INDIAN INSTITUTE OF INFORMATION TECHNOLOGY

Bhagalpur-83210, Bihar, INDIA

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

IIIT, Bhagalpur

Antenna & Microwave Engineering Lab(EC314)

Mohammad Imran Shekh(2001094)
Vinay V Chotia (2001051)
Manish Kumar Tyagi(2001044)
Nishant Sirvi(2001088)

Submitted to: -

Dr.Prakash Ranjan and
Mr.Rajan Kumar

Microwave & Antenna Lab

Experiment-1

Introduction to Microwave Communications

Microwaves are electromagnetic waves (E.M. waves) having a wavelength in the micron range. Though microwave frequencies refer to those from 1GHz to 106GHz but generally used for those wavelengths measured in centimeters, roughly from 10cm to 1cm (3 to 30GHz) and the waves having wavelengths less than 1cm corresponds to higher frequencies (>30 GHz) are called millimeter waves (mm waves).

MICROWAVE FREQUENCIES

IEEE Microwave Frequency Band:

The designation	Frequency range in GHz
HF	0.003 to 0.03
VHF	0.03 to 0.3
UHF	0.3 to 1.0
L-Band	1.0 to 2.0
S-Band	2.0 to 4.0
C-Band	4.0 to 8.0
X-Band	8.0to 12.0
Ku-Band	12.0 to 27.0
K- Band	18.0 to 27.0
Ka-Band	27.0 to 40.0
Millimeter	40.0 to 300
Sub-millimeter	300 and above.

CHARACTERISTIC FEATURES OF MICROWAVE AND APPLICATIONS

Most of the applications of microwave arise from the characteristic features and their advantages. The first important characteristic is that the microwave is highly directive which makes it possible for microwave communication used for telephone networks, radio broadcasting, and television systems. Like any other energy, microwave energy has a healing effect, it is used in a microwave oven for home cooking, drying machine, drying inks, and in food processing industries.

Microwaves are capable of energetically interacting with matter and so used in microwave spectroscopy for structural analysis. Apart from scientific research, the absorption of the microwave by molecular resonance is well suited for various industrial measurements like control of pollution by checking the concentration of different gases from an exhaust chimney.

MICROWAVE SYSTEMS:

Usually, a microwave system consists of a transmitter subsystem, consisting of a microwave oscillator, waveguide, transmission antenna, and a receiver subsystem; that includes a receiving antenna, waveguide a microwave detector, power and frequency meter. The intermediate region between the transmitter and receiver, as well as the inner hollow space of the waveguide, may be filled up with air or dielectric medium. The electromagnetic wave traverses with the speed of light through the air but a dielectric medium such as Teflon and even water will slow down the waves. If the medium has the dielectric constant, then wavelength (λd) in the dielectric is given by

$$\boldsymbol{\lambda d = \lambda 0/\sqrt{\epsilon}}$$

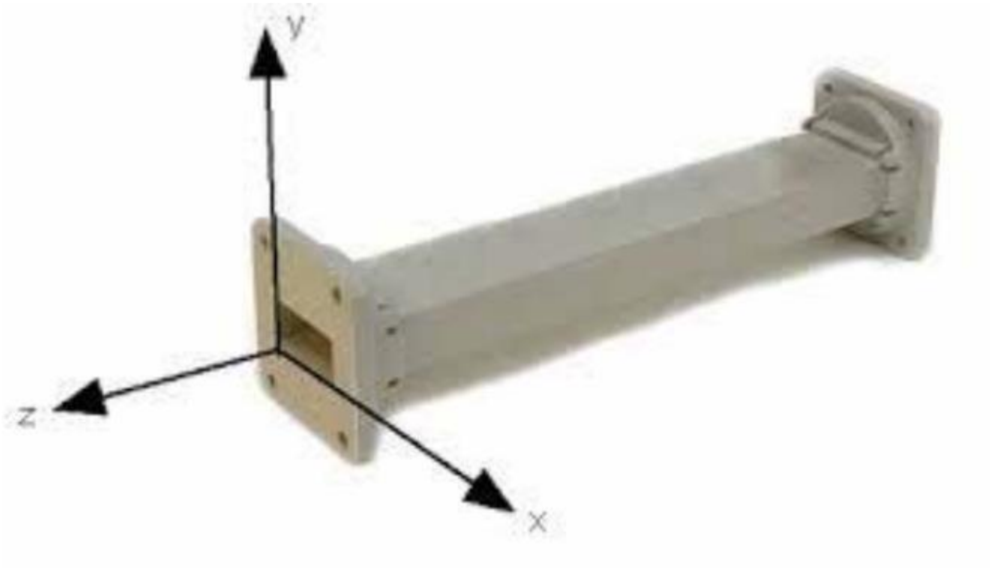
Where $\lambda 0$ is the free-space wavelength.

STUDY OF MICROWAVE COMPONENTS:

RECTANGULAR WAVEGUIDE

Waveguides are manufactured to the highest mechanical and electrical standards and mechanical tolerances. L and S-band waveguides are fabricated by precision brazing of brass-plates and all other waveguides are in extrusion quality. W.G. sections of specified length can be supplied with flanges, painted outside and silver or gold plated in the side.

Frequency : 8.2 - 12.4 GHz



FIXED ATTENUATORS

Fixed Attenuators are meant for inserting a known attenuation in a waveguide system. These consist of a lossy vane inserted in a section of the waveguide, flanged on both ends. These are useful for the isolation of waveguide circuits, padding and extending the range of measuring equipment.

Frequency: 8.2-12.4GHz

TUNABLE PROBE

These are meant for exploring the energy of the EF in a suitably fabricated section of the waveguide. The depth of penetration into a waveguide - section is adjustable by the knob of the probe. The tip picks up the RF power from the line and this power is rectified by the crystal detector, which is then fed to the VSWR meter or indicating instrument.

WAVEGUIDE DETECTOR MOUNT (TUNABLE)

Tunable Detector Mount is simple and easy to use the instrument for detecting microwave power through a suitable detector. It consists of a detector crystal mounted in a section of a Waveguide and shorting plunger for matching purposes. The output from the crystal may be fed to an indicating instrument. In K and R bands detector mounts the plunger is driven by a micrometer.

Freq. Range (Ghz) : 8.2 - 12.4

KLYSTRON MOUNT

Klystron mounts are meant for mounting corresponding Klystrons such as 2K25, 723A/B, 726A or RK - 5976, etc. These consist of a section of waveguide flanged on one end and terminated with a movable short on the other end. An octal base with cable is provided for Klystron.

Freq. Range (GHz) 8.2 -12.4

SLIDE SCREW TUNERS

Slide screw tuners are used for matching purposes by changing the penetration and position of a screw in the slot provided in the center of the waveguide. These consist of a section of waveguide flanged on both ends and a thin slot is provided in the broad wall of the Waveguide. A carriage carrying the screw is provided over the slot. A VSWR up to 20 can be tuned to a value of less than 1.02 at a certain frequency.

MULTIHOLE DIRECTIONAL COUPLERS

Multihole directional couplers are useful for sampling a part of Microwave energy for monitoring purposes and for measuring reflections and impedance. These consist of a section of Waveguide with the addition of a second parallel section of waveguide thus making it a four-port network. However, the fourth port is terminated with a matched load. These two parallel sections are coupled to each other through many holes, almost to give uniform coupling; minimum frequency sensitivity and high directivity.

Frequency Range (GHz) : 8.2 - 12.4

E PLANE TEE

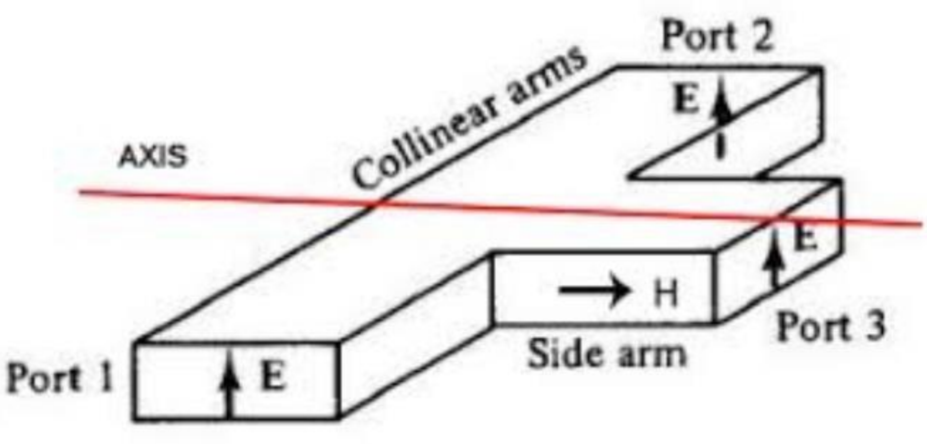
E - plane tee are series type T - junction and consists of three section of waveguide joined together in order to divide or compare power levels. The signal entering the first port of this T - junction will be equally dividing at second and third ports of the same magnitude but in the opposite phase.

Frequency Range (GHz) : 8.2-12.4

H - PLANE TEE

H - Plane Tee is a shunt type T - junction for use in conjunction with VSWR meters, frequency - meters and other detector devices. Like in E-plane tee, the signal fed through the first port of H - plane Tee will be equally divided in magnitude at second and third ports but in the same phase.

Frequency Range (GHz) : 8.2 - 12.4



MAGIC TEE

EH, H Tee consists of a section of the waveguide in both series and shunt waveguide arms, mounted at the exact midpoint of the main arm. Both ends of the section of the waveguide and both arms are flanged on their ends. These Tees are employed in balanced mixers, AFC circuits, and impedance measurement circuits, etc. This becomes a four-terminal device where one terminal is isolated from the input terminal.

Frequency Range (GHz) : 8.2 - 12.4

MOVABLE SHORT

Movable shorts consist of a section of the waveguide, flanged on one end and terminated with a movable shorting plunger on the other end. By means of this non-contacting type plunger, a reflection coefficient of almost unity may be obtained.

Frequency Range (GHz) : 8.2 - 12.4

MATCHED TERMINATION

These are low power and non-reflective type of terminations. It consists of a small and highly dissipative taper flap mounted inside the center of a section of the waveguide. Matched Terminations are useful for USWR measurements of various waveguide components. These are also employed as dummy and as a precise reference load with Tee junctions, directional couplers, and other similar dividing devices.

Freq. Range (GHz) :8.2 - 12.4

GUNN OSCILLATORS

Gunn Oscillators are solid-state microwave energy generators. These consists of waveguide cavity flanged on one end and micrometer driven plunger fitted on the other end. A Gunn-diode is mounted inside the Waveguide with BNC (F) connector for DC bias. Each Gunn oscillator is supplied with calibration certificate giving frequency vs micrometer reading.

Freq: 8.2 - 12.4 GHz,

PIN MODULATORS

Pin modulators are designed to modulate the CW output of Gunn Oscillators. It is operated by the square pulses derived from the UHF(F) connector of the Gunn power supply. These consist of a pin diode mountedinside a section of Waveguide flanged on its both ends. A fixed attenuationvane is mounted inside at the input to protect the oscillator.

Frequency Range (GHz) : 8.2 - 12.4

ISOLATORS

The three-port circulators may be converted into isolators by terminating one of its port into a matched load. These will work over the frequency range of circulators. These are well-matched devices offering low forwardinsertion loss and high reverse isolation.

Frequency Range (GHz) : 8.2 – 12.4

Experiment-2

Aim: - To design and simulation of 50ohm microstrip line using HFSS

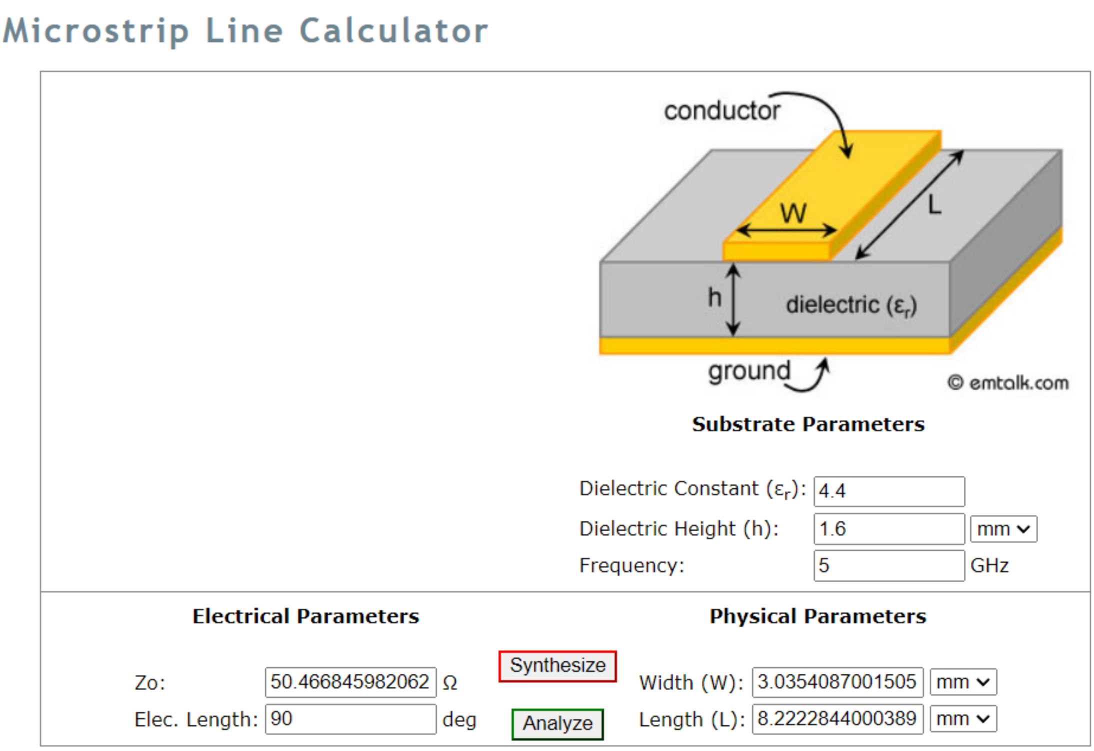
Apparatus Used: -

HFSS Software.

