R.V. COLLEGE OF ENGINEERING®

OBSERVATION / DATA SHEET

Date ______ Name Lakhan Singh. H

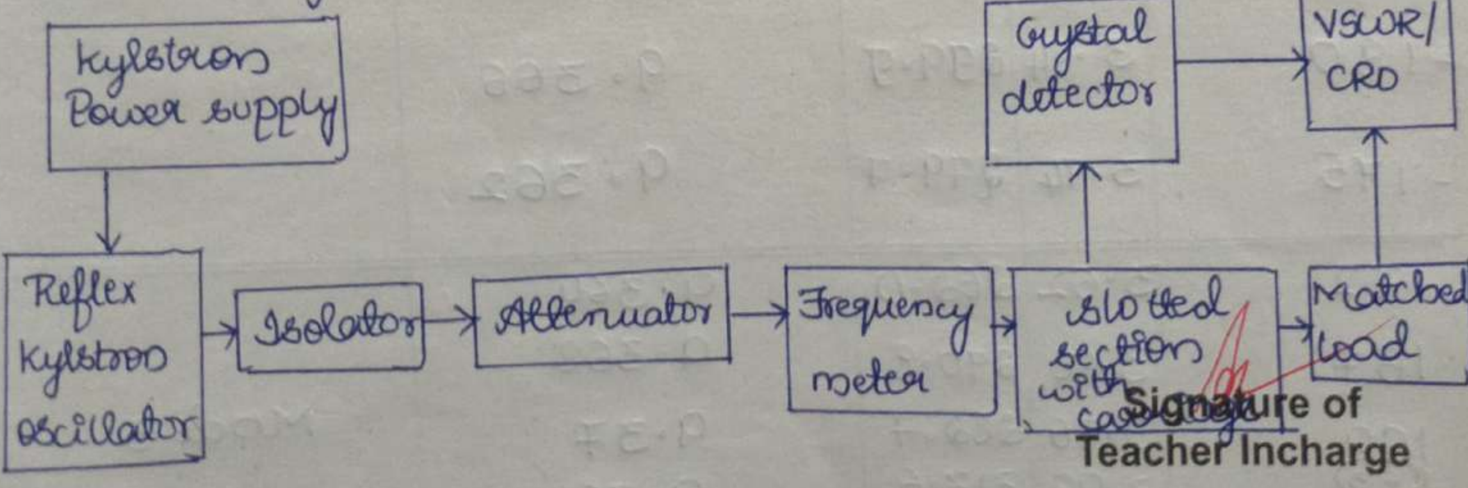
Dept./Lab ECE / MSCOR Class VII B Expt./No. 1

Title Study of Mode curves of Reflex klystron source.

Aim: To conduct a suitable experiment on reflex klystron 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: Kylstron power supply, isolator, frequency meter, variable attenuator x-band detector, wave guide to BNC adaptor and CRO/ VSWR meter.

Block diagram:



Signature of Teacher Incharge

Tabular Columns:

Repeller vtg	Vp-p (V)	Power (mW)	frequency (GHz)	
-245	2.12	89.88	9.523	
-240	2.28	103.96	9.522.	
-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	0.28	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	9.526	
-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

ate ____________ Name Lakhan Singh.H

Dept./Lab ECE - MWRS Class VII B Expt./No. 1

Title Kylstron

$v_1 = -185$ $f_1 = 9.528$ GHz

$v_2 = -140$ $f_2 = 9.524$ GHz.

$$\frac{v_1}{v_2} = \frac{n + 1.75}{n + .75}$$

$$\frac{185}{140} = \frac{n+1.75}{n+.75}$$

$$.321n = .7589$$

$$\therefore \underline{\underline{n = 2.36 \cong 2.}}$$

Transit time:

$$t_1 = \frac{n + 0.75}{f_1} = \frac{2.75}{9.528 \times 10^9} = \underline{\underline{0.2886 \text{ nsec.}}}$$

$n = 2$

$$t_2 = \frac{n + 1.75}{f_2} = \frac{3.75}{9.524 \times 10^9} = \underline{\underline{.393 \text{ nsec.}}}$$

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3. Electronic timing range,

for $t_1 = (f_2 - f_1) = 9.528 - 9.526 = 2MHz$

$t_2 = (f_2 - f_1) = 9.524 - 9.523 = 1MHz$

4. Electronic timing sensitivity,

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

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

$D_1 = 16.5$

$D_2 = 14.8$

$D_3 = 12.5$

$\therefore \lambda g = 2(14.8 - 12.5)$

$\therefore \lambda g = \underline{\underline{4.6 cm}}$

λe =

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Date ____________ Name Lakhan Singh.H

Dept./Lab ECE/MWSR Class VII B Expt./No. 1

Title Kylstron.

Result:

Mode	Case 1	Case 2.
Transit time	0.1836nsec	0.2887nsec
Electronic tuning range	2MHZ	16MHZ.
Electronic tuning sensitivity.	66.66 KHZ/V	100. KHZ/V.

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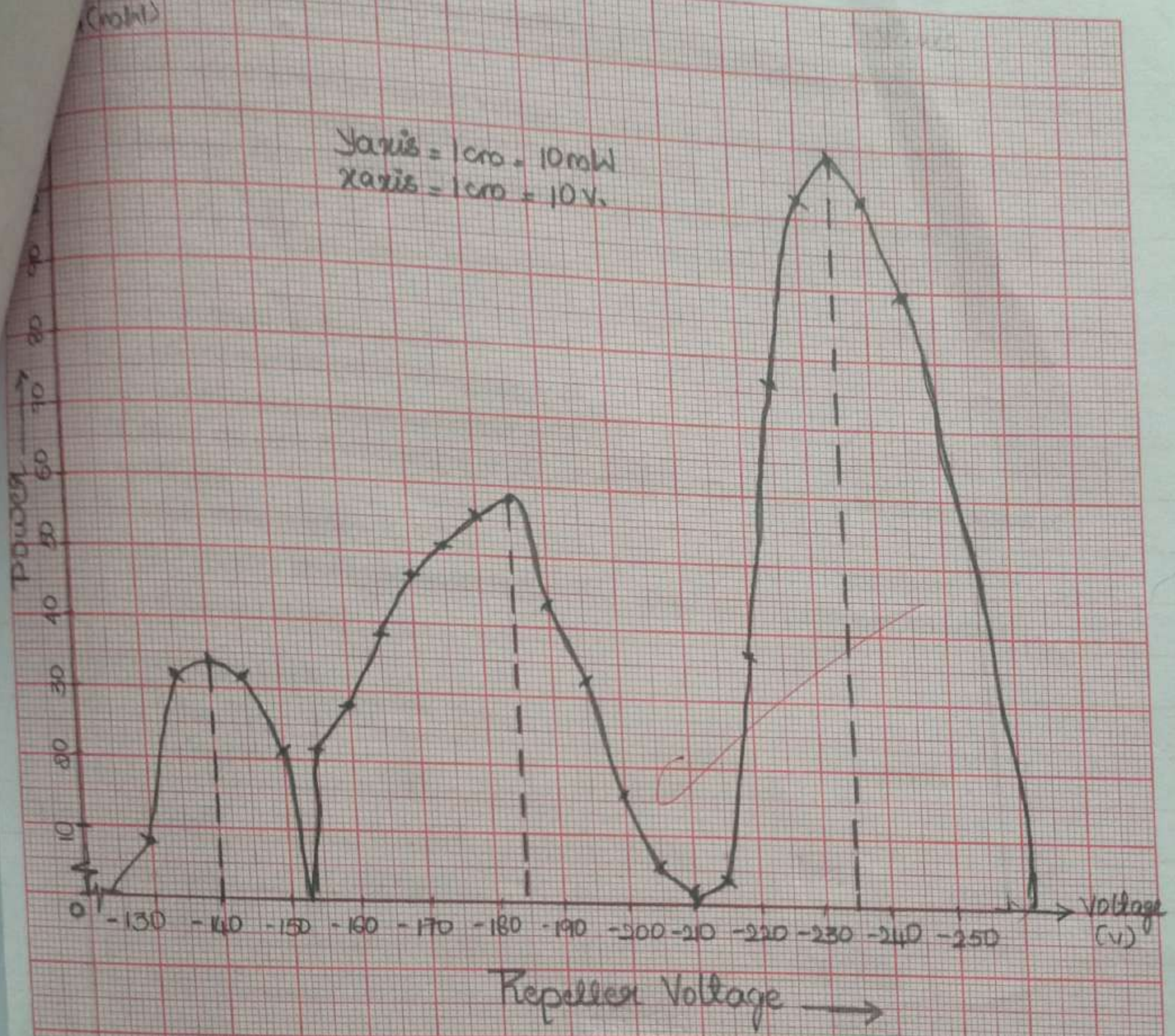
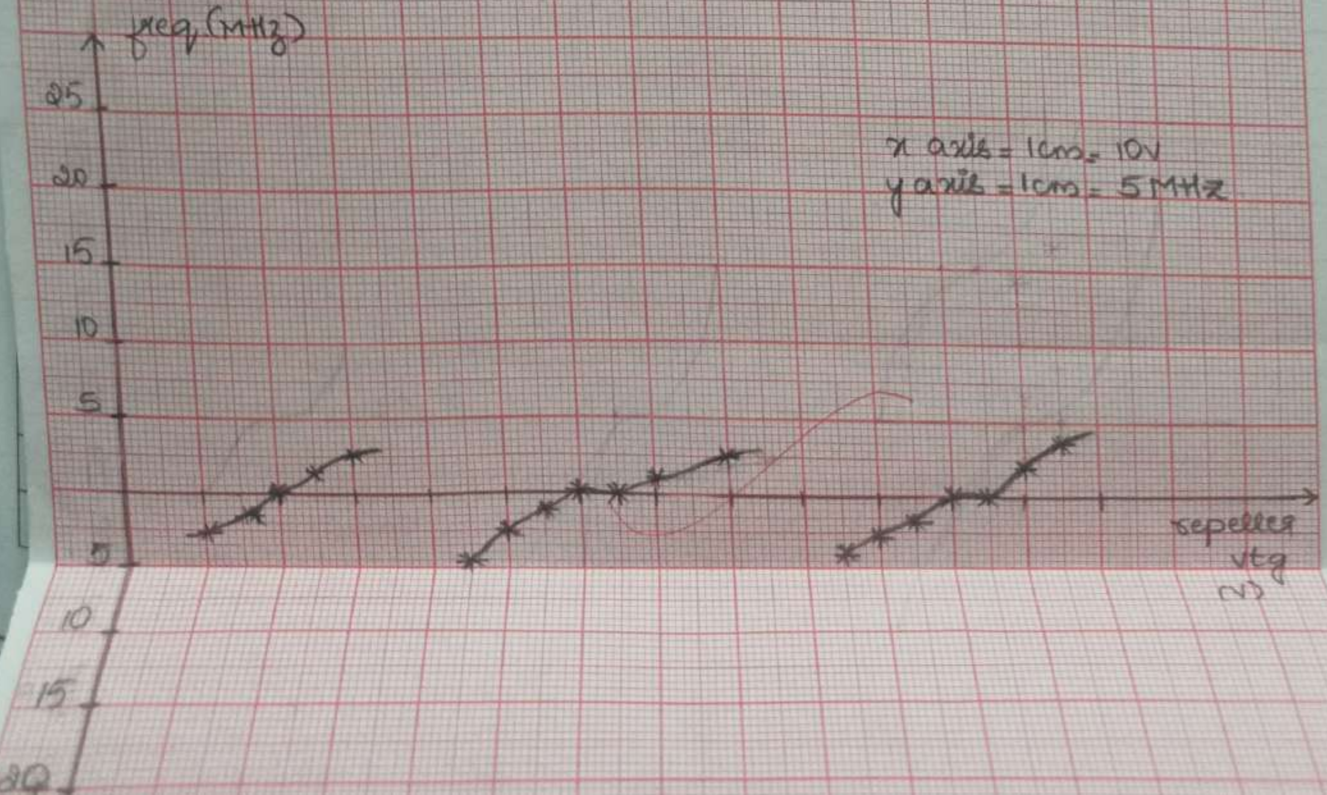


Expected Mode Curves.



