date \_\_\_\_\_

Dept./Lab ECE LABS

Class VII B Expt./No. 7

Title Design & simulation of patch antenna & optimetrics using HFSS.

aim: Design & simulation of a coaxial-fed rectangular microstrip patch, printed dipole & horn antenna @ a specified resonant frequency with HFSS software.

apparatus: 64 bit PC, Analysis HFSS designs soft.

### Procedure:

1. Probe - fed patch antenna with optimetrics.
2. Restore archive & save optimetrics  $\rightarrow$  patch1.
3. Checking local variable feed - pos & patch-length
4. Design variable are local variable.
5. start parametric analysis setup.
6. parametric Analysis setup - Add sweep
7. HPC & Analysis options
8. HPC: Analysis configuration  $\rightarrow$  Analyse optimetric
9. save, validate & analyse HFSS Design optimetric
10. view s - parameter Result  $\rightarrow$  optimetric
11. start optimisation Analysis  
Startup  $\rightarrow$  optimisation

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Name: feed - POS

Include:

min: 10mm

max: 12mm

12. opens optimization analysis setup dialog  
→ Goals tab.
13. optimisation setup, edit, calculation Range  
Select 1.08 GHz
14. optimisation setup dialogue → variable  
→ optimetrics → patch1 and for patch3
15. optimisation Result table → optimetrics
16. S parameter Results setup & plot P3.
17. Analytic derivatives S-parameter nonim plot.
18. Add tuning plot to S parameter.
19. Analytic derivative: Radiation pattern nonim Trace (1012)
  - Setup 1: last adaptive
  - Geometry: Infinite sphere
  - Intrace tab: category: Gain  
Quantity: Gain total  
function: dB.
20. Analytic Derivatives: Radiation patterns tuning trace
21. Analytic derivatives: Radiation pattern tuning plot (2013).

**Observations:**

Micromstrip patch antenna was low profile antenna with conventional antenna. They have more advantages and better prospects like light weight, low volume and cost.

At given freq 1.8 GHz, the rectangular micromstrip patch antenna & dipole antenna were designed and simulated in software.

The S parameter plot was obtained & analysed along with the radiation patterns with performance for various patch width & feed position values.

Sl.No	Criteria	Max Marks	Marks obtained
<b>Data sheet</b>			
1	Problem statement	10	
2	Design & specifications	10	
3	Expected output	10	
<b>Record</b>			
4	Simulation/ Conduction of the experiment	15	
5	Analysis of the result	15	
6	Viva	40	
7	Total	100	
Scale down to 10 marks			

# R.V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Date \_\_\_\_\_ Name Sakthi Singh \_\_\_\_\_

Dept./Lab ECE - MWRS Class VII B Expt./No. 9

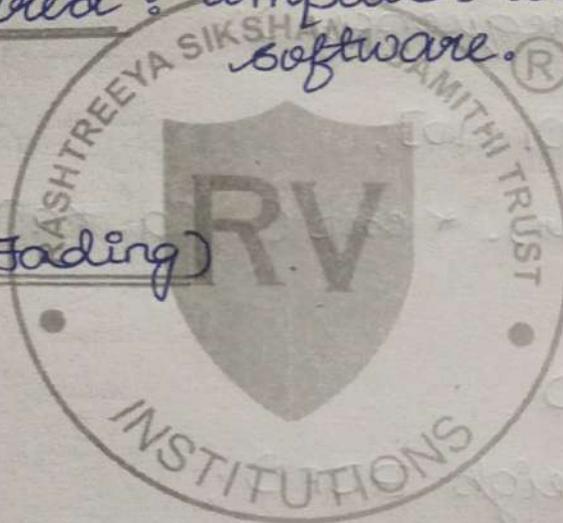
Title Performance Analysis of Rayleigh Fading channel model.

Aim: Performance Analysis of Rayleigh Fading channel model using MATLAB.

Equipment required : Computer with MATLAB software.