Theory: -

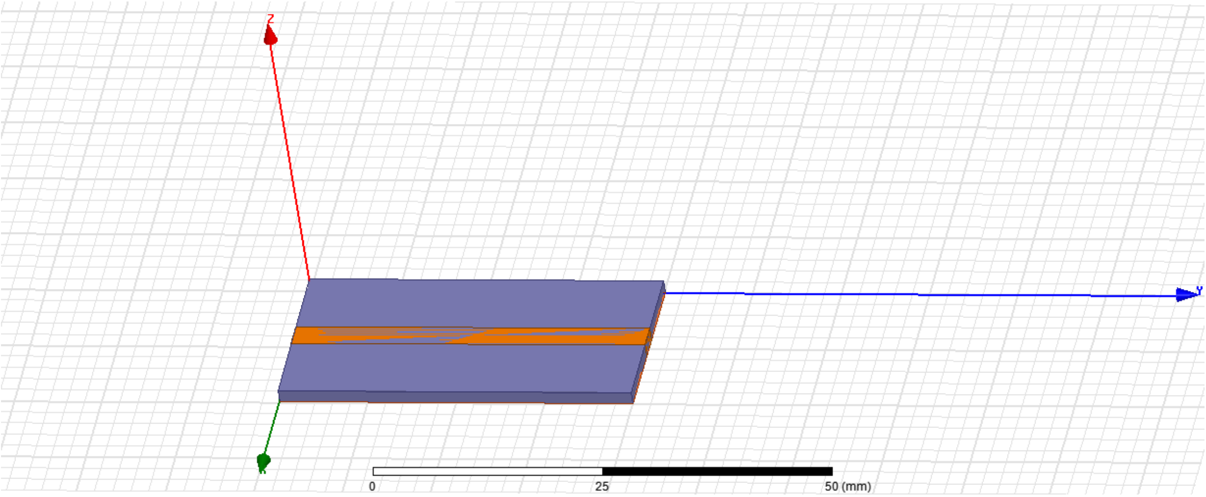
Microstrip antennas have been one of the most innovative topics in antenna theory and design in recent years,and are increasingly finding application in a wide range of modern microwave systems. A microstrip transmission line consists of a narrow metallic trace separated from a metallic ground plane by a slab of dielectric material. This is a natural way to implement a transmission line on a printed circuit board, and so accounts for an important and expansive range of applications.

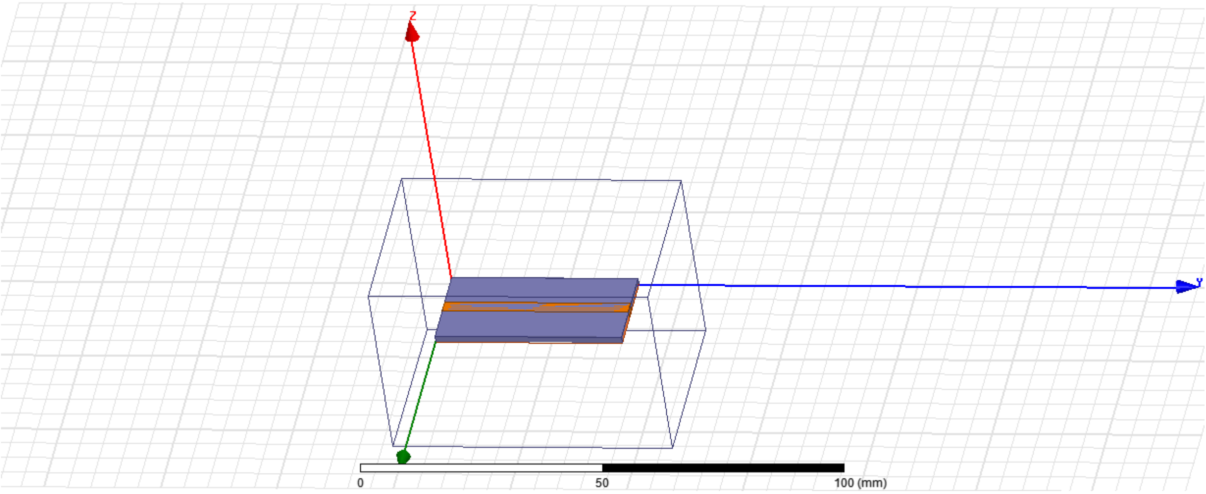
The length and width of the microstrip is determined by online calculated as per the online calculator and the dielectric substrate used in the design of microstrip is FR4 .and its constant is around 4.4.and dielectric height is around 1.6mm and frequency is around 5Ghz the z0 will be 50 ohm since we are designing the 50 ohm microstrip. and the electric length is around 90 degree since the characteristics impedance doesn't depend upon the length.

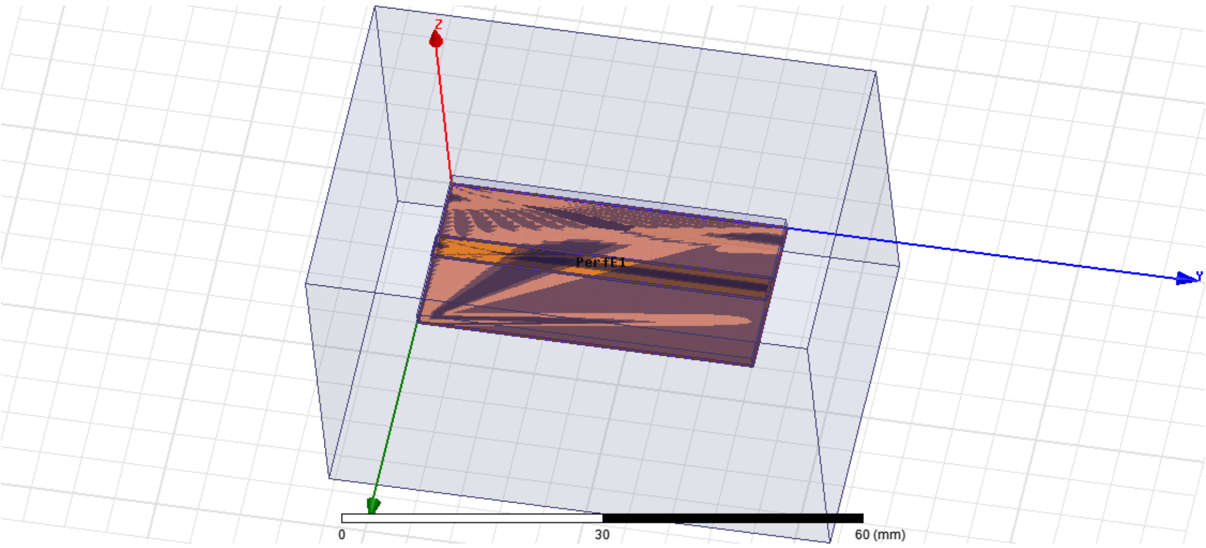


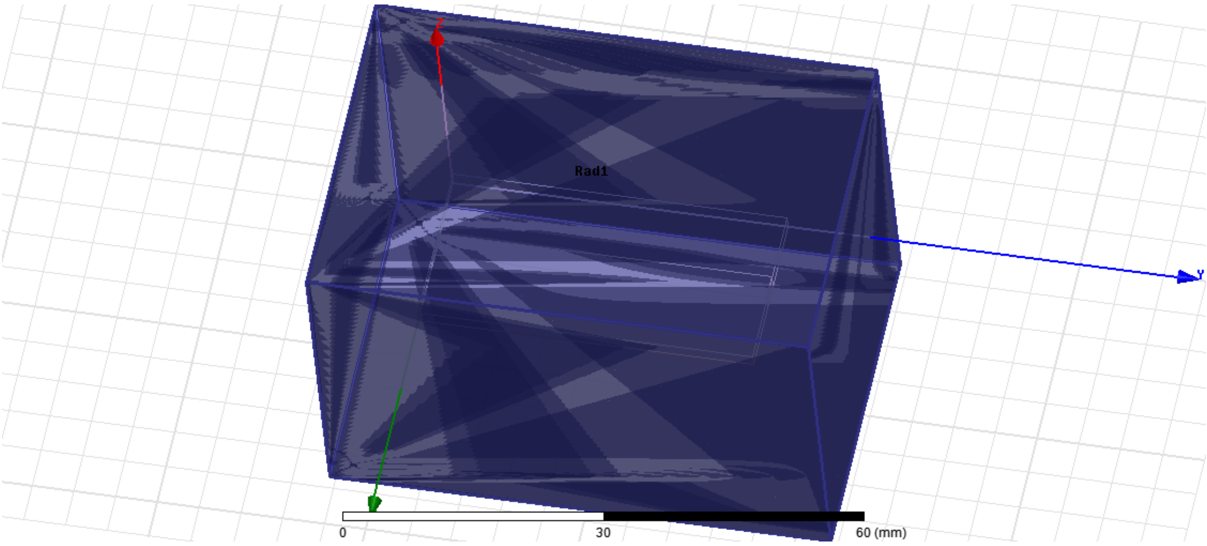
Name-Mohammad Imran Shekh Roll no-2001094 Branch-ECE