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 TE10 mode in rectangular waveguide λ0, λg and λc are related as below

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

λ_0, wavelength in free space in m

λ_g, guided wavelength in waveguide in m

λ_c, cut-off wavelength in waveguide in m

Measure the cut-off wavelength of TE_{10} mode by λ_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 λ_0 is calculated. Operating frequency inside waveguide is $f_0 = {c}/{\lambda_0}$ which can be verified by measured frequency in frequency meter.

TABULAR COLUMN:

S.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	76.83	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	31.25	9.523	
24	-130.	7.2	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:

i. *Never look into the open end of a waveguide or transmission line that is connected to other equipment.*

ii. *Do not place any part of your body against the open end of a waveguide or transmission line.*

iii. ***Turn off the microwave power source when assembling or disassembling components.***

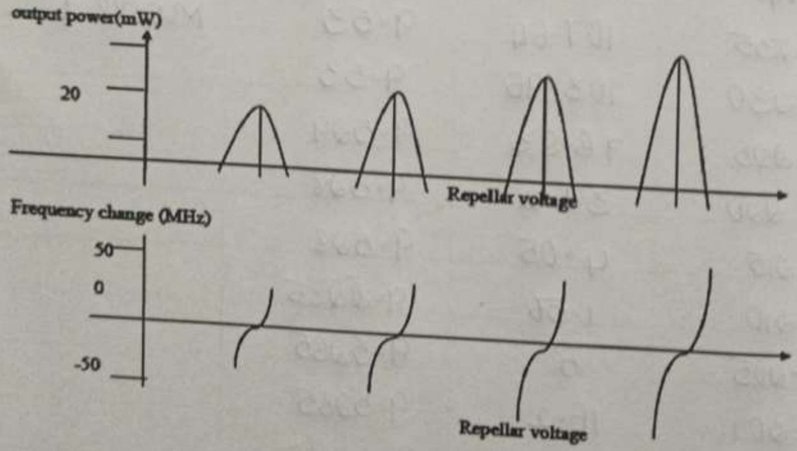


Fig 1.2: Expected Mode curves of a klystron

7. RESULT

Mode No.	Case(1)	Case(2)
Transit time	0.12886×10^{-9} s	0.388×10^{-9} s
Electronic tuning Range	2MHz	1MHz
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 tuning 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 plot 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			9.5/10
Staff Signature:			

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OBSERVATION / DATA SHEET

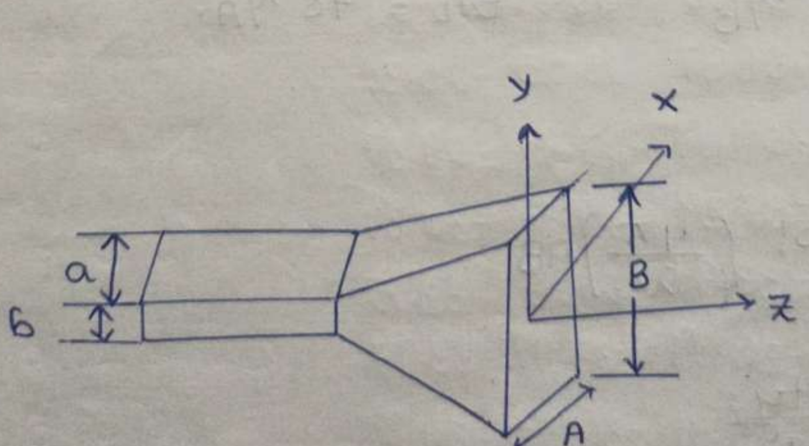
Date ______ Name Lakhan Singh .H

Dept./Lab ECE / MCWSR. 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 comparision.

Equipment required: Kylstron 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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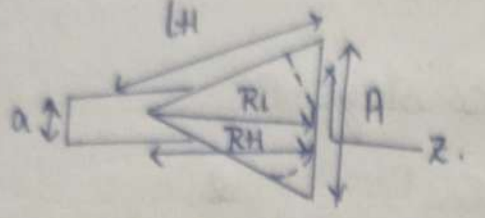
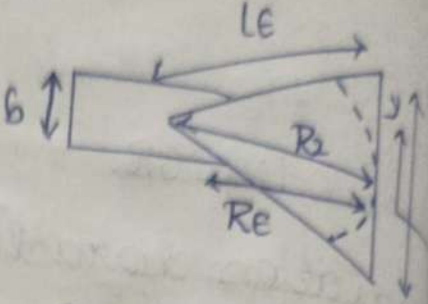


cross section through
xz plane (H plane)



cross section thr
yz plane (E pl

* The normalised radiation pattern of horn

$F_H(\theta) = \frac{1+\cos\theta}{2} f_H(\theta)$ where, $f_H(\theta) \propto \int_{-A/2}^{A/2} \cos \frac{\pi x'}{A} e^{-j\beta}$

↳ H-plane

$e^{j\beta}$

$F_E(\theta) = \frac{1+\cos\theta}{2} f_E(\theta)$ where $f_E(\theta) \propto \int_{-B/2}^{B/2} e^{-j\beta \sqrt{R_2^2 + y'^2}} e^{j\beta}$

↳ E plane.

* half power beamwidth :

$\theta_E = 54\, \lambda/B$ $\qquad \theta_H = 78\, \lambda/A.$

* Gain:

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

* Directivity:

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

2

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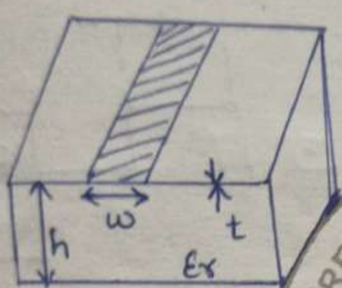
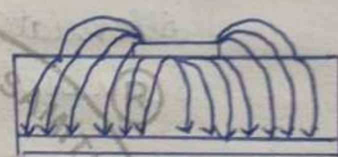
OBSERVATION / DATA SHEET

ate ______ Name Lakhan Singh. H

ept./Lab ECE/ MWOSR Class VII B Expt./No. 2

Title Microstrip Patch antenna.





Electric field lines across plane for microchip line.

The normalised radiation pattern of microstrip patch antenna:

for E: $-90 \le \phi \le 90$; $\theta = 90$

$$E(\phi) = \frac{\sin\left(k_0h/2 \cos\phi\right)}{k_0h/2 \cos\phi} \sin\phi$$

for H: $0 \le \theta \le 180$; $\phi = 0$.

$$E(\theta) = \sin\theta \frac{\sin\left[k_0h/2 \sin\theta\right]}{k_0h/2 \sin\theta} \frac{\sin\left[k_0w/2 \sin\theta\right]}{k_0w/2 \sin\theta}.$$

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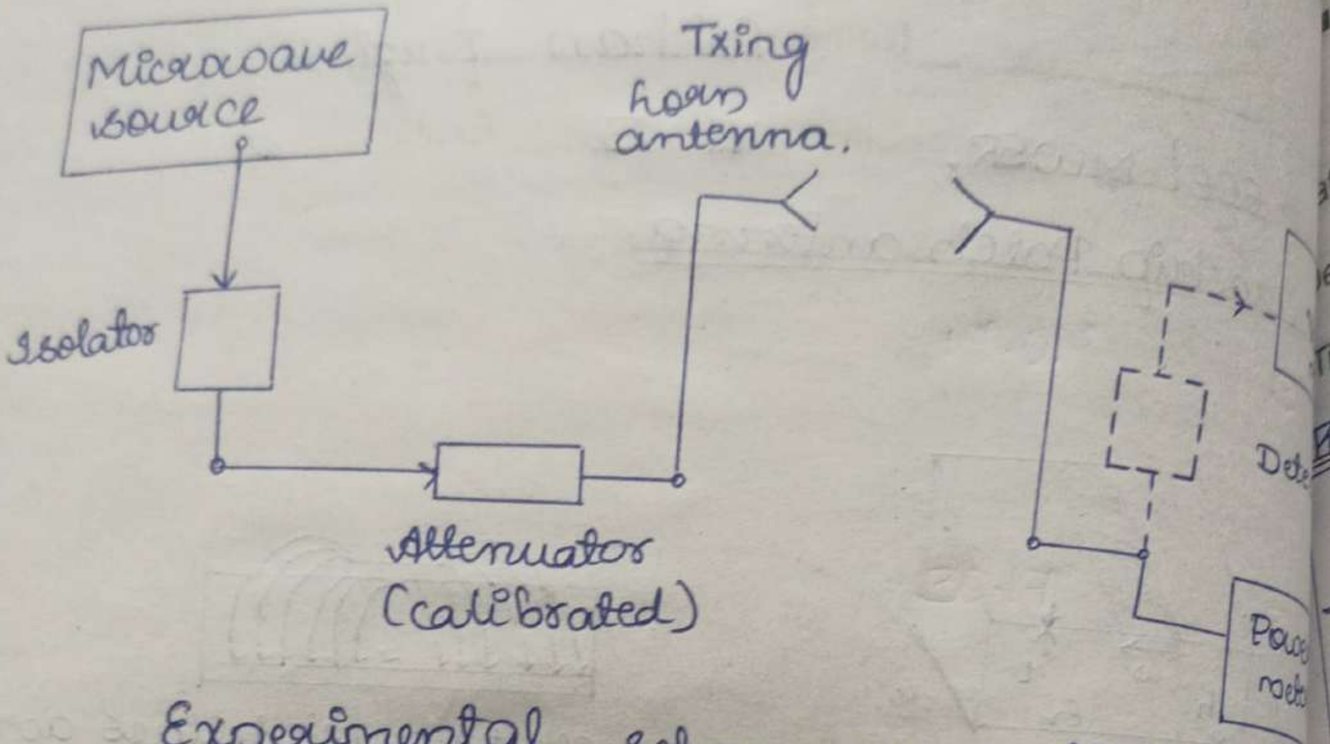
Teacher Incharge

Block diagram:



Experimental setup for radiation pattern measurement.

6. Tabular columns:

	HORN antenna				Patch Antenna			
	Power in H Plane (mW)		Power in E Plane		E plane		H plane	
Angle	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

ate ______ Name Lakhan Singh . K

ept./Lab EEC / MSWE Class VII B Expt./No. 2

Title ______

Result:

Parameter.	HORN Antenna	Patch Antenna.
The transmitted power (Pt)		
The operating fz	9.51GHz	
The operating wavelength	3.15cm	
distance b/w Tx & Rx (R)	.6989m	
The recieved power (Pr)		

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Antenna Parameter	Theoritical	Pra
Half power beamwidth (θ_E)	17.01°	13°
Half power beamwidth (θ_H)	30.17°	30°
Gain	51.67	26.02
Directivity.	78.97	105.