Matlab code :

BPSK (AWGN Fading)



clc;

close all;

N = 20000;

SNR\_limit = 35;

SNR\_dB = -5: 0.5: SNR\_limit;

SNR = 10^(SNR\_dB/10);

u = rand(1, N);

m = floor(2 \* rand(1, N));

vaa = 1;

nstd = sqrt(vaa);

y = (zeros(1, N));

Pe\_BPSK\_sim = (zeros(1, length(SNR)));

Pe\_BPSK\_sim = (zeros(1, length(SNR)));

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Pe-DPSK-BPM = Geows(1, length(SNR));

% Generation rayleigh random variable

$$a = \text{sqrt}(-2 * \text{var} * \log(\text{Pe}));$$

fig(1);

hist(r, 100);

title('rayleigh random variable histogram');

xlabel('random variable R');

ylabel('frequency');

a = [0 : 0.01 : 10];

$$R = (\text{a} * \text{var}) * \exp(-\text{a} * a) / (2 * \text{var});$$

fig(2);

plot(a, R)

title('rayleigh PDF');

xlabel('random variable');

ylabel('probability');

legend('variance = 1');

% BPSK simulation

$$\text{Pe-BPSK-id} = 0.5 * (1 - \text{sqrt}(\text{var} * \text{SNR}) / (1 + \text{sqrt}(\text{SNR})));$$

% BFSK simulation

$$\text{Pe-BFSK-id} = 0.5 * (1 - \text{sqrt}(\text{var} * \text{SNR} / (2 + \text{var} * \text{SNR})));$$

# V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

e \_\_\_\_\_ Name Dakhan Singh - H  
 pt./Lab ECE - MIWRS Class VII B Expt./No. 9

Title Rayleigh fading  
DPSK simulation

$$Pe - DPSK - id = 0.5 \cdot (1 + \gamma_{av} * SNR);$$

% Comparisons of error for AWGN and rayleigh

$$Pe - BPSK - NF = 0.5 * erfc(\sqrt{SNR});$$

$$Pe - BFSK - NF = 0.5 * erfc(\sqrt{SNR_1/2});$$

$$Pe - DPSK - NF = 0.5 * \exp(-SNR);$$

fig(3)

Semilog (SNR-dB, Pe-BPSK\_id, 's.-', SNR-dB,  
 BFSK\_id, 'r\*-', SNR-dB, Pe-DPSK\_id, 'r--',  
 SNR-dB, Pe-BPSK\_NF, 'b.-', SNR\_dB, BFSK\_NF,  
 'b\*-', SNR-dB, Pe-DPSK\_NF, 'b--');

axis([-5 SNR\_limit 0.000001]);

title('performance of BPSK, BFSK, DPSK');

xlabel('SNR(db)');

ylabel('prob of error');

legend('Pe of BPSK with fading,'

'Pe of BFSK with fading,' 'Pe DPSK with fading,'  
 'Pe of BPSK without fading,' 'Pe BFSK without fading');

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Teacher Incharge

## BPSK:

clc;

$$Eb = 1;$$

$$Eb-NO_{-dB} = 0.5 : 35;$$

$$NO_{-Orea}-2 = Eb + 10 \cdot (-EbNo_{-dB}/10)$$

$$\sigma = 1;$$

$$\gamma_{dB} = \sigma^2;$$

BER = zeros (1, length (EbNo\_dB));

% calculation error probability:

for i = 1: length (EbNo\_dB);

no\_errors = 0;

no\_bits = 0;

while no\_errors <= 10

u = rand

alpha = sigma \* sqrt (-2 \* log (u));

noise = sqrt (NO\_Orea - 2(i)) \* randn;

y = alpha + sqrt (Eb) + noise;

if y <= 0

y-d = 1;

else

y-d = 0;

end

# I. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Name Sakhan Singh. H  
Lab No. EC-MSUR Class VII B Expt./No. 9  
Title Rayleigh modeling

$$\text{no\_bits} = \text{no\_bits} + 1;$$

$$\text{no\_errors} = \text{no\_errors} + y - d;$$

end

BER(i) = no\_errors/no\_bits;  
end.