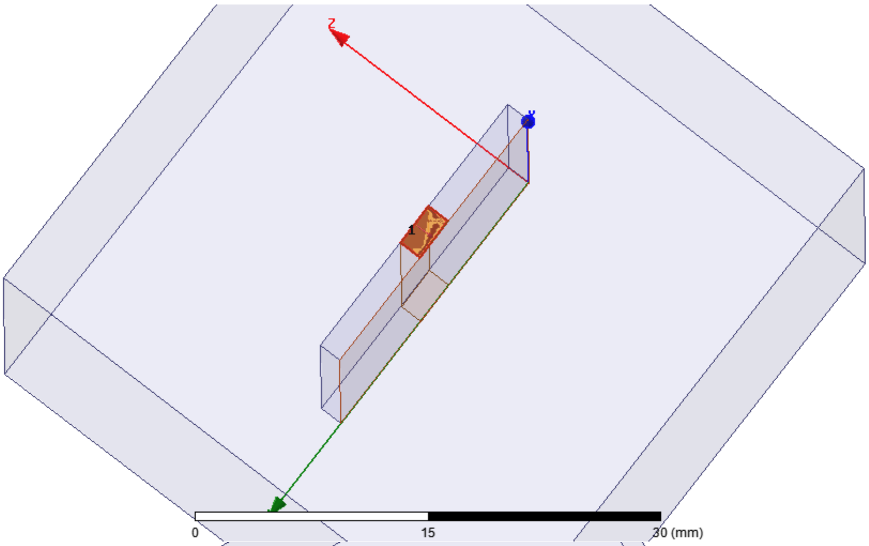
Micro Strip Line Design: -

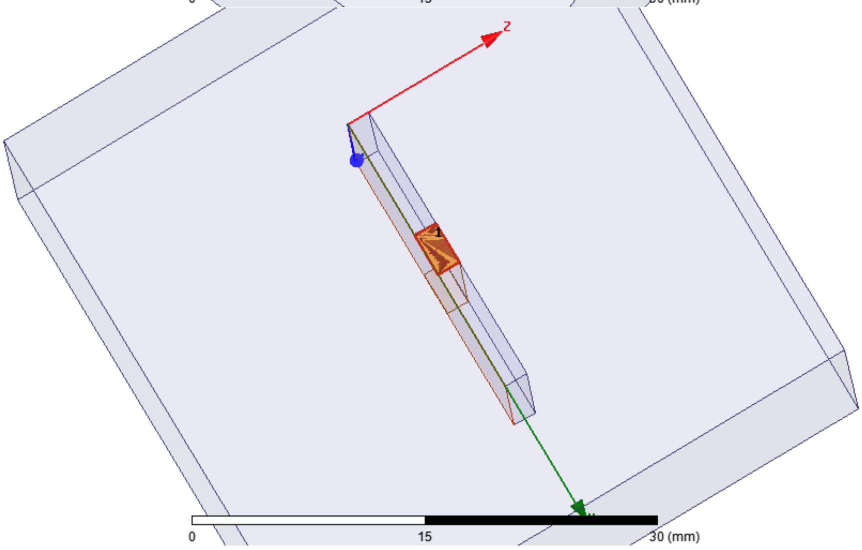






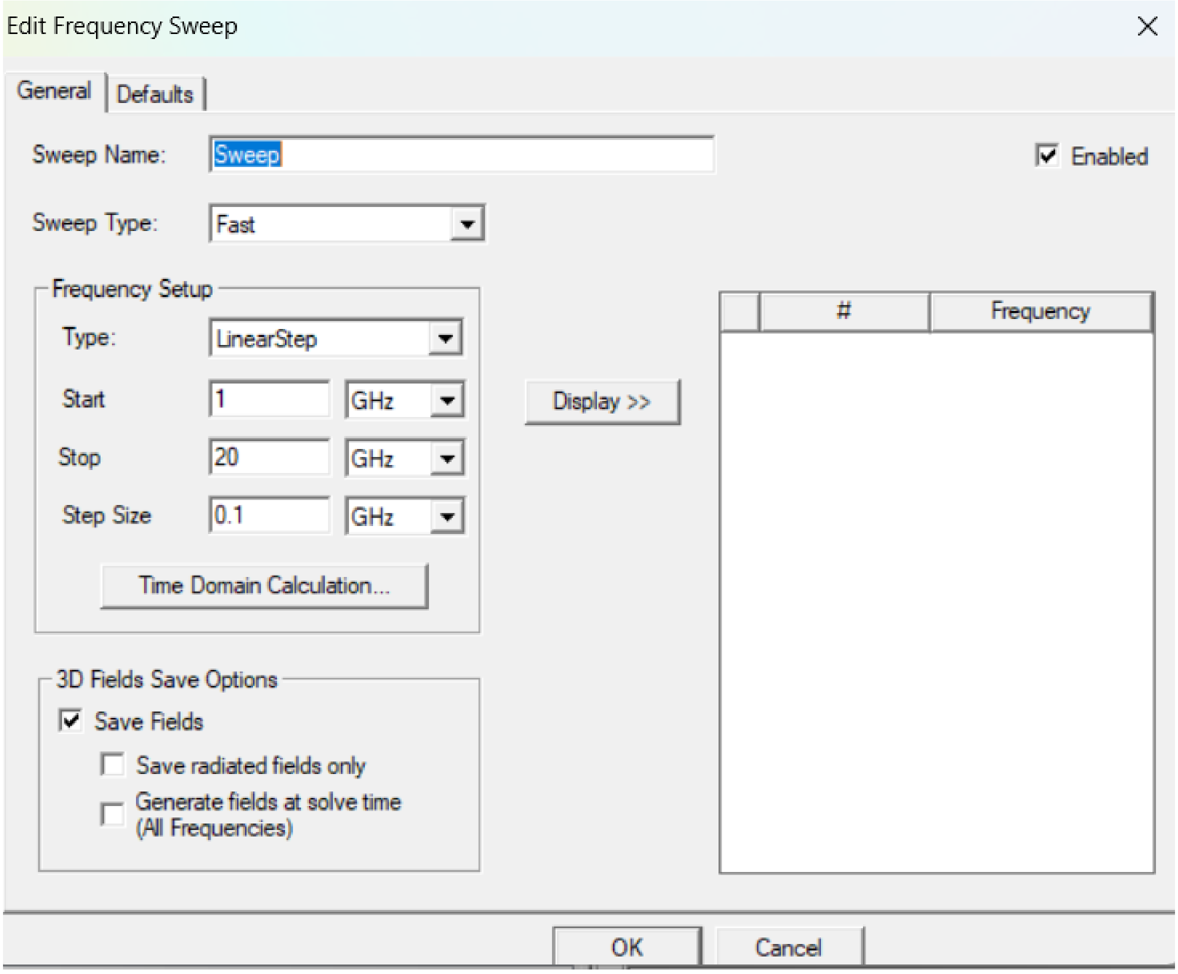

Rad1
0
30
60 (mm)


1
0
15
30 (mm)

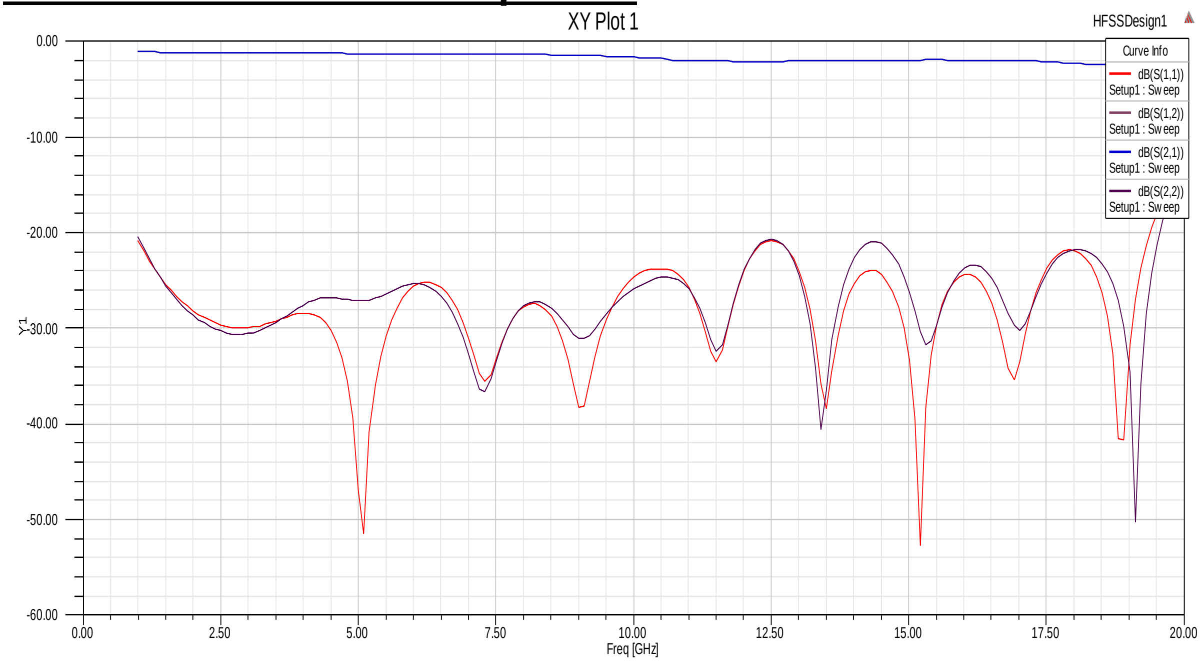

1
0
15
30 (mm)

Name-Mohammad Imran Shekh Roll no-2001094 Branch-ECE

Setup and Frequency Sweep: -



Result for 50 ohm microstrip line :-



Conclusion: -

I was able to design 50ohm microstrip line and analyzed the output of the design.

Experiment 3

Aim: - To design and analysis of H-Plane Tee using HFSS software.

Apparatus: -

HFSS Software.

Theory: -

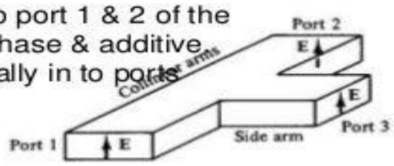
An H-Plane Waveguide Tee can be thought of as a two-way in-phase power divider/combiner. This means that it is additive in nature. When two input signals are fed to port 1 & 2, the output at port 3 is in phase and additive. When the input signal is fed to port 3, the signal is split into two equal parts that are in-phase at port 1 & 2. The properties of an H-Plane Tee can be defined by its scattering matrix [S], which is a 3x3 matrix as there are 3 possible inputs and 3 possible outputs. The scattering coefficients S13 and S23 are equal because the junction is symmetrical in plane.

The s-matrix of the h-plane tee is shown below:-

H Plane Tee

An H plane tee is a waveguide tee in which the axis of its arm is shunting the E field or parallel the H field to main guide as shown .

- It can be seen that if two input waves are fed in to port 1 & 2 of the collinear arm the output wave at port 3 will be in phase & additive.
- If the input is fed to port 3 the wave will split equally in to ports 1 & 2 in phase & same magnitude.



The S matrix of H Plane tee is similar to that of E plane tee as shown

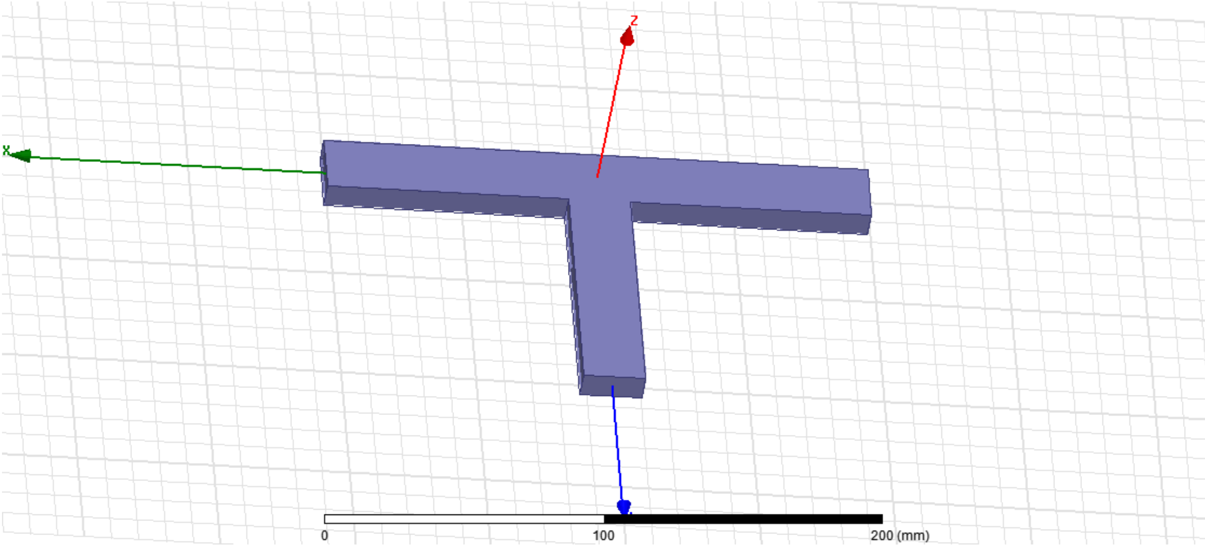
$$S = \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{11} & -S_{13} \\ S_{13} & -S_{13} & S_{33} \end{bmatrix}$$

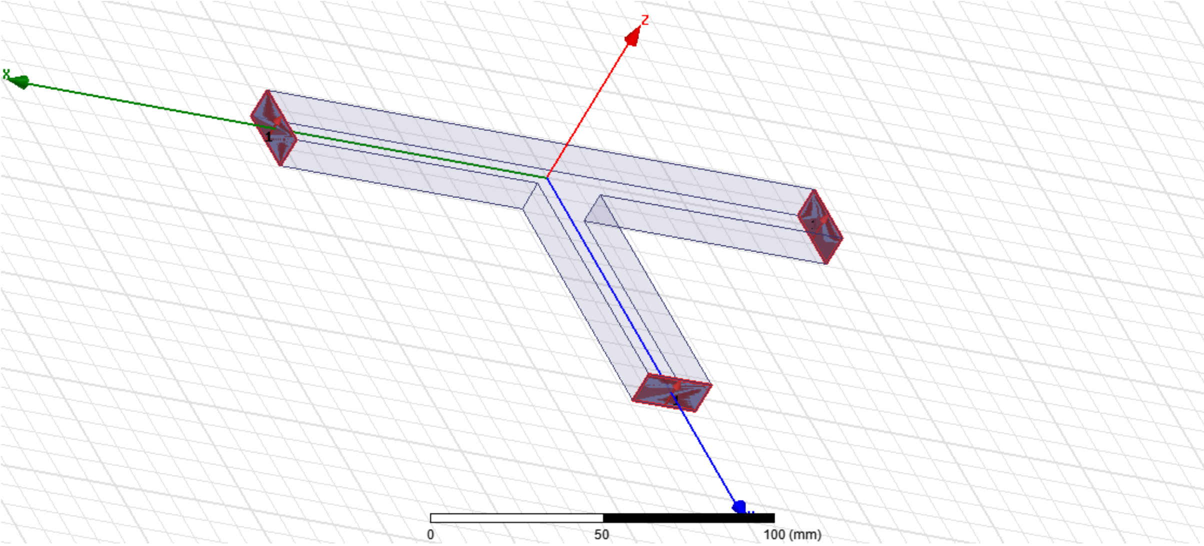
but $S_{13}=S_{23}$.

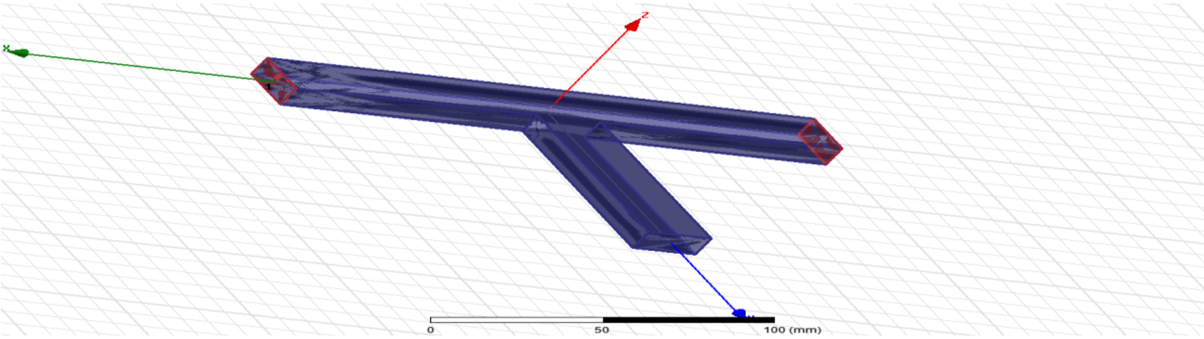
$$S = \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{11} & S_{13} \\ S_{13} & S_{13} & S_{33} \end{bmatrix} \text{ If all ports are matched } S = \begin{bmatrix} 0 & S_{12} & S_{13} \\ S_{12} & 0 & S_{13} \\ S_{13} & S_{13} & 0 \end{bmatrix}$$