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OBSERVATION / DATA SHEET

Date ______ Name Lakhan Singh.H

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

Title horn antenna.

freq = 9.51GHz

$$\lambda = c/f = \frac{3\times10^8}{9.51\times10^9} = 0.0315\,m = 3.15\,cm$$

A = 8cm

B = 10cm

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

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

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

$$D = \frac{41253}{\theta_E\,\theta_H} = 78.97$$

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

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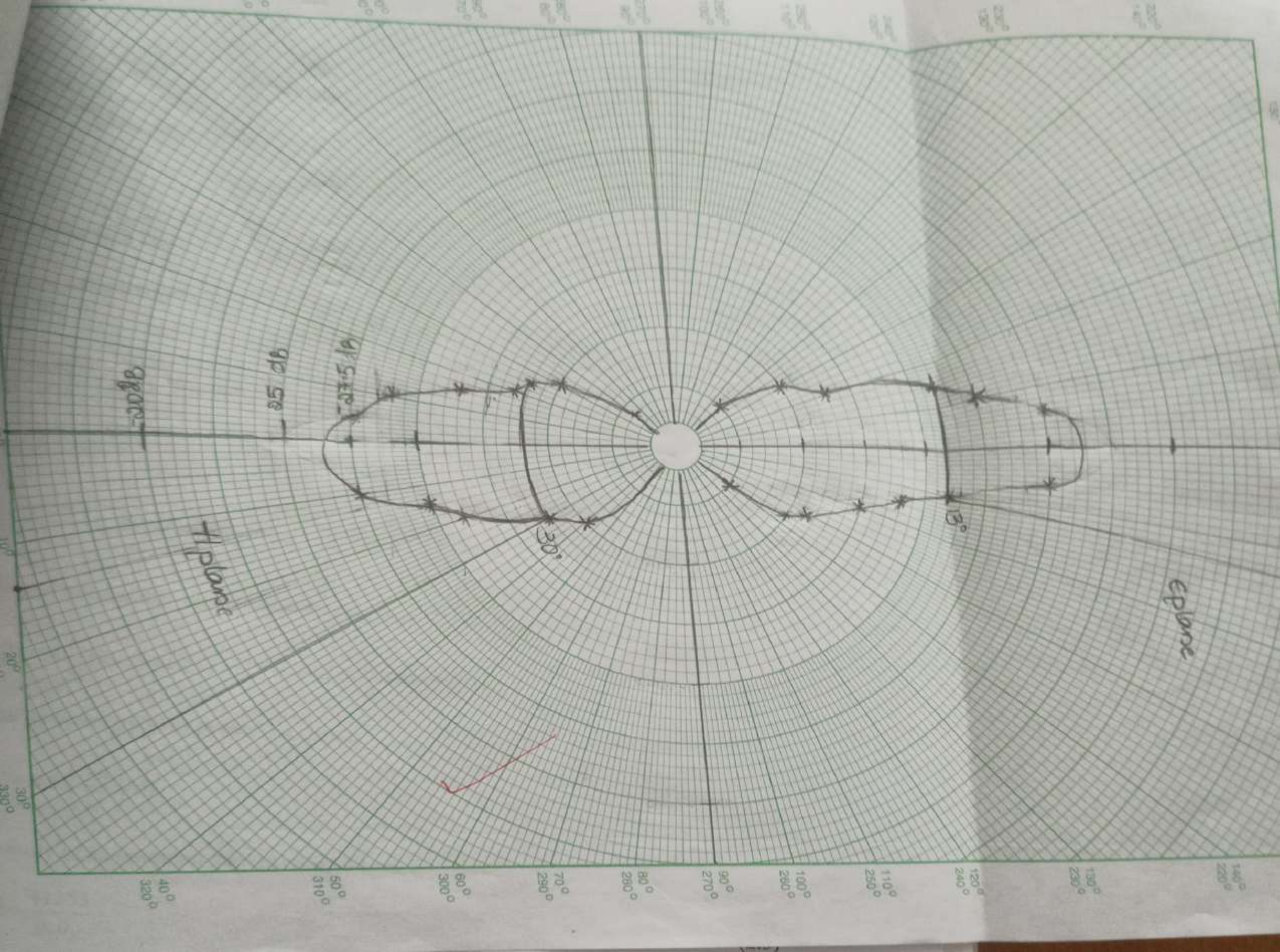

-20dB
-25 dB
-17.5 dB
30°
13°
H plane
E plane

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)	.6989 m	
The received power (Pr)	.512 mW	
Antenna Parameters	**Theoretical**	**Practical**
Half power Beamwidth(θ_E)	17.01	13
Half power Beamwidth(θ_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 Tx and Rx is kept sufficiently large for far field radiation
* Value of beamwidth is taken for every 5° towards left and right
* It is observed if both antenna faces each other, the power recieved is max i.e 0°.
* If rotate the tx 5° everytime, the power Rx decreases.
* The radiation pattern the is observed is plotted on polar graph.
* The theoritical values and practical values are compared in the tabular form.

Sl.No	Criteria	Max Marks	Marks obtained
	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	14
6	Viva	40	32
7	Total	100	91
Scale down to 10 marks			9.1/10
Staff Signature:			

1

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OBSERVATION / DATA SHEET

Date 1/11/2023 Name Lakhan Singh. H

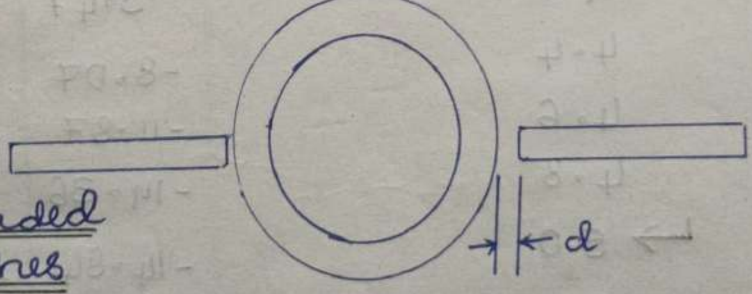
Dept./Lab ECE / MWRS Class VII B Expt./No. 3

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

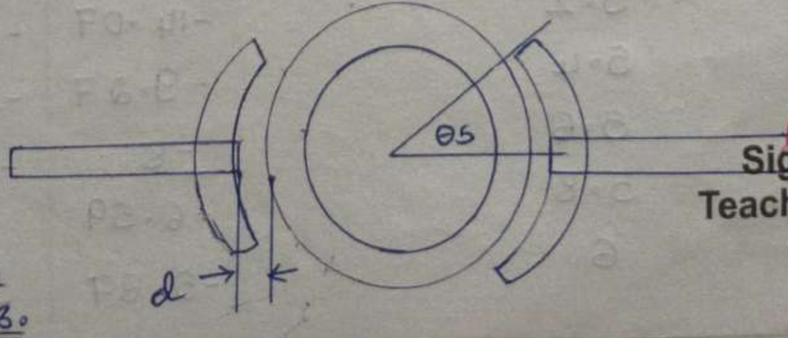
Aim: To characterise the microwave passive components @ 'C' band range of frequencies

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



6. coupling arcs.

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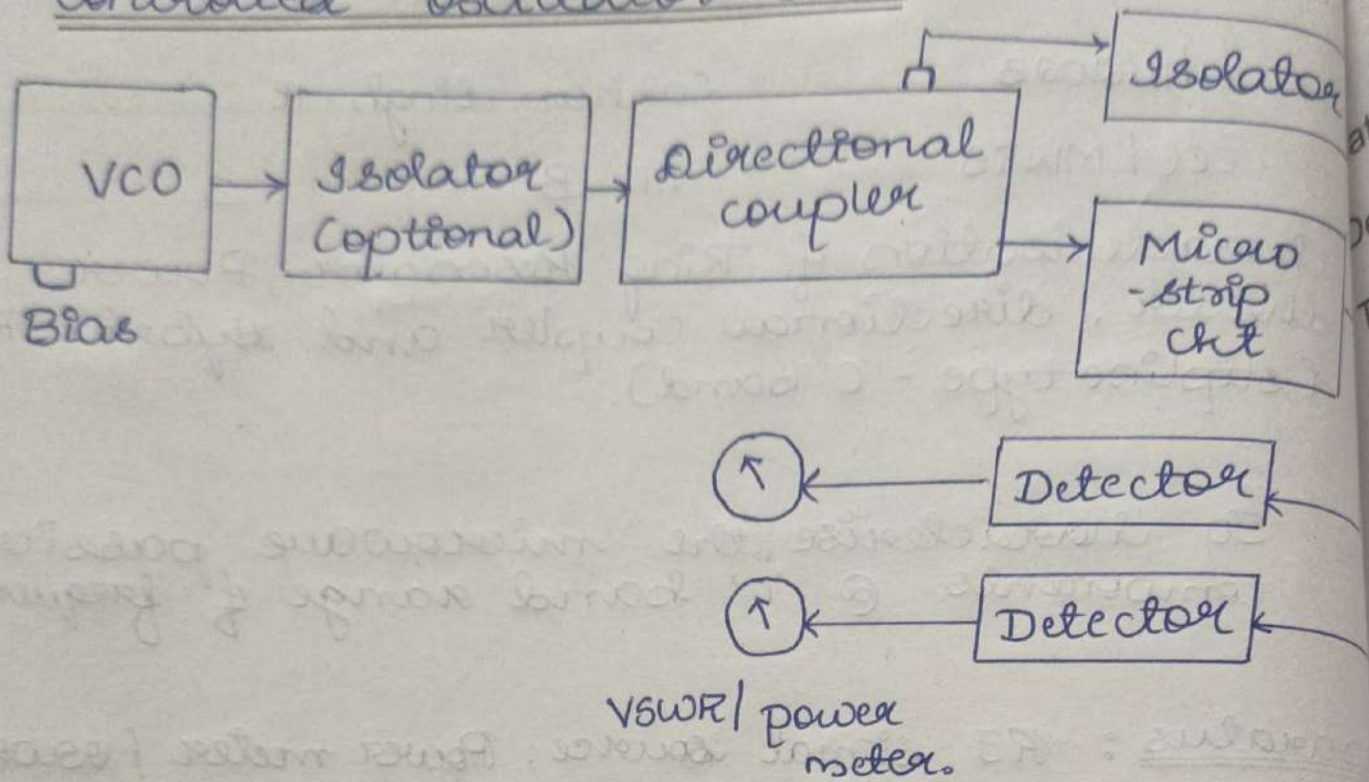
Measurement setup based on Voltage controlled oscillator (VCO).



Tabular column:

Sl. no	Frequency (GHz)	Recieved Power (dB)		
		Pi	Po	Po - Pi
1	3.8	-5.79	-40	34.21
2	4.0	-5.47	-40	34.53
3	4.2	-5.47	-40	34.53
4	4.4	-8.07	-40	31.93
5	4.6	-11.87	-40	28.13
6	4.8	-14.36	-37.87	23.51
7	→ 5.0	-14.84	-23.43	8.59
8	5.2	-14.07	-26.72	12.65
9	5.4	-9.27	-34.59	28.96
10	5.6	-8	-37.96	29.96
11	5.8	-6.59	-40	33.41
12	6	-5.87	-38.15	34.13

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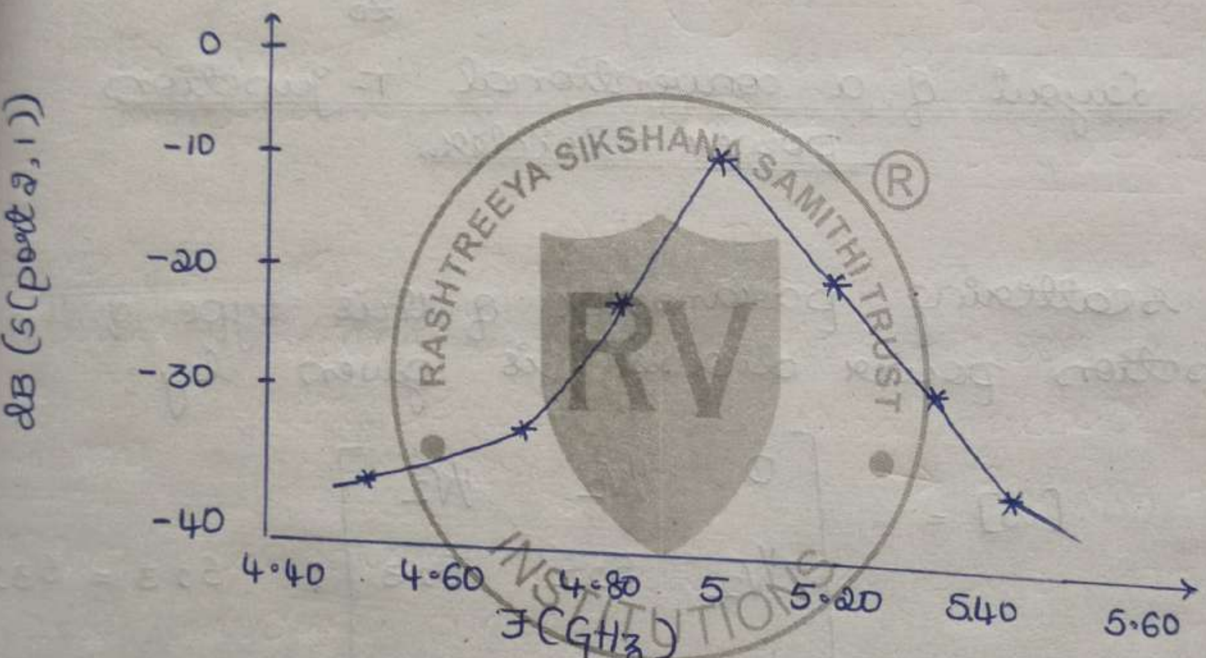
OBSERVATION / DATA SHEET

ate 1|11|2023 Name Lakhan Singh.H

ept./Lab ECE/ MWSR Class VII B Expt./No. 3

Title Ring Resonator

Expected result:



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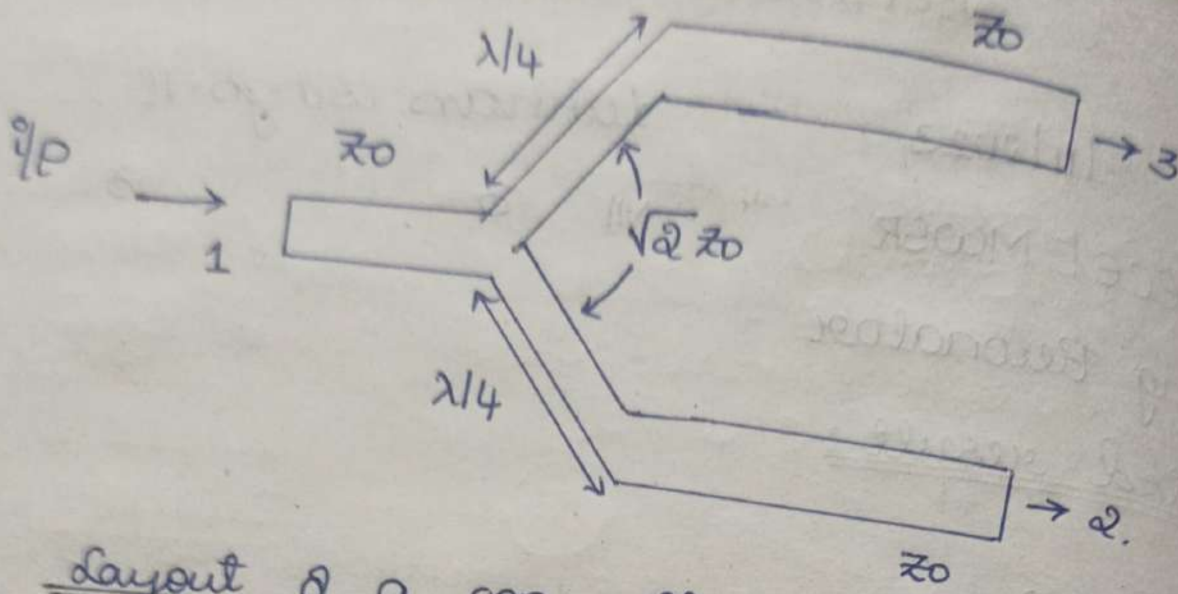
2. Power divider.



Layout of a conventional T-junction power divider.

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

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

unitary condition,

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

$$|S_{22}| = |S_{33}| = -|S_{23}| = 1/2.$$

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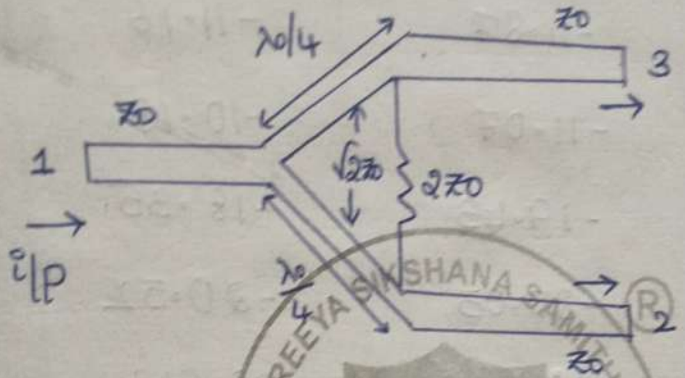
OBSERVATION / DATA SHEET

Date 1/11/2023 Name Lakhan Singh .H

Dept./Lab ECE / MWSR Class VII B Expt./No. 3a

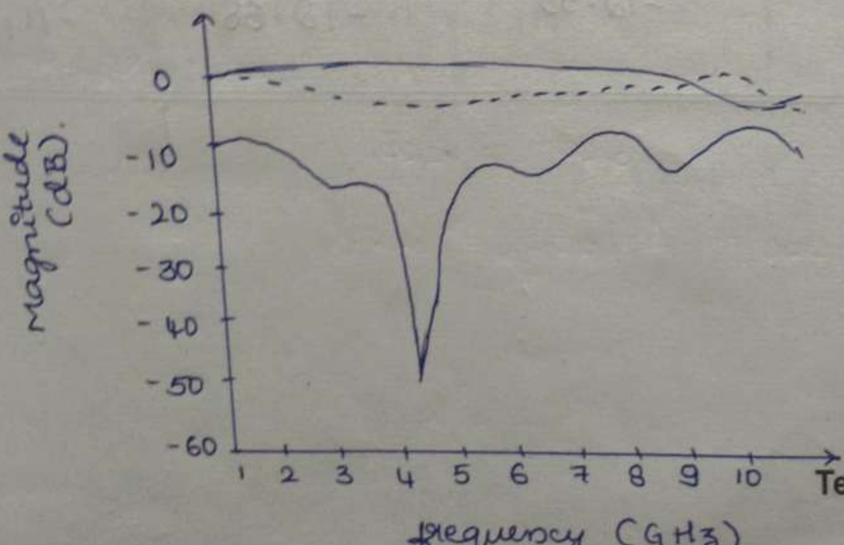
Title Power divider.



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:



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Tabular column:

Sl no	frequency (GHz)	Rx power (dB) in P_2, Match P_3, P_1 = i/p	Rx power (dB) in P_3, Match P_2, P_1 = i/p	Rx P... in P_3, ... P_2 ...
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

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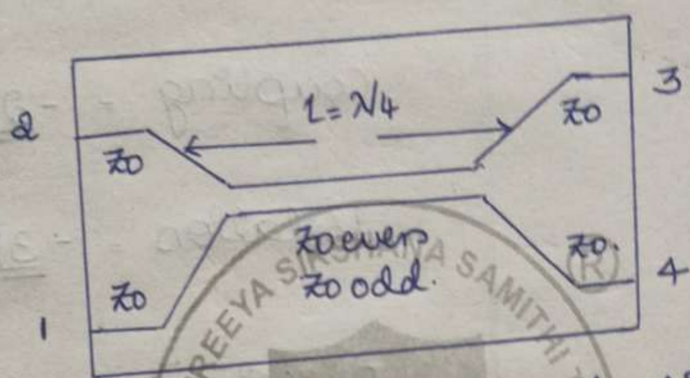
OBSERVATION / DATA SHEET

Date 1|11|2023 Name Lakhan Singh.H

Dept./Lab ECE | MCWSR Class VII B Expt./No. 3

Title Parallel coupled directional coupler.



Layout of a parallel coupled directional coupler.

Parameters:

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

Insertion loss = $-20\log_{10}|S_{41}|$

Coupling = $-20\log|S_{21}|$

Isolation = $-20\log|S_{31}|$

Directivity = Isolation - Coupling.

Signature of Teacher Incharge

Result:

Sl. no	Parameter (dB)
1	Insertion loss = -24.79
2	coupling = -29.7
3	Isolation = -31.49
4	Directivity = -1.79

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

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

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

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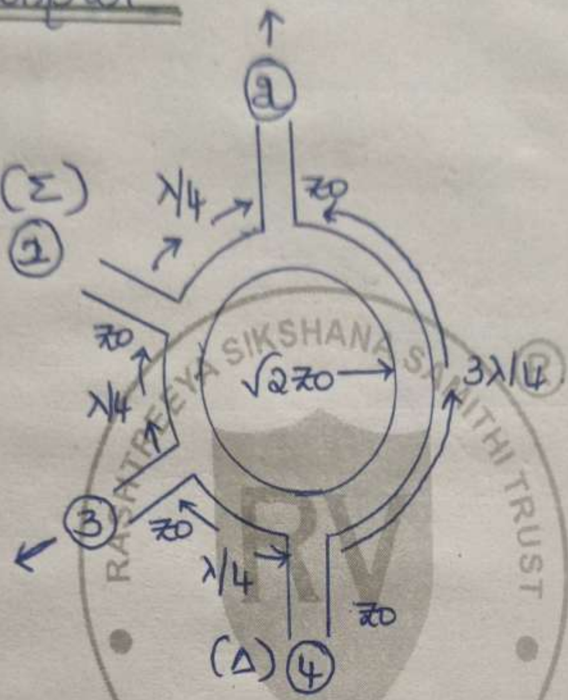
te 1/11/2023 Name Lakhan Singh. H

pt./Lab ECE/ MSWR Class VII B Expt./No. 3

le Hybrid coupler



Layout of a rat race hybrid coupler.

Result:

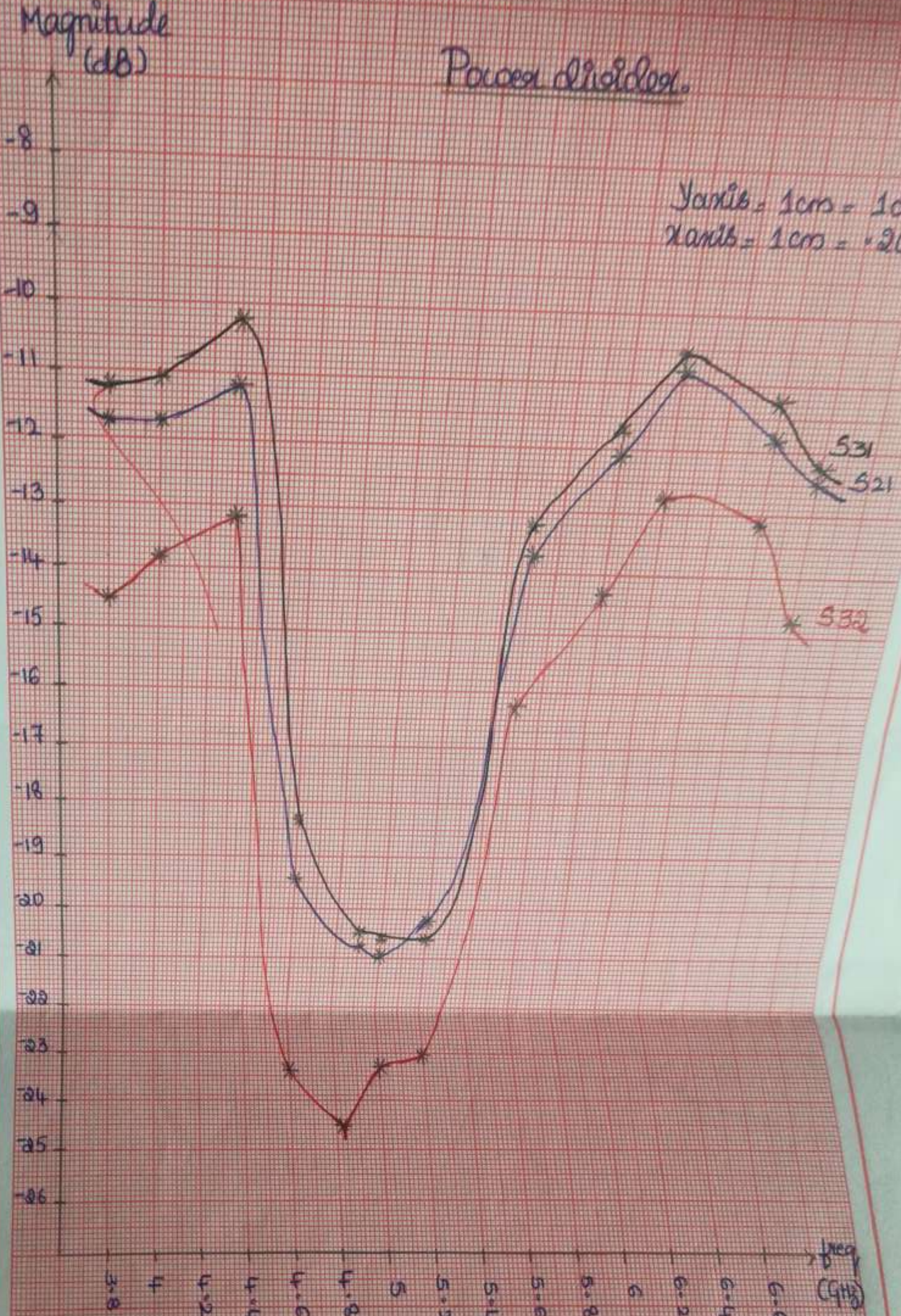
Sl. no	Parameter (dB)
1	Insertion loss: -25.58
2	coupling: -25.67
3	Isolation: -28.48
4	Directivity:- -2.79.