7. Calculation & ~~exaxc prob using theoretical~~

$$\rho_{ho\_6} = Eb / (No\_over - 2 * var);$$

$$P_2 = 1/2 * (1 - \sqrt{\rho_{ho\_6}} / (1 + \rho_{ho\_6}));$$

8. Plot results

Scilab (Eb\_No\_dB, BER, ' - \* ', Eb\_No\_dB, P2, ' -o')

title ('monte carlo simulation for BPSK');

xlabel ('Average SNR/bit (dB));

ylabel ('Error probability');

legend ('monte carlo simulation', 'Theoretical value');

Signature of  
Teacher Incharge

```
BER(i) = no_errors/no_bits ;%estimated error probability
```

```
end
```

```
% Calculation of error probabilit using the theoretical formula:
```

```
rho_b = Eb./No_over_2*var;
```

```
P2 = 1/2*(1-sqrt(rho_b./(1+rho_b))); %the theoretical value
```

```
% Plot the results:
```

```
semilogy(EbNo_dB, BER, '-* ', EbNo_dB, P2, '-o')
```

```
title('Montecarlosimualtion for Performance of BPSK signal');
```

```
xlabel('Average SNR/bit (dB)')
```

```
ylabel('Error Probability')
```

```
legend('Monte Carlo simulation','Theoretical value')
```

#### Observations:

- \* Probability of error decreases significantly for modulation scheme without fading with increase in signal to noise ratio (SNR)
- \* In presence of noise and interference (with monte carlo simulation), we observe the probability of error decreases.
- \* we observe a peak in rayleigh random variable distribution at range from 0.5 to 1.5 with peak probability of error of 0.6.

Sl.No	Criteria	Max Marks	Marks obtained
Data sheet			
1	Problem statement	10	
2	Design & specifications	10	
3	Expected output	10	
Record			
4	Simulation/ Conduction of the experiment	15	
5	Analysis of the result	15	
6	Viva	40	
7	Total	100	
Scale down to 10 marks			

# R.V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Date \_\_\_\_\_ Name Lakhman Singh - H \_\_\_\_\_

Dept./Lab MWORKS - ECE Class VII B Expt./No. 10 \_\_\_\_\_

Title Simulation of OFDM transmitter and Receiver.

Aim: Performance Analysis of OFDM Transmitter and Receiver using Matlab software.

Equipments Required: Computer with Matlab software

Matlab code:

clear all

nFFT = 64;

nDSC = 52;

nbitpersym = 52;

nSym = 10^4; % no. of symbol

EBNodB = [0:10] % bit to noise ratio

ESNOdB = EBNodB + 10\*log10(nDSC/nFFT) +  
10\*log10(64/180); % covering to symbol to  
noise ratio.

for ii = 1: length(EBNodB)

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Teacher Incharge

## % Transmitter

ipBit = rand(1, nBitperSym \* nsym) > 0.5;

% random 1's and 0's

ipMod = 2 \* ipBit - 1;

ipMod = reshape(ipMod, nBitperSym, nsym)

% Assigning modulated symbols to subcarriers  
from [-26 to -1, 1 to 26].

XF = [zeros(nsym, 6) ipMod(:, [nBitperSym/2])  
zeros(nsym, 1) ipMod(:, [nBitperSym/2 + 1:  
nBitperSym]) zeros(nsym, 5)];

xt = (nFFT / sqrt(nDSC)) \* ifft(fftshift(XF.'));  
% Appending cyclic prefix

xt = [xt(:, [49:64]) xt];

% Concatenating multiple symbols to form long vector

xt = reshape(xt.', 1, nsym \* 80);

% Gaussian noise

nt = 1/sqrt(2) \* [randn(1, nsym \* 80) + j \* randn(1,  
nsym \* 80)];

yt = sqrt(80/64) \* xt + 10^[-ESNdB(ii)/20] \* nt;

# R.V. COLLEGE OF ENGINEERING®

## OBSERVATION / DATA SHEET

Date \_\_\_\_\_ Name Sakhan Singh \_\_\_\_\_  
 Dept./Lab ECE - MWRS Class VII B Expt./No. 10  
 Title OFDM TX & RX.