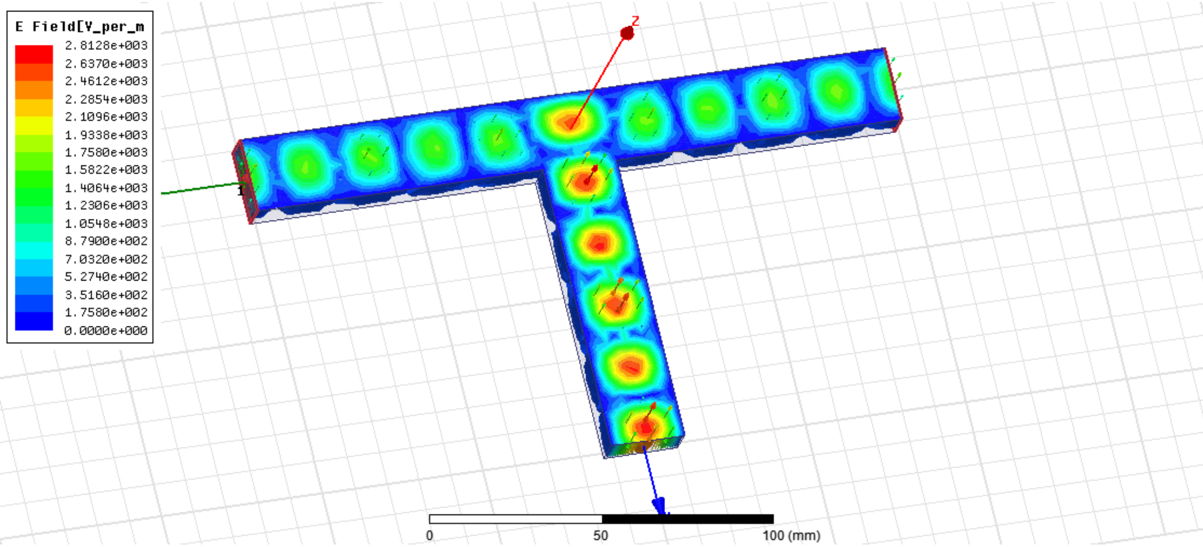
29

H plane tee Design in HFSS: -

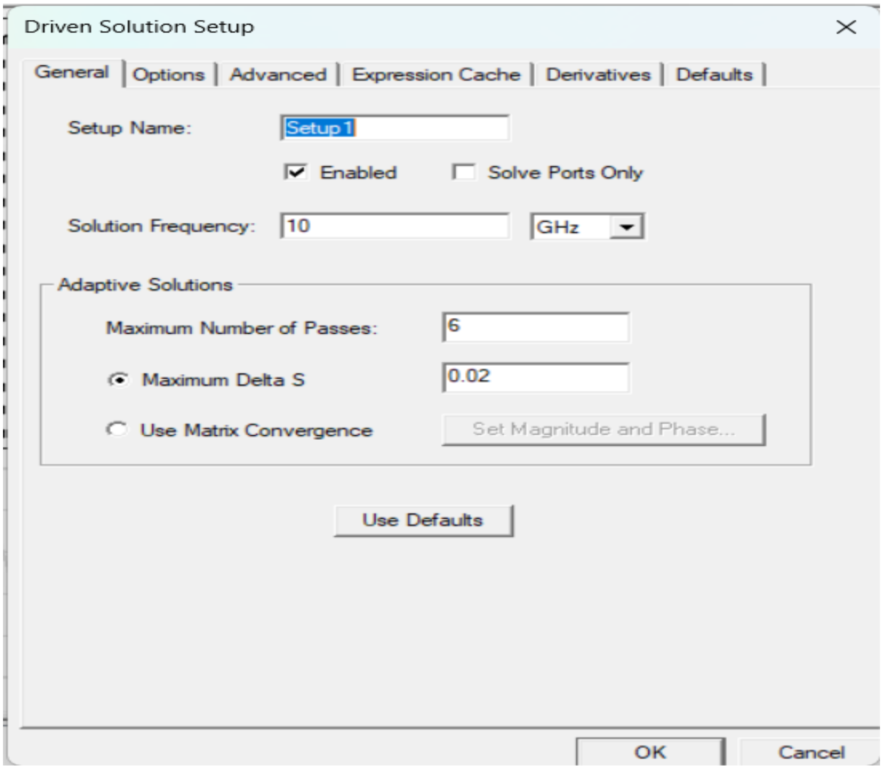




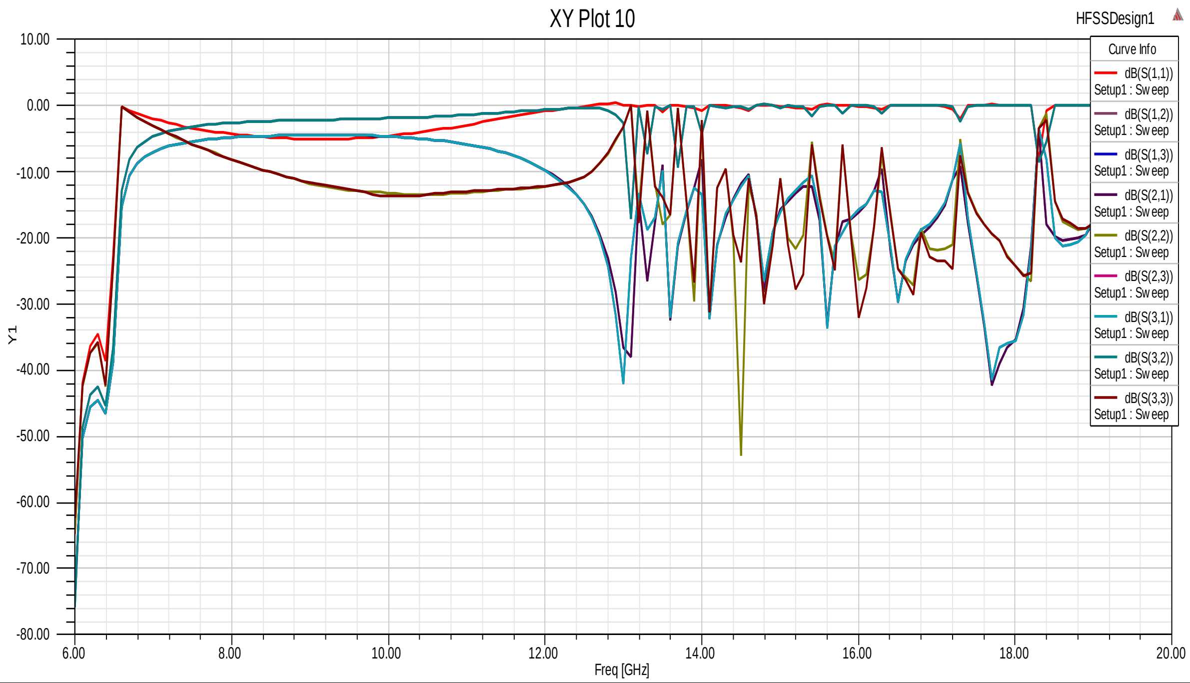



E Field[V_per_m
2.8128e+003
2.6370e+003
2.4612e+003
2.2854e+003
2.1096e+003
1.9338e+003
1.7580e+003
1.5822e+003
1.4064e+003
1.2306e+003
1.0548e+003
8.7900e+002
7.0320e+002
5.2740e+002
3.5160e+002
1.7580e+002
0.0000e+000
0
50
100 (mm)

Setup: -


Driven Solution Setup
General
Options
Advanced
Expression Cache
Derivatives
Defaults
Setup Name:
Setup1
Enabled
Solve Ports Only
Solution Frequency:
10
GHz
Adaptive Solutions
Maximum Number of Passes:
6
Maximum Delta S
0.02
Use Matrix Convergence
Set Magnitude and Phase...
Use Defaults
OK
Cancel

Output Graph: -



Result: - By observing the outputs of the h-plane tee which is a 3x3 matrix as there are 3 possible inputs and 3 possible outputs. The scattering coefficients S13 and S23 are equal because the junction is symmetrical in plane. The [S] matrix can be written as [S] = [S11 S12 S13; S12 S22 S13; S13 S13 0]. The scattering matrix for H-Plane Tee explains its scattering properties.

Experiment 4

Aim: -To design and analysis of dipole antenna in HFSS operating frequency f0=800Mhz

Apparatus: -

HFSS Software.

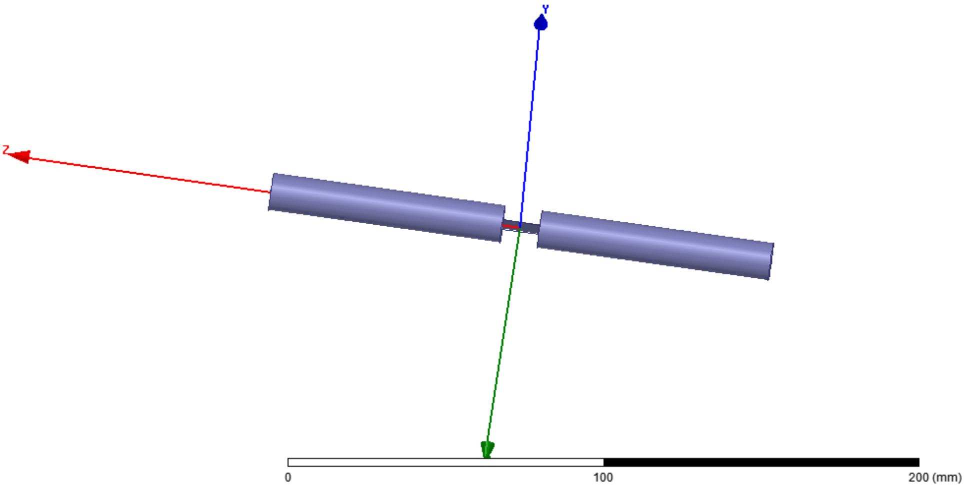
Theory: -

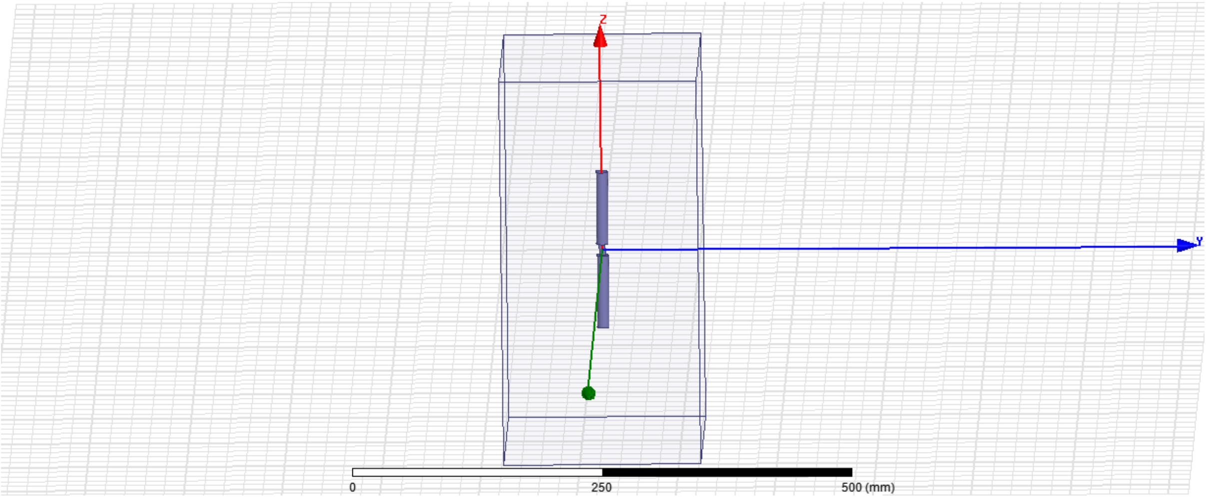
A dipole antenna is the simplest type of radio antenna, consisting of a conductive wire rod that is half the length of the maximum wavelength the antenna is to generate. This wire rod is split in the middle, and the two sections are separated by an insulator. Each rod is connected to a coaxial cable at the end closest to the middle of the antenna. A dipole antenna is also known as a doublet or dipole aerial and is defined as a type of RF (Radio Frequency) antenna, consisting of two conductive elements such as rods or wires.

The dipole is any one of the varieties of antenna that produce a radiation pattern approximating that of an elementary electric dipole. Some advantages of dipole antennas include their ability to pick up radio frequencies quickly and improve the reception of TV or radio. They also offer the advantage of receiving balanced signals due to their two-pole design, which enables the device to receive signals from a variety of frequencies and helps sort out problems caused by conflicting signals without losing reception quality. Dipole antennas are available in different forms such as basic, folded, and half-wave dipole. They are also omnidirectional when sending and receiving signals. Additionally, they are relatively easy to build and install.

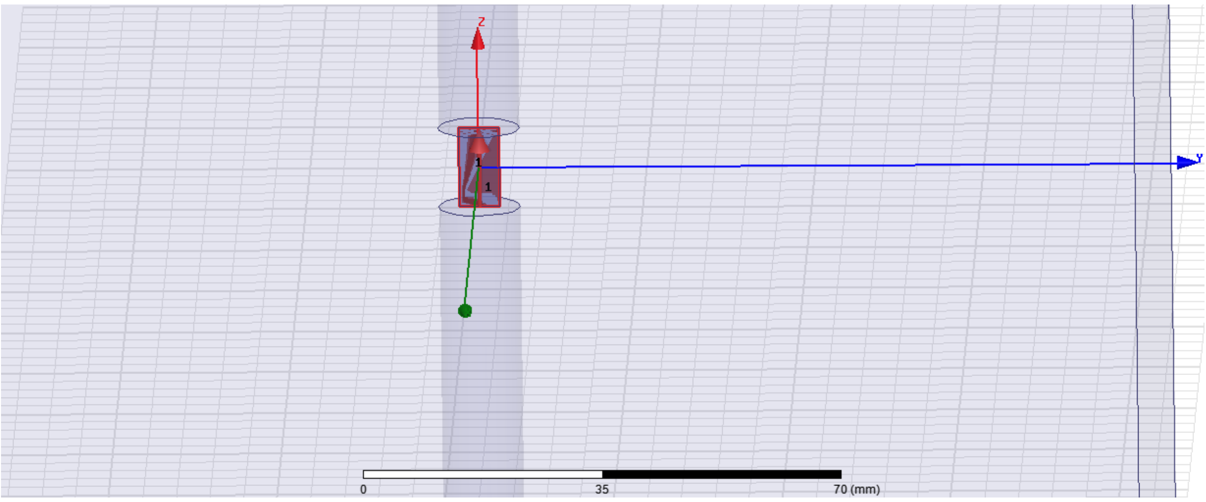
Name-Mohammad Imran Shekh Roll no-2001094 Branch-ECE