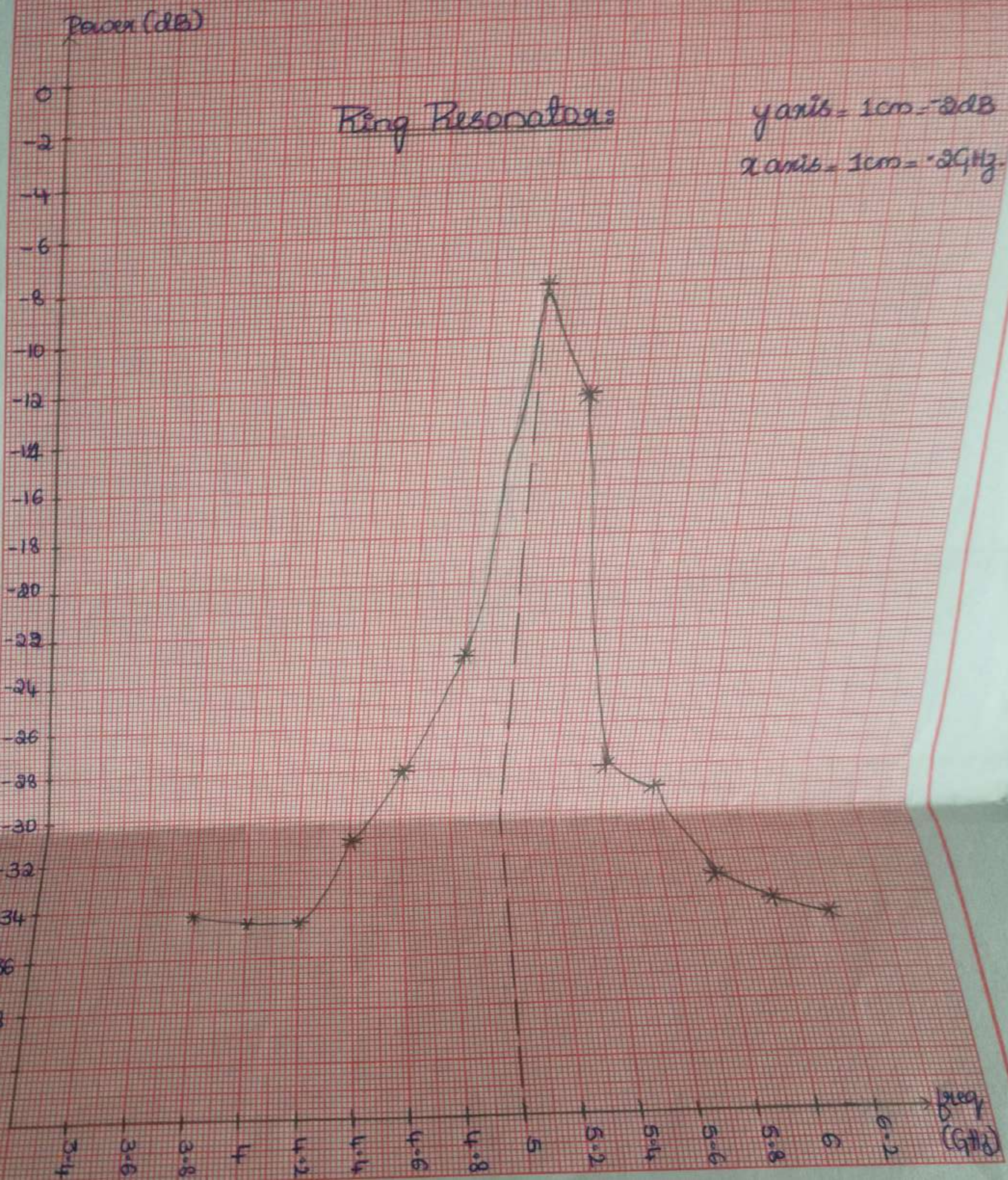
$S_{21} = -19.23dB$
$S_{41} = -19.03dB$
$S_{31} = -26.51dB$

Signature of
Teacher Incharge

Power divider.

Y axis = 1cm = 1dB
X axis = 1cm = ·2GHz.




Ring Resonator:
y axis = 1cm = 2dB
x axis = 1cm = ·2GHz
Power (dB)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
-32
34
freq (GHz)
3·4
3·6
3·8
4
4·2
4·4
4·6
4·8
5
5·2
5·4
5·6
5·8
6
6·2

PROCEDURE:

To measure return and insertion loss characteristics of the mic[...]
resonant 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.

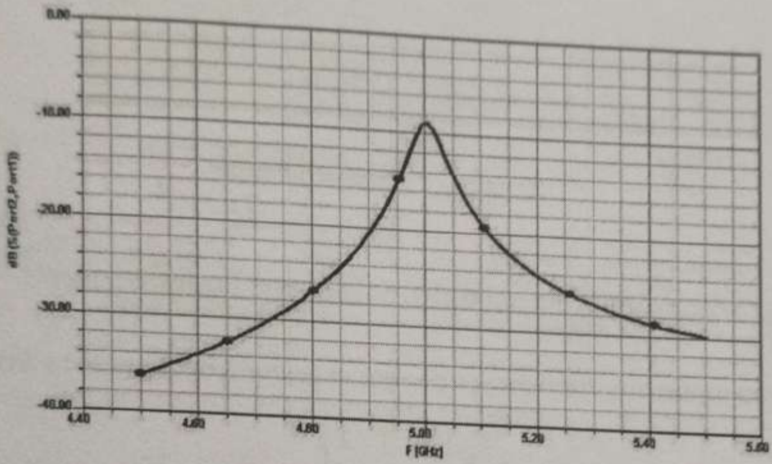
1. Set up the system as shown in Fig 3.3.
2. Measure the input power fed to the Microstrip ring resonator circuit at a selected VCO frequency.
3. Measure the reflected power by noting the reading of the detector connected to the directional coupler and the forward power by noting the reading of the detector 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= λg, calculate the effective dielectric constant and the permittivity of the substrate used. This should be 3.2.

Tabular column:

Sl No	Frequency (GHz)	Received power (dB)		
		Pi	Po	Po - Pi
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	4.6	-11.87	-40	28.13	
6	4.8	-14.36	-37.87	23.51	
7	5	-14.84	-23.43	8.59	S1
8	5.2	-9.27	-26.72	12.65	
9	5.4	-8	-34.59	28.96	
10	5.6	-6.59	-37.96	29.96	

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.

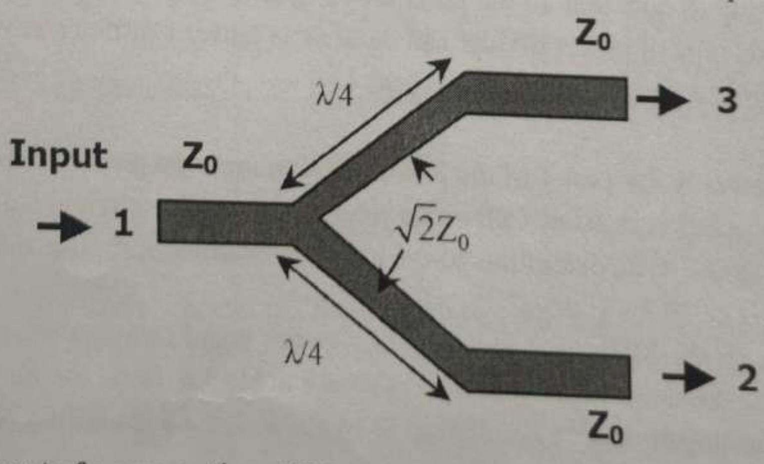


Fig. 3.4 Layout of a conventional T-junction Power Divider

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

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

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

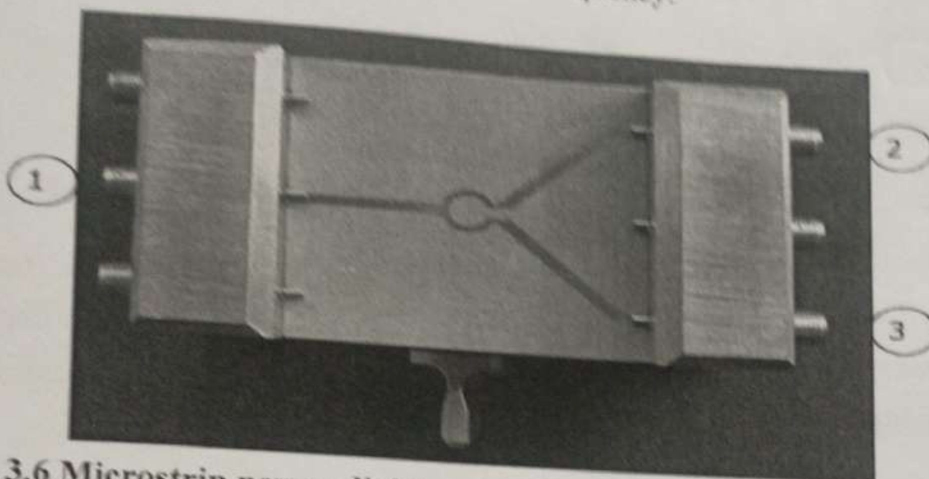
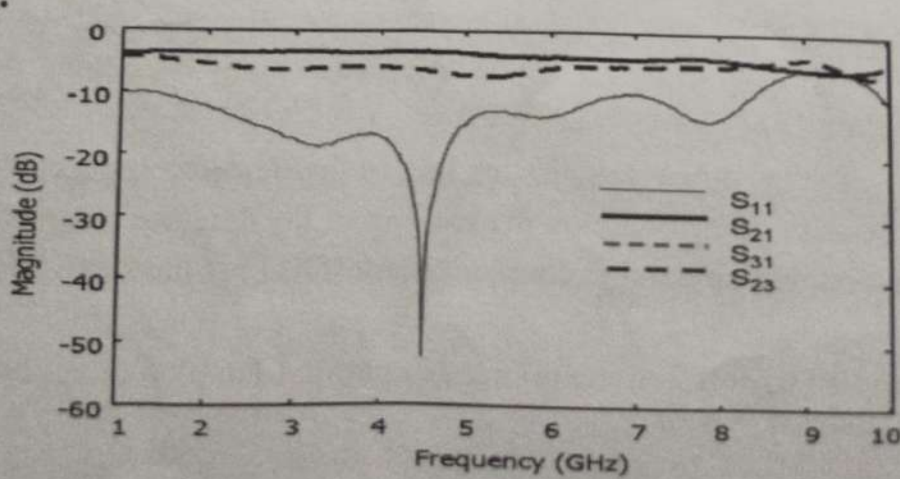


Fig. 3.6 Microstrip power divider circuit without resistor in the test jig

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:

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

coupling= $-20\log|S_{21}|$, Isolation= $-20\log|S_{31}|$ S3 - S1

and Directivity=Isolation-Coupling.