### % Receiver

$yt = \text{reshape}(yt.^*, 80, n\text{sym}).^*$ ;  
 $yt = yt(:, [17:80]);$  % removing cyclic prefix.  
 % converting of frequency domain  
 $yF = (\text{sqrt}(n\text{DSO})/\text{nFFT}) * \text{fftsift}(\text{fft}(yt.^*).^*);$   
 $yMod = yF(:, [6 + [1:n\text{BitPerSym}/2] : 7 + [n\text{BitPerSym}/2  
 + 1 : n\text{BitPerSym}]]);$

### % BPSK demodulation

% +ve value  $\rightarrow 1$ , -ve value  $\rightarrow -1$ ;  
 $ipModLat = 2 * \text{floor}(\text{real}(yMod/2)) + 1;$   
 $ipModLat = (\text{find}(ipModLat > 1)) = +1;$   
 $ipModLat (\text{find}(ipModLat < -1)) = -1;$

### % converting modulated values into bits:

$ipBitLat = (ipModLat + 1)/2;$   
 $ipBitLat = \text{reshape}(ipBitLat.^*, n\text{BitPerSym} * n\text{Sym}, 1).^*;$

Signature of  
Teacher Incharge

% counting the errors,

$n_{\text{err}}(i) = \text{size}(\text{find}(\text{ipBit}(\text{t}) - \text{ipBit}(i), 2))$ ,

end

$\text{SimBer} = n_{\text{err}} / (\text{nSym} * \text{nBitPerSym})$ ;

$\text{theoryBer} = (1/2) * \text{erfc}(\text{sqrt}(10.1 * (\text{EBNODB}/10)))$

close all;

Fig Semilogy (EBNODB, theoryBer, 'bs-', linewidth)

hold on

Semilogy (EBNODB, SimBer, 'mx-', 'Linewidth', 2);

axis ([0, 10, 10<sup>-5</sup>, 1])

grid on

legend ('theory', 'simulation');

xlabel ('Eb/No, dB')

ylabel ('Bit Error Rate')

title ('Bit error probability curve for BPSK  
using OFDM')

```

        %ounting the errors
r(ii) = size(find(ipBitHat - ipBit),2);

ber = nErr/(nSym*nBitPerSym);
erryBer = (1/2)*erfc(sqrt(10.^^(EbN0dB/10)));
%all: Fig
%ilogy(EbN0dB,theoryBer,'bs-','LineWidth',2);
%ilogy(EbN0dB,simBer,'mx-','LineWidth',2);
axis([0 10 10^-5 1]);
grid on
legend('theory', 'simulation');
xlabel('Eb/No, dB');
ylabel('Bit Error Rate');
title('Bit error probability curve for BPSK using OFDM')

```

### CONCLUSION:

Observations:

An OFDM signal consists of a no. of closely spaced modulated carriers.

The inverse FFT can therefore be used to realise the basic OFDM signal @ Tx & FFT can be used to recover the symbols @ Rx.

The mitigation of effect ISI which frequently happens with signal of short symbol due to errors in multipath.

As the no. of sub carriers increases the BER starts to deviate from theoretical value

Sl.No	Criteria	Max Marks	Marks obtained
Data sheet			
1	Problem statement	10	
2	Design & specifications	10	
3	Expected output	10	
Record			
4	Simulation/ Conduction of the experiment	15	
5	Analysis of the result	15	
6	Viva	40	
7	Total	100	
Scale down to 10 marks			