Dipole antenna Design in HFSS software: -

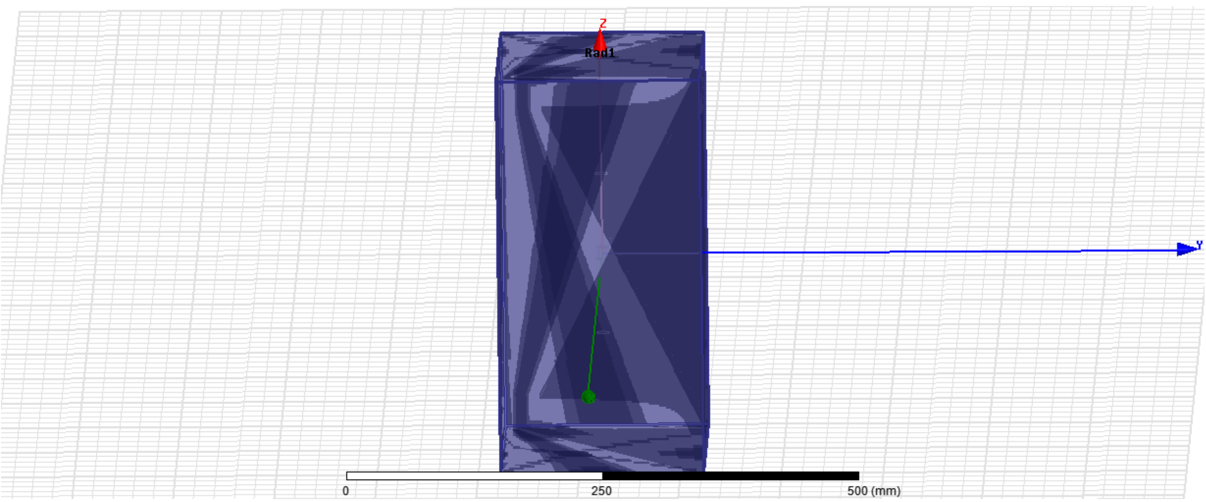




Excitation in Antenna: -

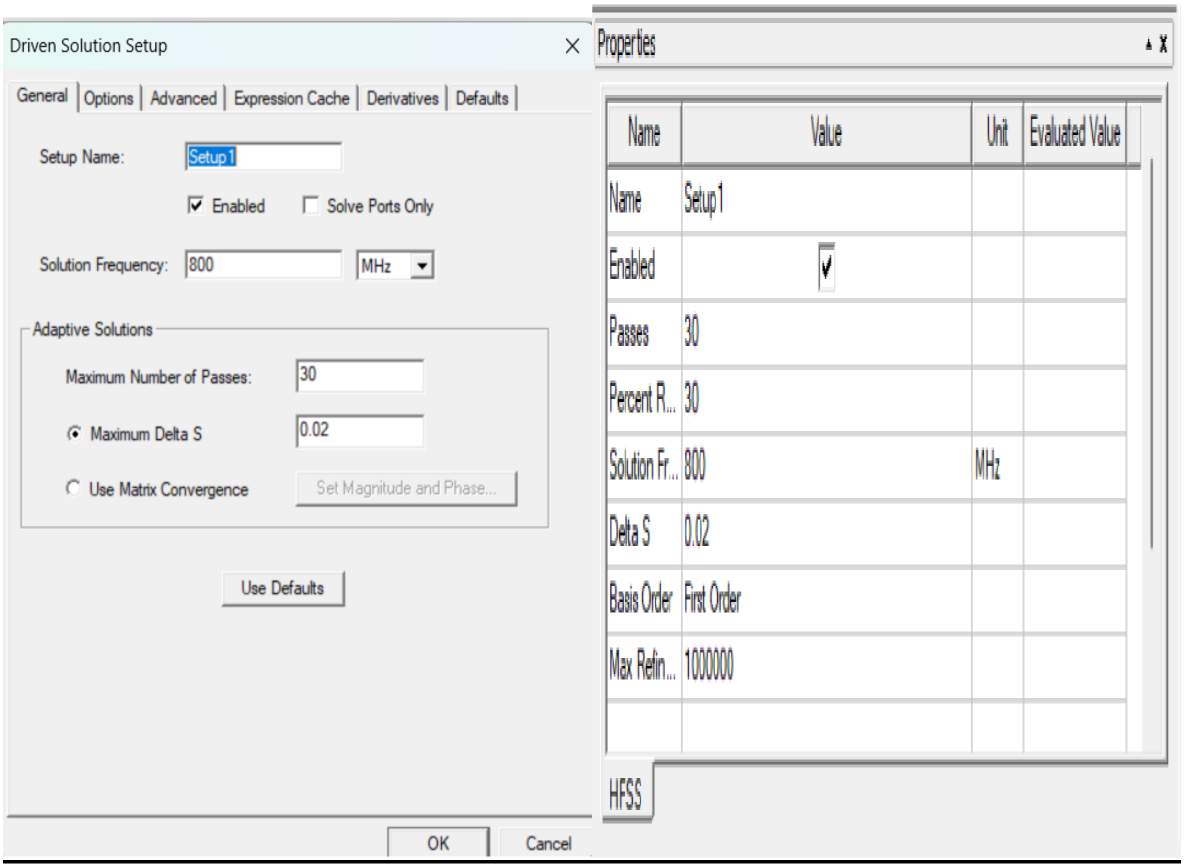


Radiation in BOX: -

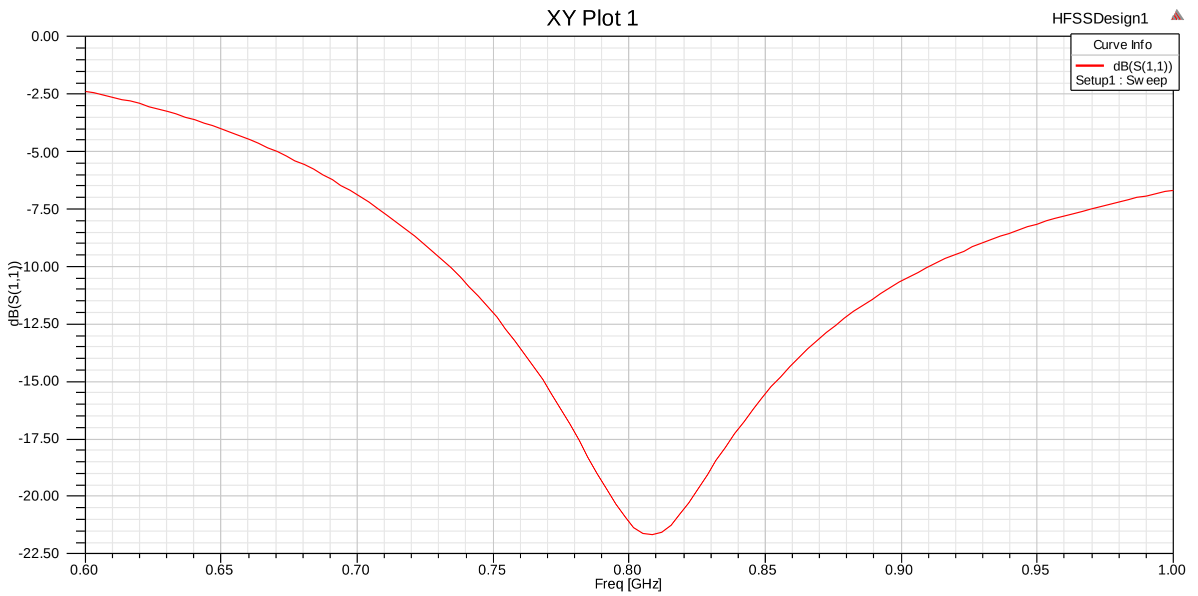


Name-Mohammad Imran Shekh Roll no-2001094 Branch-ECE

Analysis setup of antenna: -

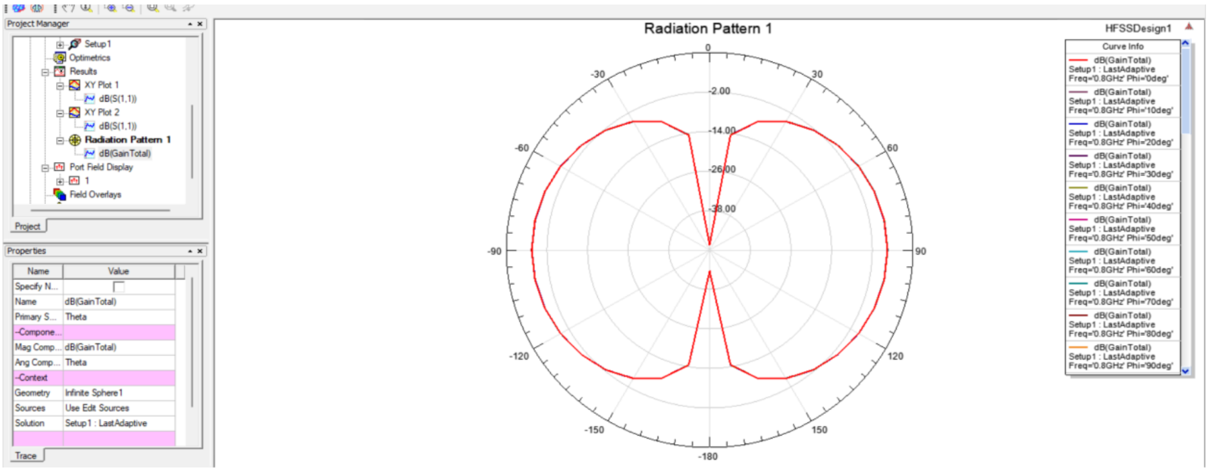


Result (Graph) for dipole antenna: -

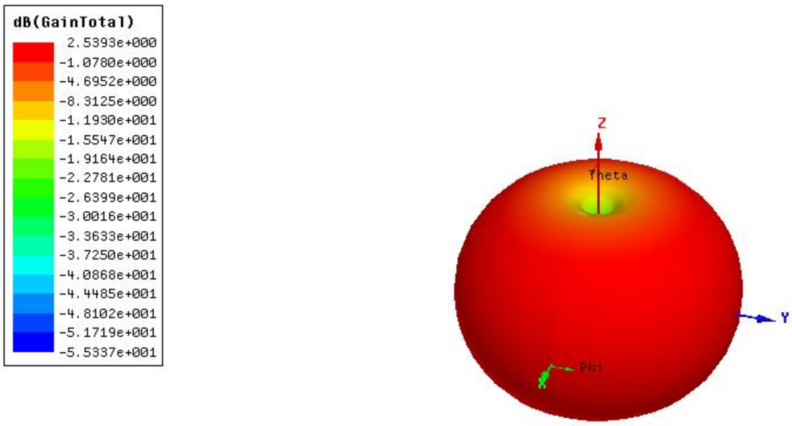


Above graph show that minimum is at the central frequency of dipole antenna.

2D radiation Pattern: -



3D radiation Pattern: -



Result: -

The results of the dipole antenna experiment in HFSS show the 2D and 3D radiation patterns of the antenna at a central frequency of 800 MHz. The 2D radiation pattern displays the radiated power in a plane perpendicular to the antenna's axis, while the 3D radiation pattern shows the power distribution in all directions around the antenna. Both patterns exhibit characteristics such as beamwidth, directivity, and side lobe levels. These results provide insight into the performance of the dipole antenna at 800 MHz and may suggest areas for improvement in the design.

Experiment 5

Aim: - To design and analysis magic tee using the HFSS software.

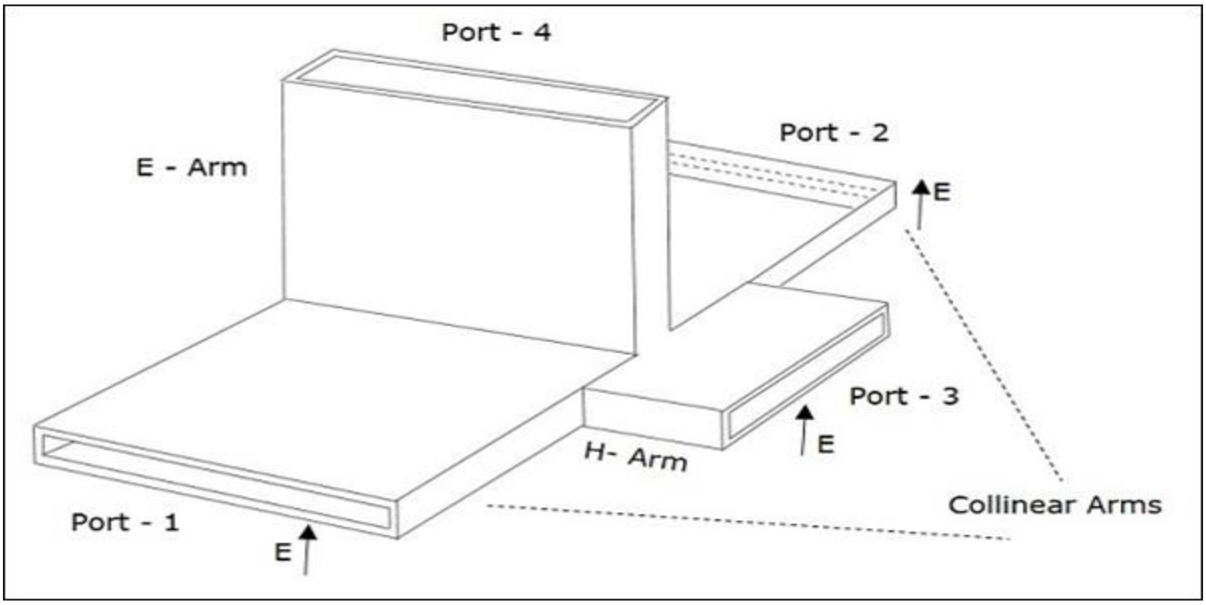
Apparatus: -

HFSS Software.