Result:

Sl No	Parameter(dB)
1	Insertion loss = -24.79 S41 = -17.36.
2	Coupling = -29.7 S21 = -30.87
3	Isolation = -31.49 S31 = -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.

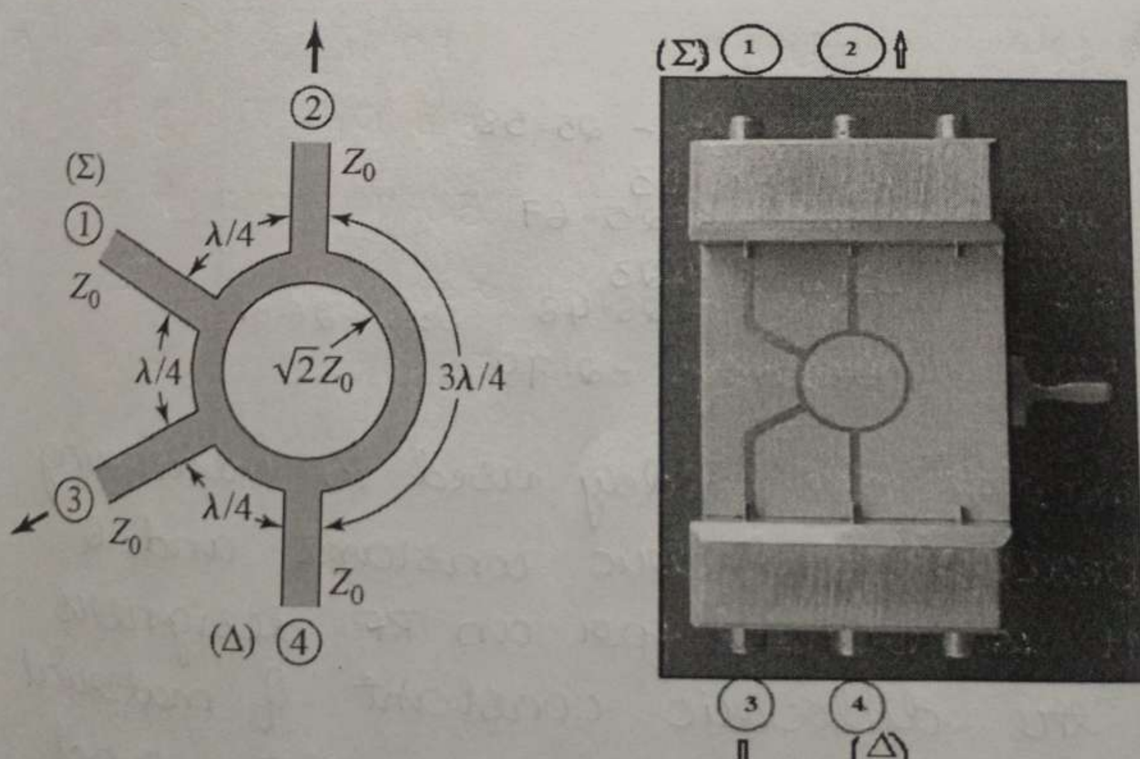


Fig. 3.9: a) Layout of a rat race hybrid coupler b) Microstrip Rat Race Hybrid Coupler Circuit

from ports 2 and 3 and port 4 is isolated. These signals have 180^0 phase shift. When used as a combiner, signals are fed to ports 2 and 3. Difference signal is available at port 4 (Δ-port) and the signal is available at port 1 (Σ-port).

Procedure:

Pick up the Microstrip Rat Race Hybrid Coupler circuit board from the AMTK and mount the in the test jig as shown in Fig 3.10. Here we use top two pairs of input/output SMA connectors. 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 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 designers to know the dielectric constant of material when designing at high freq ckt and one reliable method is using a ring resonator.

1

R.V. COLLEGE OF ENGINEERING®

OBSERVATION / DATA SHEET

Date ____________ Name Lakhan Singh . H

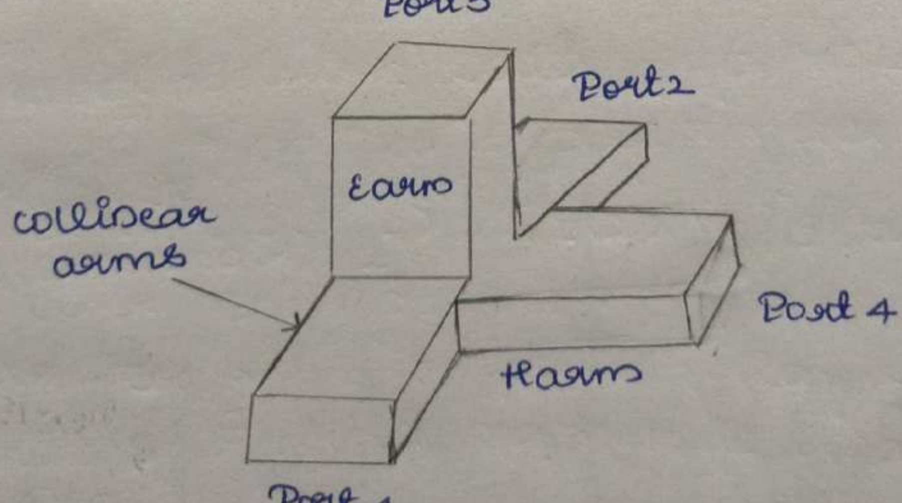
Dept./Lab ECE - MWRS Class VII B Expt./No. 4

Title Characterization of Microwave Magic Tee, Directional coupler, circulator, Tunable attenuator and isolator.

Aim: To determine S parameter and plot S-matrix for passive microwave devices such as waveguide E plane, H plane, Magic Tee, Circulator, Directional coupler, Attenuator.

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

Magic Tee:



Signature of Teacher Incharge

A magic tee is combination of E plane and H plane Tee.

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

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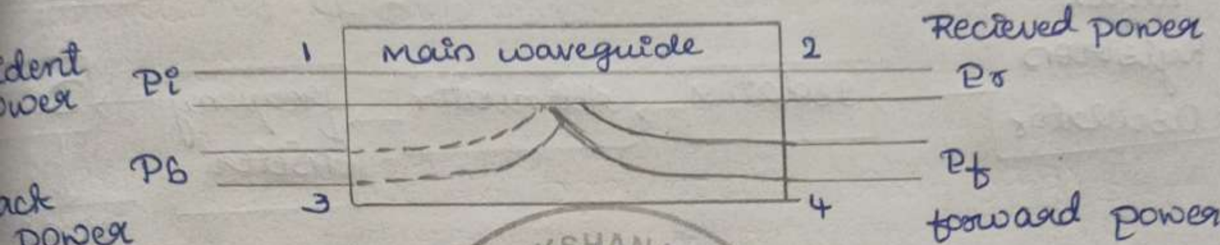
OBSERVATION / DATA SHEET

te ______ Name Lakhan Singh.H

pt./Lab ECE - MCWRS Class VII B Expt./No. 4

le Directional coupler.



Direction coupler.

coupling factor (C) = $10\log_{10}(P_i/P_f)$ dB

Directivity (D) = $10\log_{10}(P_f/P_b)$ dB

Isolation (I) = $10\log_{10}(P_i/P_b)$ dB

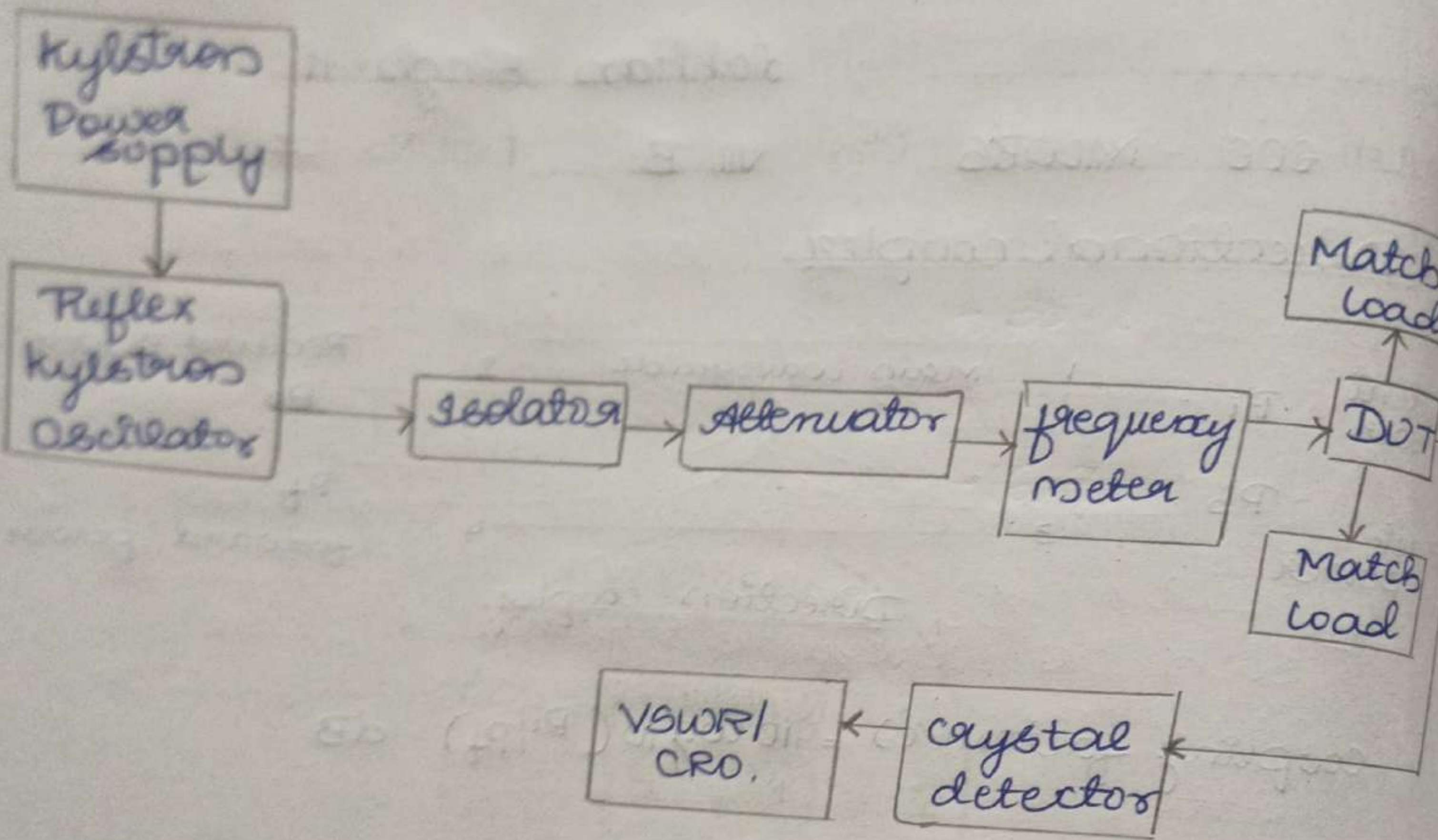
Isolation in dB = coupling factor + Directivity.

S matrix:

Sl.no	Parameter	value (dB
1	S_{12}	-17.8
2	S_{21}	-17.7
3	S_{32}	0

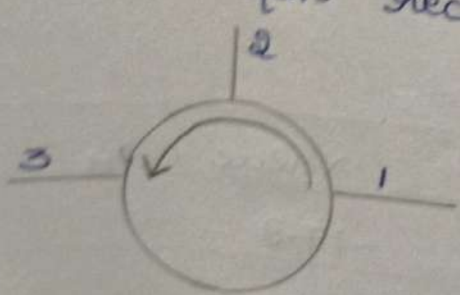
Signature of Teacher Incharge

Block diagram



S matrix determination setup for passive devices.