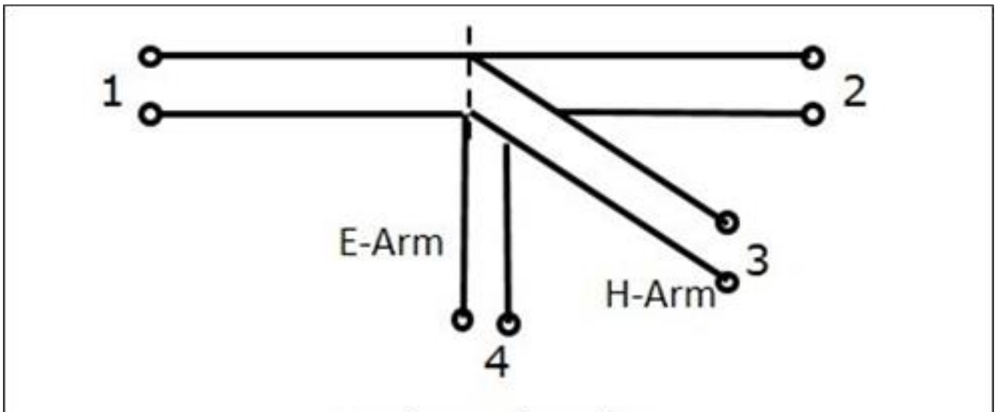
Theory: - An E-H Plane Tee junction is formed by attaching two simple waveguides one parallel and the other series, to a rectangular waveguide which already has two ports. This is also called as **Magic Tee**, or **Hybrid** or **3dB coupler**.

The arms of rectangular waveguides make two ports called **collinear ports** i.e., Port 1 and Port 2, while the Port 3 is called as **H-Arm** or **Sum port** or **Parallel port**. Port 4 is called as **E-Arm** or **Difference port** or **Series port**.

The cross-sectional details of Magic Tee can be understood by the following figure.



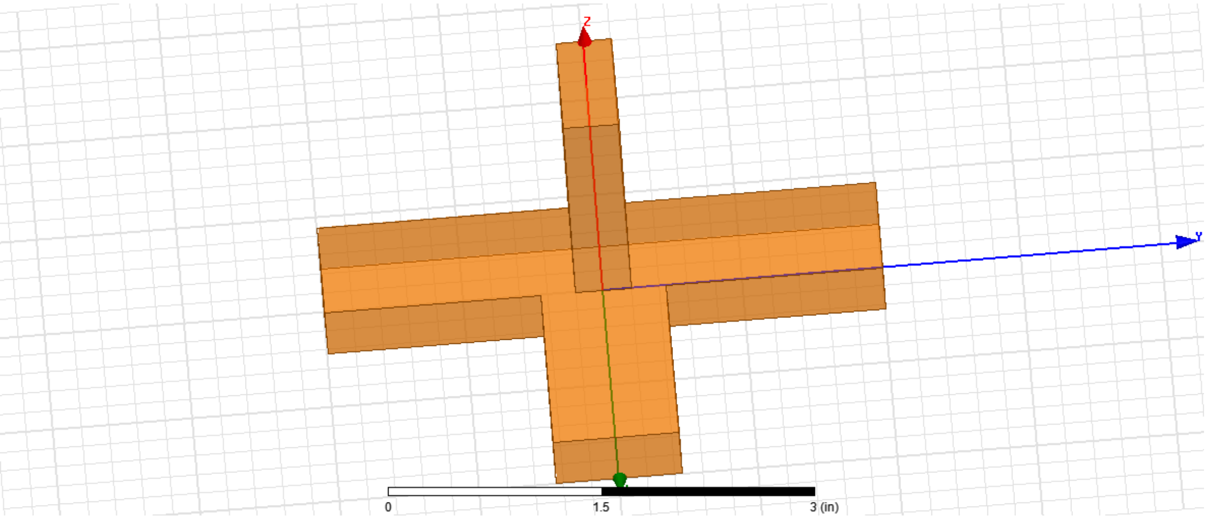
The following figure shows the connection made by the side arms to the bi-directional waveguide to form both parallel and serial ports.



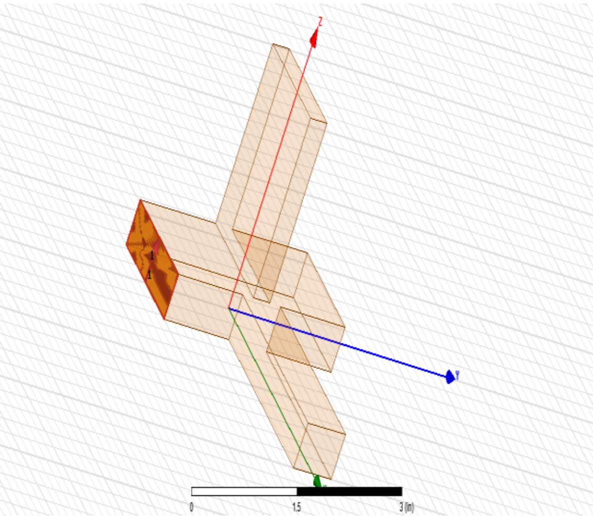
Magic Tee junction

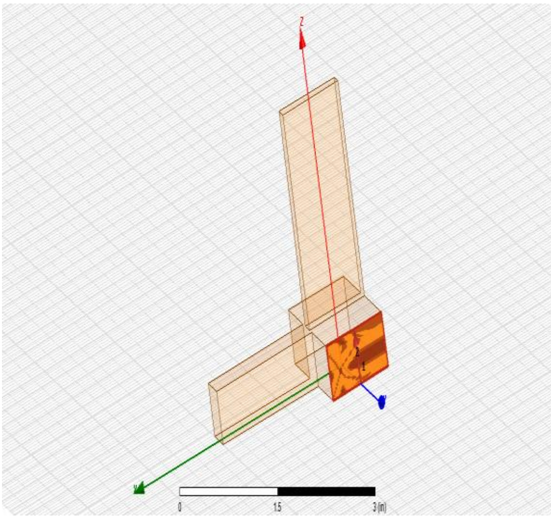
$$[S] = \begin{bmatrix} 0 & 0 & \frac{1}{2} & \frac{1}{\sqrt{2}} \\ 0 & 0 & \frac{1}{2} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \end{bmatrix}$$

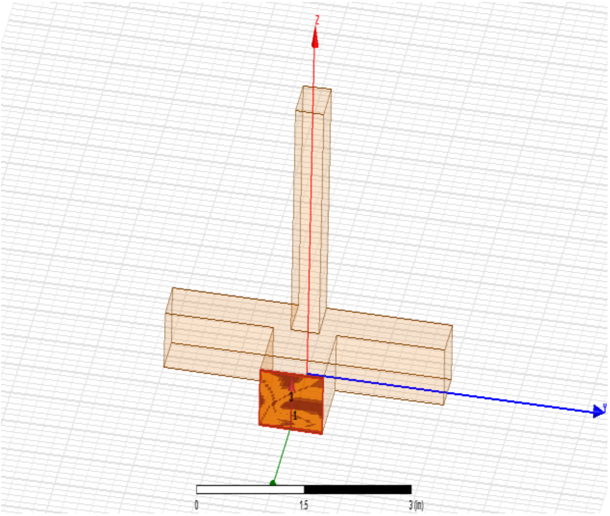
Magic Tee design in HFSS: -

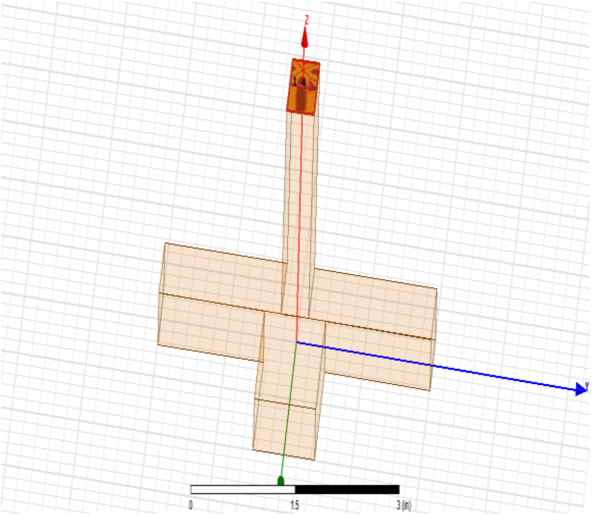


Excitation at Ports: -

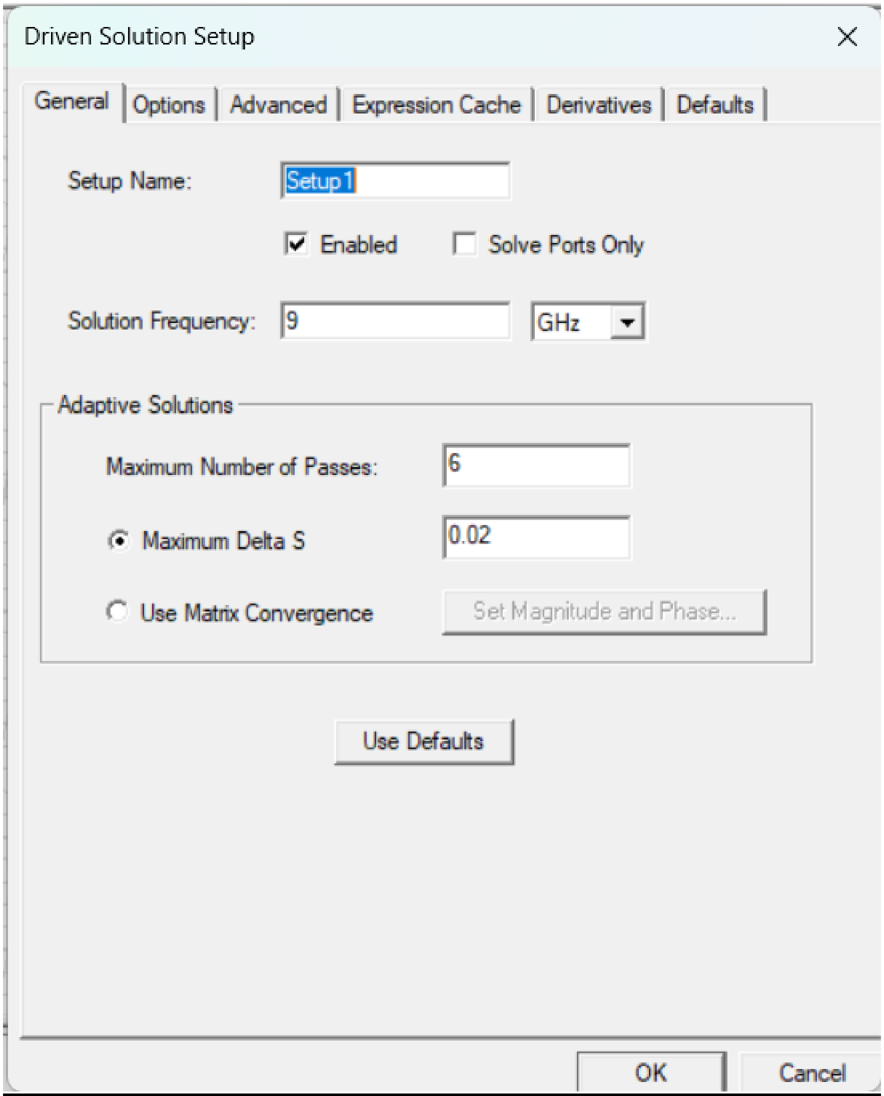






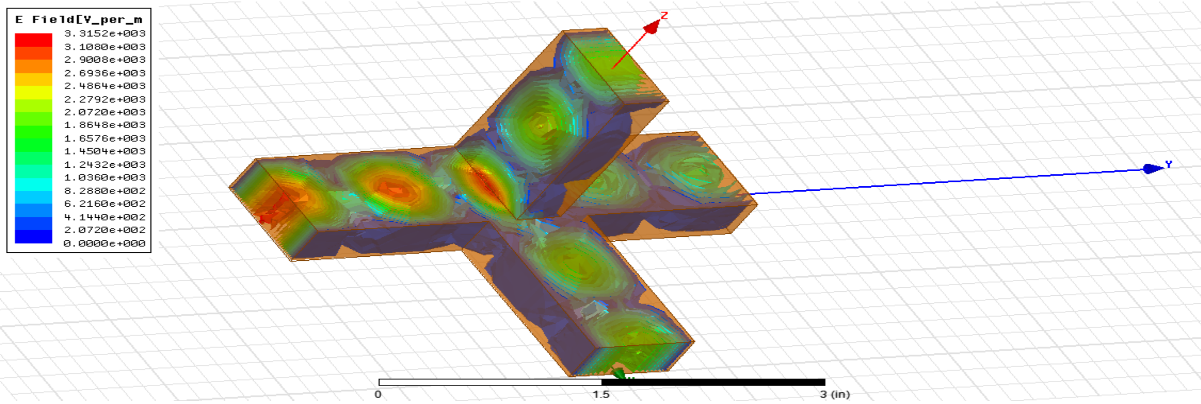


Analysis Window: -



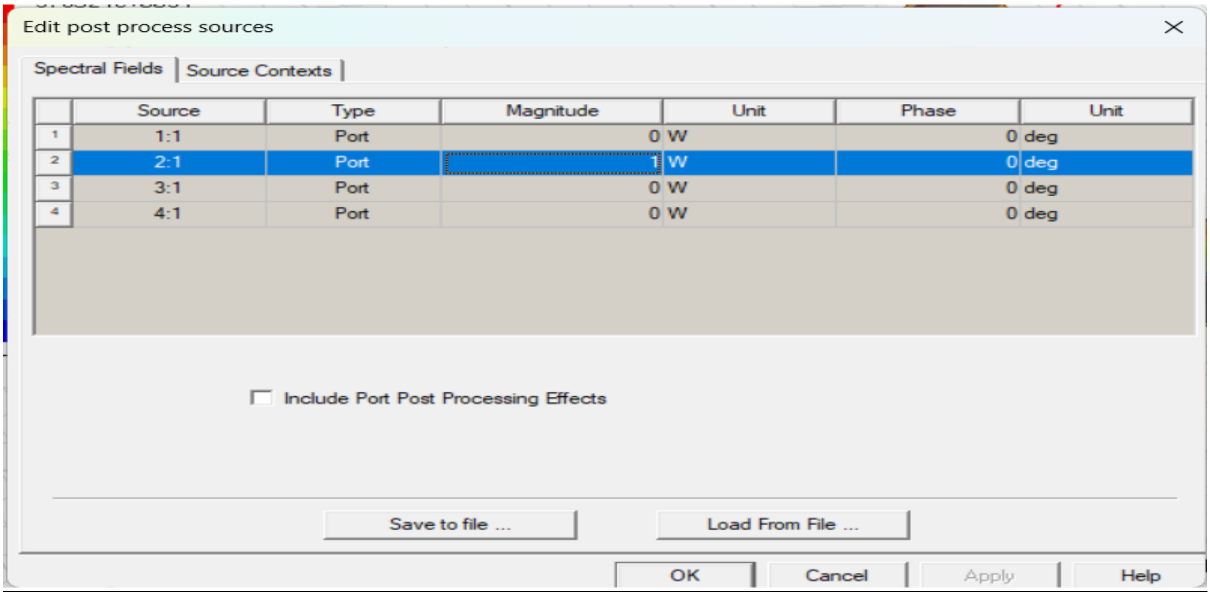
Name-Mohammad Imran Shekh Roll no-2001094 Branch-ECE