Circulator: Three port circulator are non reciprocal devices.



circulator.

ideal S matrix:

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

(3)

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OBSERVATION / DATA SHEET

ate ______ Name Lakhan singh . H

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

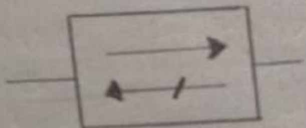
Title circulator & isolator.

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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Teacher Incharge

S matrix of isolator.

Sl no	Parameter	value (dB)
1	S_{12}	-35.8
2	S_{21}	-16.9.

Tee

1. Equipment's are connected as shown in the Fig 4.3.
2. Keep the repeller voltage at maximum, beam voltage at minimum before switching on power supply and also switch on the fan.
3. Switch on klystron power supply and increase the beam voltage to 250V. Note down beam current.
4. Adjust the repeller voltage and detector knob to get maximum output (P_i) on CRO/SWR meter keeping frequency meter detuned.
5. 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.
6. The readings are noted and the parameters like insertion loss, isolation and power division are calculated using necessary equations.
7. The input power to any given can be measured by removing the magic tee and connecting the crystal detector and CRO.

Directional Coupler

1. The experimental set up is as shown in Fig 4.3.
2. Energize the microwave source for particular frequency of operation.
3. Set any reference level of power on CRO/SWR meter, and note the reading (reference level let P_i).
4. 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	S31=S32	-19.13
2	S41=S42	-45
3	S34=S43	0

S-matrix of a Directional Coupler

Sl No	Parameter	Value (dB)
1	S12	-17.8
2	S21	-17.7
3	S32	0

CIRCULATOR AND ISOLATOR

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

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

S-Matrix of Circulator

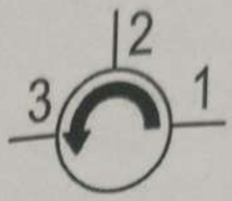


Fig 4.4: Circulator

An isolator is a two-port device that transmits microwave or radio frequency power in one directio 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

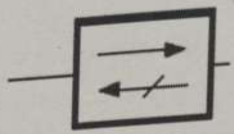


Fig 4.5: Isolator

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:

Sl 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 in comparison to allowed direction a high isolation is provided.

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			
Staff Signature:			

(2)

R.V. COLLEGE OF ENGINEERING®

OBSERVATION / DATA SHEET

Date ______ Name Lakhan Singh H

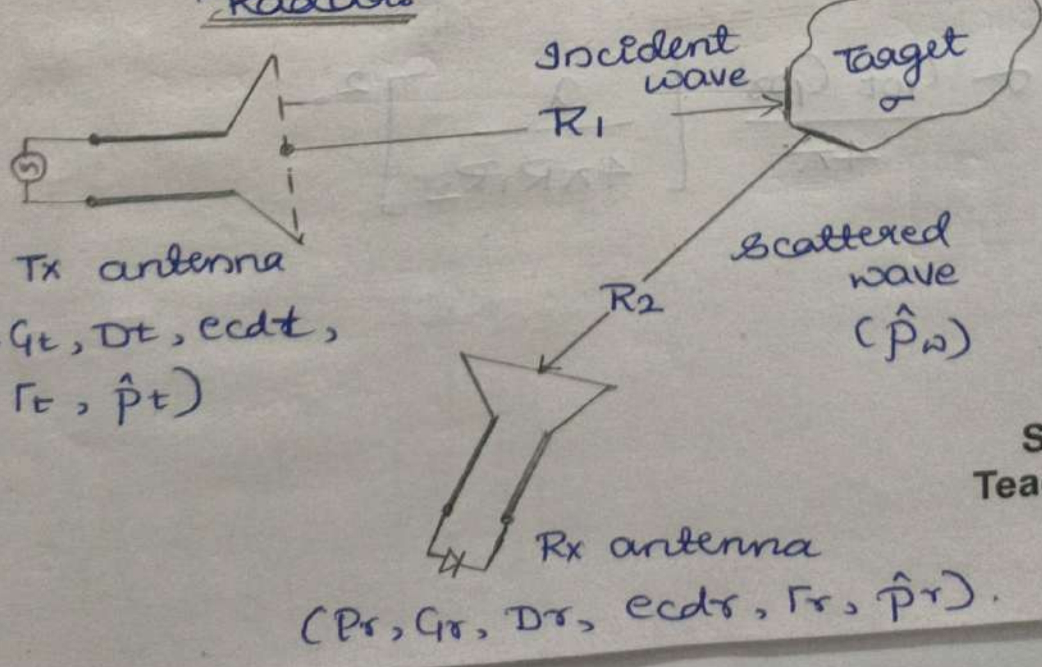
Dept./Lab ECE - MWRS Class VII B Expt./No. 5

Title Illustration 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: Klystron 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.



Signature of Teacher Incharge

$\rightarrow P_r = A_r W_s = e_{cdt} e_{cdr} \sigma \dfrac{P_t D_t(\theta_t, \phi_t) D_r}{4\pi}$

$* \left(\lambda / 4\pi R_1 \right.$

$\rightarrow$ Rx power to i/p power

$\dfrac{P_r}{P_t} = e_{cdt}\, e_{cdr}\, \sigma \dfrac{D_t(\theta_t, \phi_t)\, D_r(\theta_t, \phi_t)}{4\pi} \left(\right.$

$\rightarrow$ losses included.

$\dfrac{P_r}{P_t} = e_{cdt}\, e_{cdr} (1 - |\Gamma_t|^2)(1 - |\Gamma_r|^2)\, \sigma \dfrac{D_t D_r}{4\pi}$

$\times \left(\dfrac{\lambda}{4\pi R_1 R_2} \right)^2 |\hat{\rho}_w \cdot \hat{\rho}$

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

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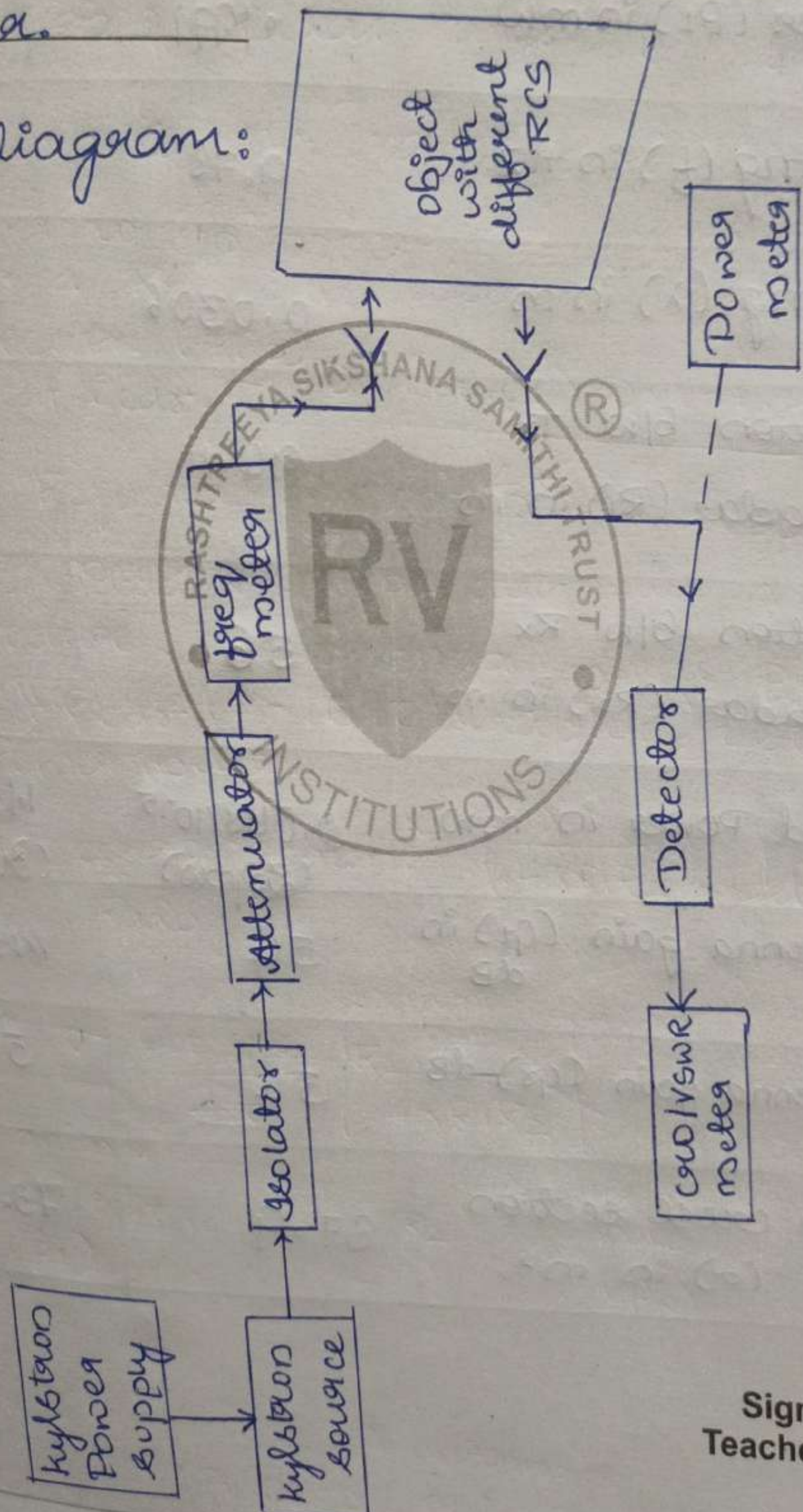
OBSERVATION / DATA SHEET

Date ______ Name Lakhan Singh. H

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

Title Radar.

Block diagram:



Signature of Teacher Incharge

Tabular Column

Parameter	Target 1	Targ
Tx power (P_t) in mW	.1971	.1971
operating (f) in Hz	9.78	9.78
operating (λ) 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
Recieved Power in mW	2.048×10^{-5} (2qmw)	$1.15 * 10^{-5}$ (2umw)
Tx antenna gain (G_t) in dB	54	~~1.6~~54X
Rx antenna gain (G_r) dB	54	54
Radar cross section (σ) in m^2.	87.9	73.01

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

TABULAR COLUMN

LTS

Parameters	Target 1	Target 2
ransmitted power (Pt) in mW	0.1971	0.1971
Operating frequency (f) in Hz	9.78	9.78
Operating wavelength (λ) in meter	0.0306	0.0306
e separating distance between transmitter and target 1) in meter	94.11	85.35
e separating distance between target and receiver enna (R2) in meter	54	54
e received power (Pr) in mW	304mW	1.15×10^{-5} (34mW)
e transmitter antenna gain (Gt) in dB	54	54
e receiver antenna gain (Gt) in dB	54	54
e Radar cross section (σ) in cm^2	87.9.	73.01

ervations:

ic 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

1.

Date ______ Name Lakhan Singh. H

Dept./Lab ECE / MCORS Class VII B Expt./No. 06

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

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

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

Equations: $v_p = c/\sqrt{\epsilon_e}$

$$\beta = k_0\sqrt{\epsilon_e}$$

$$\epsilon_e = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\frac{1}{\sqrt{1+12d/w}} \rightarrow i$$

$$\frac{w}{d} = \begin{cases} \frac{8e^4}{e^2 \cdot A-2} & \text{for } w/d < 2 \\ \frac{2}{\pi}\left[B-1-\ln(2B-1)+\frac{\epsilon_r-1}{2\epsilon_r}\left\{\ln(B-1)+.39-\frac{.61}{\epsilon_r}\right\}\right] & \text{for } w/d > 2. \end{cases}$$

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

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

Signature of Teacher Incharge

S(1,1), S(2,1), S(1,2), S(2,2)

Steps:

1. Insert Hfss design.
   a. Project → Insert Hfss design.
2. Creating ground plane for microchip line.
3. Draw → Rectangle → mouse pointer in align Co
4. Draw rectangle with arbitary x & y di
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 → usingmouse → origin (0,0,0)
    x size = 20mm, y size = 40mm → Ok.
11. Rename the box width substrate & choose substrate material solid → vaccum → 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. sheets → unsaigned → Rect1 → Double click → Name → "line", colour → orange → Ok.
14. change dimension & position.
    sheets → line → create Rect.