Magnetic Field in Magic Tee: -

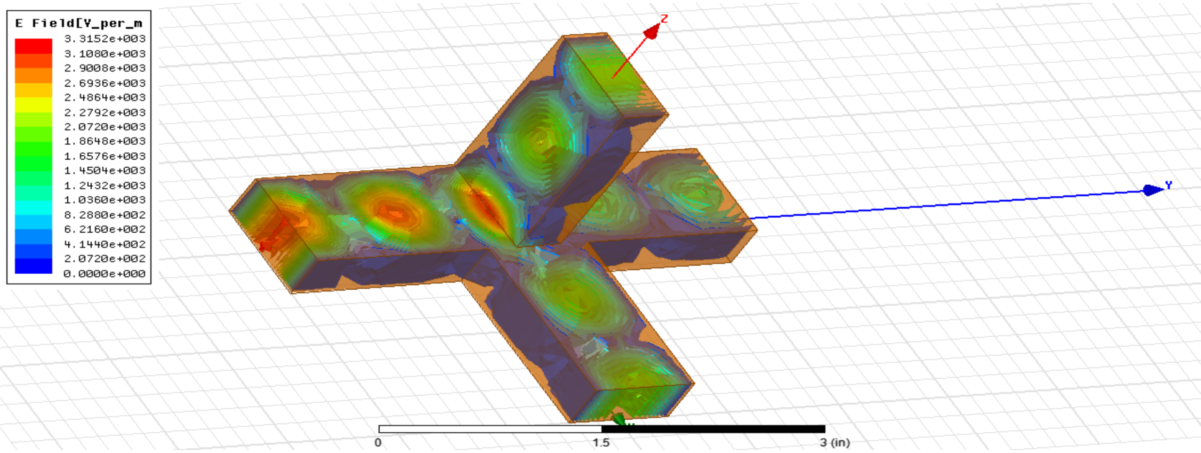


Output for Different Cases: -

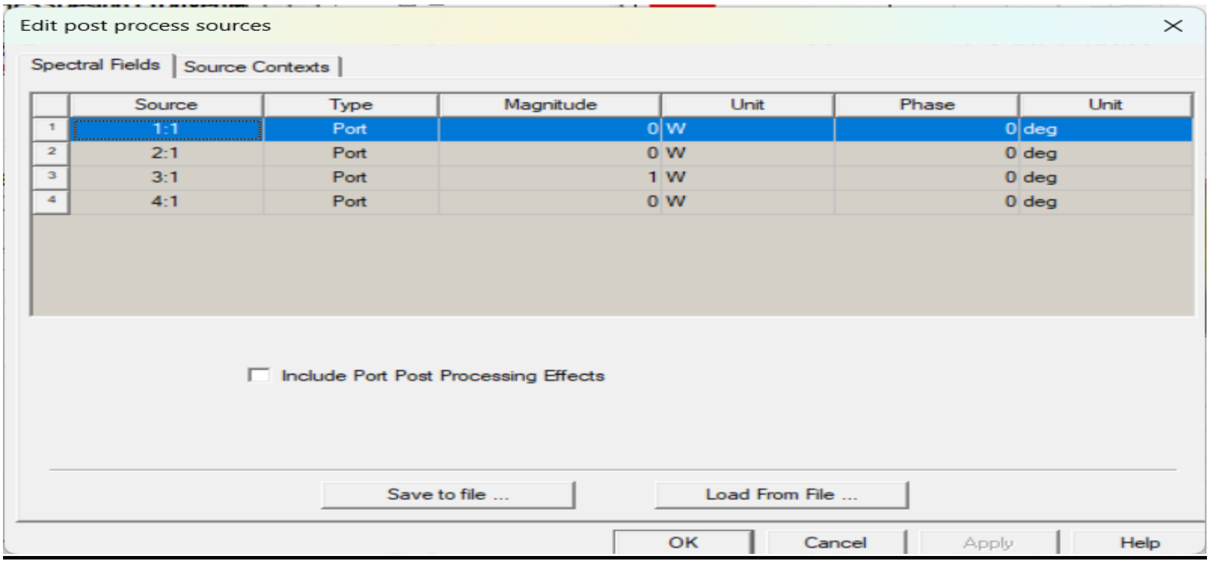
Case 1: -



Output for Case 1:



Case 2: -



Edit post process sources

Spectral Fields | Source Contexts

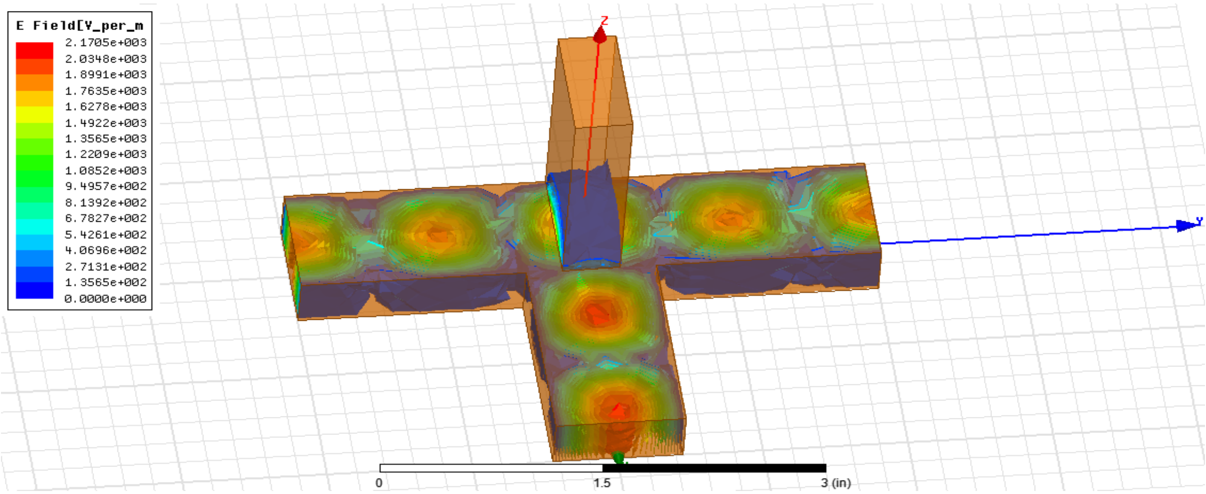
	Source	Type	Magnitude	Unit	Phase	Unit
1	1:1	Port	0	W	0	deg
2	2:1	Port	0	W	0	deg
3	3:1	Port	1	W	0	deg
4	4:1	Port	0	W	0	deg

Include Port Post Processing Effects

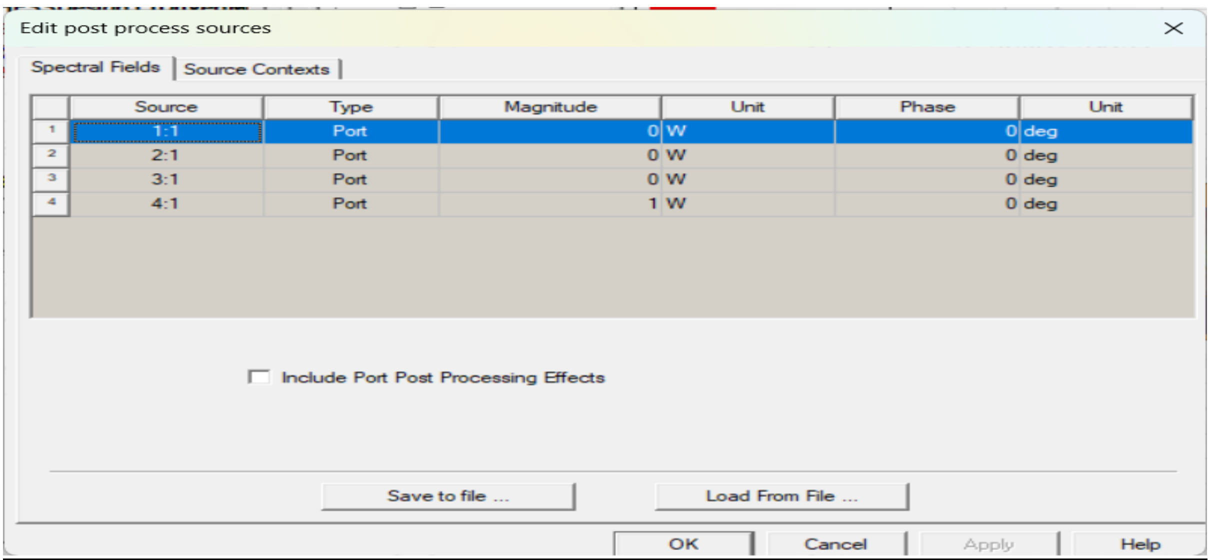
Save to file ... Load From File ...

OK Cancel Apply Help

Output for case 2:



Case 3: -



Edit post process sources

Spectral Fields | Source Contexts

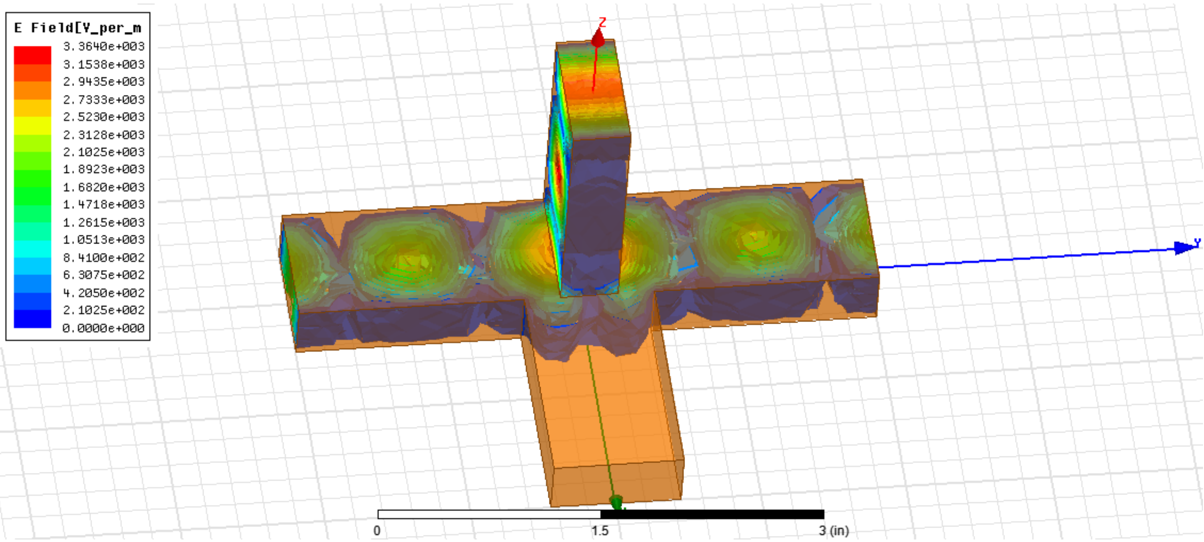
	Source	Type	Magnitude	Unit	Phase	Unit
1	1:1	Port	0	W	0	deg
2	2:1	Port	0	W	0	deg
3	3:1	Port	0	W	0	deg
4	4:1	Port	1	W	0	deg

Include Port Post Processing Effects

Save to file ... Load From File ...

OK Cancel Apply Help

Output for case 3: -



Power Obtained: -

At port 1: -

1:1	(-18.9, -82.3)	(-7.48, -44.8)	(-4.35, -6.19)	(-3.55, -151)

At port 2: -

2:1	(-7.48, -44.8)	(-18.8, -83.6)	(-4.37, -6.27)	(-3.54, 28.3)

At port 3: -

3:1	(-4.35, -6.19)	(-4.37, -6.27)	(-5.73, -140)	(-55.8, -54.7)

At port 4: -

4:1	(-3.55, -151)	(-3.54, 28.3)	(-55.8, -54.7)	(-9.37, 89.7)

Result: -

Based on your Magic Tee experiment in HFSS, you have obtained power results for each port. These results can be used to analyse the behaviour of the Magic Tee and understand how power is distributed between the ports. By comparing the power levels at each port, you can determine the level of isolation and coupling between them. This information can be used to optimize the design of the Magic Tee for specific applications.