R.V. COLLEGE OF ENGINEERING

OBSERVATION / DATA SHEET

Date ________ Name Lakhan Singh.R

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

Title Microstrip & Hybrid Ring.

16. using ctrl 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 manage 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 interations execution.

Signature of Teacher Incharge

25. Hfss → validate check if error is displayed than

check the boundary, dimensions & excitations

25. Hfss → validation check if error is displ
than check the boundary, dimension &
excitations.

26. After validation → Execute Analyse all.

Hfss procedure for hybrid Ring.

28. for port line:

$f = 2.4G$, $\varepsilon_r = 4.4$, $H = 1.6mm$, $Z_0 = 50$
$L = 90°$ port width 3mm.

for inner radius:

$f = 2.4G$, $\varepsilon_r = 4.4$, $H = 1.6mm$, $Z_0 = 70.7\Omega$
$L = 540°$. Radius width $= 1.62mm$
length $= 105mm$.

29. Design parameter:

width $(70.7\Omega) = 1.62mm$
length $(70.7\Omega) = 10.5mm$
$R = 15.9mm$
$r = 17.52mm$.

30. Rectangle design:

x size = 3mm
y size = 24mm
position = -1.5, -30, 0

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OBSERVATION / DATA SHEET

Date ________ Name Lakhan Singh.H

Dept./Lab ECE- MWRS 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 polyhedron
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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Teacher Incharge

Results:

construct a table of s parameter for microstrip line & plot s parater matri

parameter	dB
S_{11}	-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 -20dB showing not much reflection on designed freq. Hence micro strip wire typically can operate b/w 1 to 20GHz.

* The S_{12} or S_{21} (Transmission coefficient) is around 0 to -30dB, which suggest that transmission happens around 1 to 20GHz. 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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OBSERVATION / DATA SHEET

Date ______ Name Lakhan Singh.H

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

Title Design and simulation of Rectangular Waveguide and Magic Tee using HFSS.

Aim: To design, simulate and analyze the Rectangular waveguide and Magic Tee.

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.

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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.

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OBSERVATION / DATA SHEET

Date ______ Name Lakhan Singh.H

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

Title Rectangular wave guide

- copy the inner wall defination 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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→ modeler → Boolean → subtract.

→ In modeler tree, select Box1 and copy p with Not assigned solid, apply

Name: air

Material: air

Transparent: 1

→ In modeler tree, select air and copy paste with new air1 solid, apply

Name: Radiation

Material: air

Transparent: 1

Position: $-a/2 - 5mm, -b/2 - 5mm, 0$

x size: $a + 10mm$

y size: $b + 10mm$

z size: L

→ Now assign this box as radiation boundary modeler tree, RC on radiation solid → Assign Boundary → radiation ok.

→ Press F to enter face selection mode. select x-y plane

face → Assign excitation → wave port.

→ Integration line → new line → 3rd modeler editor.

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OBSERVATION / DATA SHEET

Date ______ Name Lakhan Singh. K

Dept./Lab ECE - MWRS Class VII B Expt./No. 1

Title Waveguide & Magic Tee.

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

Freq: 10GHz

Num of pass: 12 >

Ok.

→ setup1 → 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 → model

→ model tree, R click on Air solid :

Plot field → E → mag E.

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→ HFSS → Field → Edit sources → mode 2 ari
view result and observe the change
in E field.

→ Remove plot visibility for Mag_E.

→ model tree, R click on Air solid:
Plot field → E → vector_E.

→ field → Edit sources → activate first mode
and observe E- vector.

R click vector E → animate.

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OBSERVATION / DATA SHEET

ate ____ Name Lakhan singh.H

ept./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 → vaccum → box → create box

Position → (-11.43, 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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→ Edit → select all

→ modeler → Boolean → unite.

→ select ctrl + select all arms except faces

→ Right click mouse → Assign Boundary → Perfect E → Name → PerfE1.

→ 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

→ Hfss → validate check → Analyze all.

→ Model solution Data report → Rectangular port → choose s parameter → quantity → S(1,1), S(1,2), (S(2 2), S(2,1) click new report.

→ magic Tee → create field overlay → Plot → E → vector-E.

→ similarly E field magnitude (mag-E) plot can be seen.

PARAMETERS	(dB) @ 6GHz.
S11	0.00098 = - 60.17
S22	0.00028 = - 71.05
S33	0.00093 = - 60.63
S44	0.0012 = - 58.41
S12=S21	3. 7656. = 11.57
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 theoritical 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			

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OBSERVATION / DATA SHEET

Date ______ Name Lakhan Singh.H

Dept./Lab ECE/ MGWRS Class VII B Expt./No. 7

Title Design & simulation of patch Antenna & opti metrics using Hfss.

Aim: Design & simulation of a co axial. fed rectangular micro strip patch, printed dipole & horn antenna @ a specified resonant frequency with Hfss software.

Apparatus: 64 bit PC, Ansys HFSS design kit.

Procedure:

1. Probe - fed patch antenna with optimetrics.
2. Restore Archieve & save optimetrics → 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 → Analyse optimetric
9. save, validate & Analyse Hfss Design optimetric
10. view s - parameter Result → optimetric
11. start optimisation Analysis startup → optimisation

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Name: feed - POS
Include: ☑ checked
min: 10mm
max: 12mm

12. open optimization Analysis setup Dialog
→ Goals tab.

13. optimisation setup, Edit, calution Range →
select 1.8 GHz

14. optimisation setup Dialogue → variables
→ optimetrics → patch1 and for patch3

15. optimisation Result table → optimetric →

16. S parameter Results setup & plot P_3.

17. Analytic derivatives S- parameter nomin
plot.

18. Add tuning plot to S parameter.

19. Analytic derivative: Radiation patter nominal
Trace (10/2)

→ setup 1: last adaptive
→ Geometry: Infinite sphere
→ Intrace tab: category: Gain
quantity: Gain total
function: dB.

21. Analytic Derivatives: Radiation patterns tuning trace
(20/2).

22. Analytic Derivatives: Radiation pattern tuning plot

Observations:

Microstrip 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 microstrip patch antenna & dipole antenna were designed and simulated in software.

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

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			

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OBSERVATION / DATA SHEET

Date ________ Name Lakhan Singh H

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:

BFSK (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));
var = 1;
nstd = sqrt(var);
y = (zeros(1,N));
Pe_BPSK_sim = (zeros(1, length(SNR)));
Pe_BFSK_sim = (zeros(1, length(SNR)));
```

Signature of Teacher Incharge

```
Pe_DPSK_sim= (zeros, (1, length(SNR)));

% Generation rayleighranom variable

r= sqrt (-(2* var * log (ue)));
fig(1);
hist (r,100);
title ('raleigh random variable histogra
x label (' random variable R');
ylabel (' frequency');
a= [0:0.01:10];
R= (a/var).* exp(- (a.*a)/(2* var));
fig(2);
plot (a,R)
title ('raleigh PDF');
xlabel (' random variable');
ylabel (' probability');
legend ('variance =1');

% BPSK simulation
Pe_BPSK_id= 0.5 *(1- sqrt ((var*SNR)./(1+ var*
                                          SNR);

% BFSK simulation
Pe_BFSK_id = 0.5 * (1- sqrt (var*SNR./(2+ var*
                                          SNR))));
```

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OBSERVATION / DATA SHEET

e ______ Name dakhan singh.H

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

Title: Rayleigh fading

DPSK simulation

Pe_DPSK_id = 0.5./(1+ var*SNR);

% comparision of error for AWGN and rayleigh

Pe_BPSK_NF = 0.5 * erfc(sqrt(SNR));
Pe_BFSK_NF = 0.5 * erfc(sqrt(SNR/2));
Pe_DPSK_NF = 0.5 * exp(-SNR);
fig(3)

semilogy(SNR_dB, Pe_BPSK_id, 'r.-', 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 1]);
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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BPSK:

```
clc;
Eb=1;
EB_NO_dB = 0.5 : 35;
NO_over_2= Eb* 10.^ (-EbNO_dB/10)
sigma=1;
var= 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_error <= 10
u = rand
alpha = sigma * sqrt (-2*log (u));
noise= sqrt (NO_over_2(i))* randn;
y = alpha * sqrt (Eb) + noise;
 if y<=0
y_d =1 ;
 else
y_d = 0;
end
```

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OBSERVATION / DATA SHEET

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Date ______ Name Sakhan Singh. H

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

Title Rayleigh modeling

```
no_bits = no_bits +1;
no_errors = no_errors + y-d;
end

Ber(i) = no_errors/no_bits;
end.

% Calculation of error prob using theoritical
rho_b = Eb_No_over_2* var;
P2 = 1/2* (1- sqrt (rho_b)/(1+rho_b)));
% plot results

semilogy (EbNo_dB, BER,'-*', EbNo_dB, P2,'-0')
title ('mote carlo simulation for BPSK');
xlabel ('Average SNR| Bit (dB)');
ylabel ('Error probability');
legend ('monte carlo simulation', 'theoritical
                     value');
```

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```
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			

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OBSERVATION / DATA SHEET

Date ______ Name Lakhan Singh H

Dept./Lab MWRS - ECE Class VII B Expt./No. 10

Title Simulation of OFDM transmitter and Reciever.

Aim: Performance Analysis of OFDM Transmitter and Reciever 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); % coverting 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 (:, [1:nBitpersym/2])
     zeros (nsym, 1) ipMod (:, [nBitPersym/2+1:
     nBitPersym]) zeros (nsym, 5)];

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

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

% concating multiple symbols to form long vector
xt = reshape (xt.', 1, nsym * 80);
% Gaussian noise of unit variance, 0 mean
nt = 1/sqrt(2) * [randn (1, nsym * 80) + j * randn (1,
                          nsym * 80)];
yt = sqrt (80/64) * xt + 10^ [-EsNodB (ii)/20)* nt;
```

(3).

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OBSERVATION / DATA SHEET

Date ____________ Name Lakhan Singh H

Dept./Lab ECE - MCWRS Class VII B Expt./No. 10

Title OFDM Tx & Rx.

% Reciever

```
yt = reshape (yt.', 80, nsym).';
yt = yt (:, [17:80]); % removing cyclic prefix.

% converting of frequency domain
yF = (sqrt (nDSC)/nFFT) * fftshift (fft (yt.')).';
yMod = yF (:, [6+[1:nBitPersym/2] 7+[nBitPersym/2
              +1:nBitpersym]]);

% BPSK demodulation
% +ve value → 1 , -ve value → -1 ;
ipmodHat = 2 * floor(real(ymod/2))+1;
ipModHat (find (ipModHat >1)) = +1;
ipModHat ( find (ipModHat <-1)) = -1;

% converting modulated values into bits:
ipBitHat = (ipModHat +1)/2;
ipBitHat = reshape (ipBitHat.',
           nBitpersym * nsym,1).';
```

Signature of
Teacher Incharge

```
% counting the errors,
nErr(ii) = size(find(ipBitHat - ipBit), 2);
end

simBer = nErr/(nSym * nBitPerSym);
theoryBer = (1/2)* erfc(sqrt(10.^(EbNodB/10)

close all;
Fig semilogy(EbNodB, theoryBer, 'bs-', linewid
holdon
semilogy(EbNodB, semiBer, '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')
```

```
ounting the errors
rr(ii) = size(find(ipBitHat - ipBit),2);


er = nErr/(nSym*nBitPerSym);
ryBer = (1/2)*erfc(sqrt(10.^(EbN0dB/10)));

se all; Fig
ilogy(EbN0dB,theoryBer,'bs-','LineWidth',2);
d on
ilogy(EbN0dB,simBer,'mx-','LineWidth',2);
xis([0 10 10^-5 1])
rid 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 consist 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 duration in multipath.

As the no. of sub carrier increases the BER start to diviate from theoritical 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			