Experiment 6

Aim: -To study the Repeller mode characteristics of the Reflex

Apparatus: -

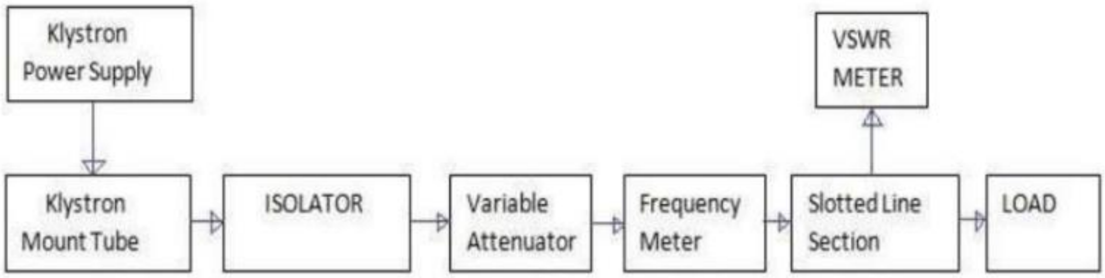
- KLYSTRON POWER SUPPLY
- KLYSTRON TUBE.
- ISOLATER
- FREQUENCY METER
- VARIABLE ATTENUATOR
- DETECTOR MOUNT
- WAVE GUIDE STANDS
- VSWR METER
- OSCILLOSCOPE
- 10.BNC CABLE
- 11.FAN FOR COOLING THE REFLEX KLYSTRON TUBE

Theory: -

The Reflex Klystron makes use of velocity modulation and current modulation to transform a continuous electron beam into microwave power. Electrons emitted from the cathode are accelerated and passed through the cavity resonator. The electron velocity is either accelerated or retarded depending on the instantaneous ac voltage across the resonator (velocity modulation). The electrons that leave the resonator and travel towards reflector need different times to return due to change in their velocities.

As a result, returning electrons group together in bunches (current modulation). As the electron bunches pass through resonator, they interact with voltage at resonator grids. The bunches pass the grid during negative ac cycle and the electrons transfer their energy to the grid. This process is repeated once per ac cycle and sustained oscillations are obtained. The frequency of oscillations is primarily determined by the dimensions of resonant cavity. Hence, by changing the dimensions of resonator (mechanical tuning of Klystron), frequency of oscillations can be varied. Frequency variation can also be obtained by adjusting the reflector and beam voltages (Electronic Tuning).

Block Diagram: -



Procedure:

I. Carrier Wave Operation

1. Connect the components and equipment as shown in the Fig.

2. Set the Variable Attenuator at the maximum attenuation position.

3. Set the Mod-Switch of Klystron Power Supply at CW position, beam voltage control knob to fully anti

clock wise and reflector voltage control knob to fully clock wise and the Meter Switch to ‘OFF’position.

4. Rotate the Knob of frequency meter to one side fully.

5. First connect the D.C micro-ammeter with Detector.

6. Switch on the Klystron Power Supply, VSWR Meter and Cooling fan.

7. Switch on beam voltage and rotate the knob slowly clockwise up to 250 V. Observe beam current value.“The Beam Current should be less than 30 mA”

8. Vary the reflector voltage slowly and watch ammeter. Set the voltage for maximum deflection in themeter.

9. Tune the plunger of Klystron Mount for the maximum output.

10. Rotate the Knob of frequency meter slowly. At some particular position there will be a dip in micro-ammeter. Note down the frequency meter reading where output current is lowest. Read frequency directly between two horizontal lines and vertical marker in case of direct reading type wave meter and use the frequency chart to find frequency from micrometre reading.

11. Change the reflector voltage and read the current and frequency for each reflector voltage.

II. Square Wave Operation

1. Connect the equipment and components as shown in the Fig 1.

2. Set Micrometer of variable attenuator at some position.

3. Set the range switch of VSWR meter at 40 dB position, input selector switch to crystal impedance position, meter switch to narrow position.

4. Set Mod-selector switch to AM-MOD position, beam voltage control knob to fully anticlockwise position.

5. Switch ‘ON’ the Klystron Power Supply, VSWR meter and cooling fan. Wait for few minutes.

6. Switch ‘ON’ the Beam voltage switch and rotate the beam voltage knob clockwise up to 300 V deflections in meter.

7. Keep the AM-MOD amplitude knob and AM-FRE, knob at the mid-position.

8. Rotate the reflector voltage knob to get deflection in VSWR meter.

9. Rotate the AM-MOD amplitude knob to get the maximum output in VSWR meter.

10. Maximize the deflection with frequency knob to get the maximum output in VSWR meter.

11. If necessary, change the range switch of VSWR meter 30 dB or 50 dB if the deflection in VSWR meter is out of scale or less than normal scale

respectively. Further the output can also be reduced by variable attenuator to set the output for any particular value.

III. Mode study on Oscilloscope.

1. Set up the components and equipment as shown in Fig.

2. Keep position of variable attenuator at minimum attenuation position.

3. Set mode selector switch to FM-MOD position, FM amplitude and FM frequency knob at mid position, keep beam voltage knob fully anticlockwise and reflector voltage knob to fully clockwise and Beam switch to 'OFF' position.

4. Keep the Time/division scale of oscilloscope around 100Hz frequency (t=0.01sec) measurement and Volt/division to lower scale.

5. Switch 'ON' the Klystron Power Supply and Oscilloscope.

6. Switch 'ON' Beam voltage and set beam voltage to 300 V by beam voltage control knob.

7. Keep amplitude knob of FM Modulator to maximum position and rotate the reflector voltage anticlockwise to get modes on the oscilloscope. The horizontal axis represents reflector voltage and vertical axis represents output power.

8. By changing the reflector voltage and amplitude of FM modulation, any mode of Klystron tube can be seen on Oscilloscope.

Observation: -

repeller voltage(v)	frequency	current(i)mA	power(VXI)mW
-75	8.9Ghz	1.77	132
-80	8.99Ghz	2.711	216
-83	9.00Ghz	2.55	211

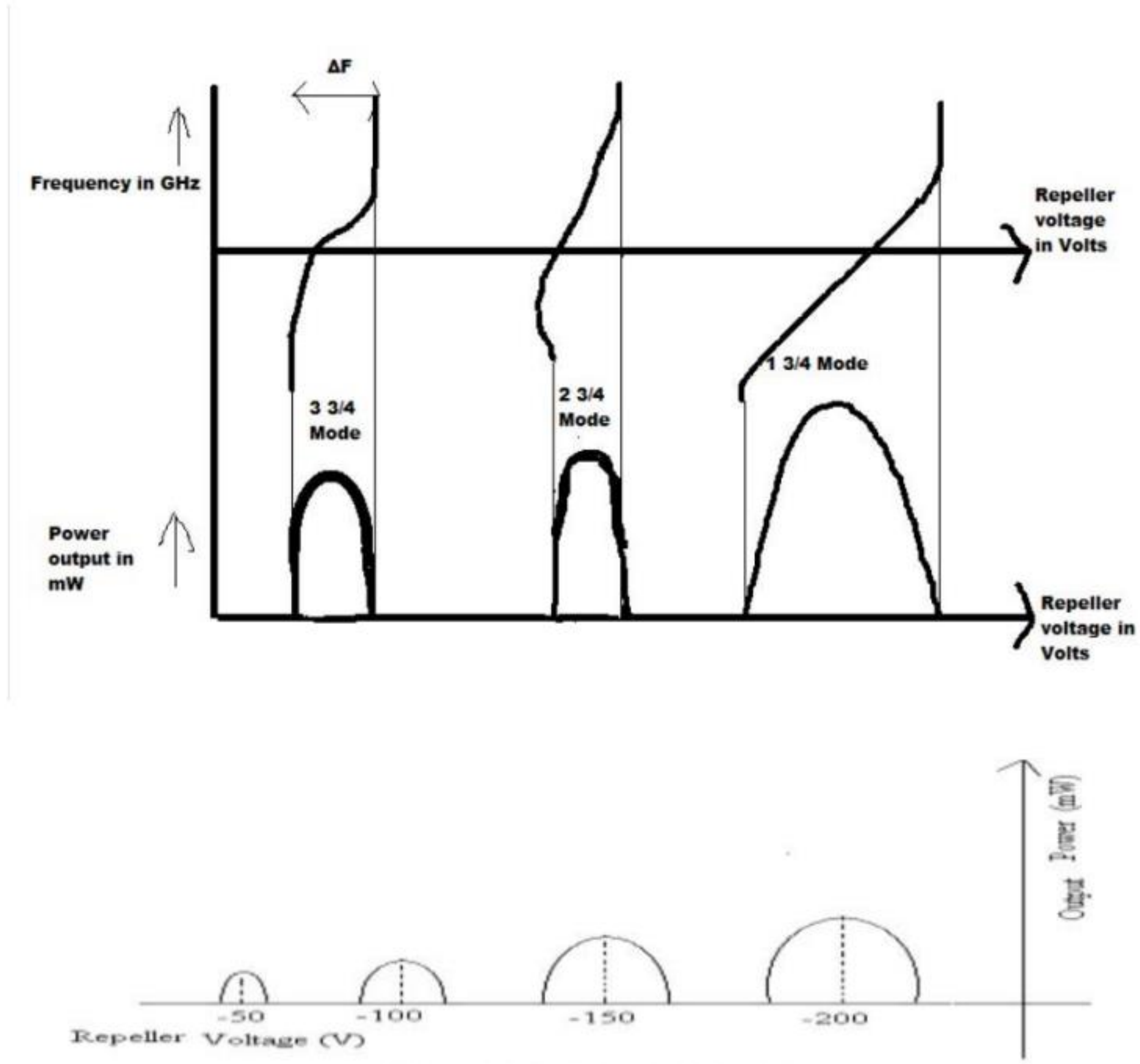


Fig. 2 Mode Study of Reflex Klystron

Precautions: -

- Make sure to set the Repeller to maximum in the klystron power supply.
- Make sure to set the beam voltage should be at minimum.
- Make sure to set rest of the nobs to minimum.

Result: -

The performance characteristics of reflex klystron tube are observed.
Inference: As the Repeller voltage increases, frequency and current of the reflex klystron tube increases.

Experiment 7

Aim: - To study the I-V characteristics of Gunn diode.

Components & Equipment Required:

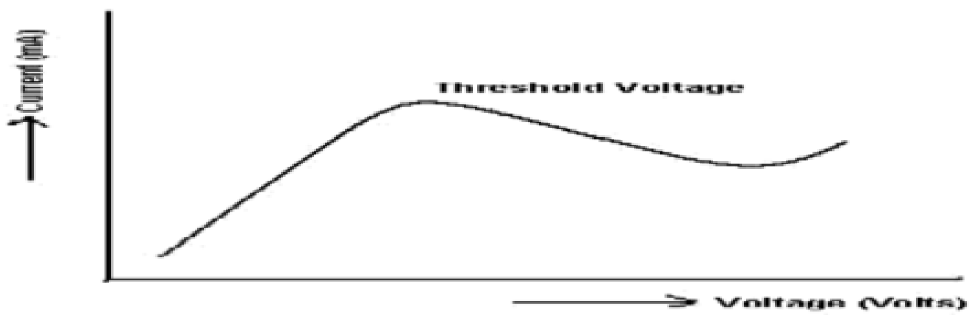
S No	Name of the Item	Specifications	Qty
1	Gunn Oscillator	8.6 to 11.6 GHz	1
2	Gunn Power Supply	Min. Output Power: 10 mW	1
3	Isolator	Min. Isolation:20 dB;	1
4	Frequency Meter	8.2 to 12.4 GHz	1
5	Variable Attenuator	Average Power:2 W;	1
6	Detector Mount	IN23	1
7	Wave Guide Stand	-	5
8	VSWR Meter	Frequency :1 KHz; Range :70 dB Minima in	1
9	PIN Modulator	Max. RF Power: 1 W	1
10	BNC Cable	-	2
11	Cooling Fan for Gunn	-	1

Theory:

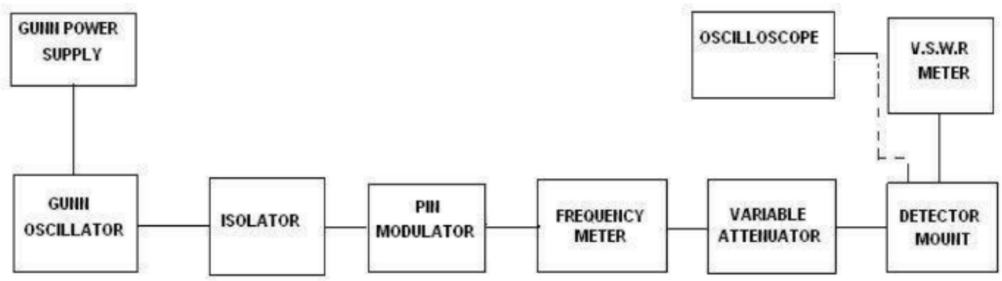
The Gunn oscillator is based on negative differential conductivity effect in bulk semi-conductors which has two conduction bands minimum separated by an energy gap (greater than thermal agitation energies). A disturbance at the cathode gives rise to high field region which travels towards the anode. When this high field domain reaches the anode, it disappears, and another domain is formed at the cathode and starts moving towards anode and so on. The time required for the domain to travel from cathode to anode (transit time) gives oscillation frequency.

In a Gunn oscillator, the Gunn diode is placed in a resonant cavity. In this case the oscillation frequency is determined by cavity dimension rather than by diode itself. Although Gunn oscillator can be amplitude-modulated with the bias voltage, a separate PIN modulator through PIN diode for square wave modulation is used.

The ideal I-V characteristics of Gunn diode are shown in Fig 1.



Block Diagram :-



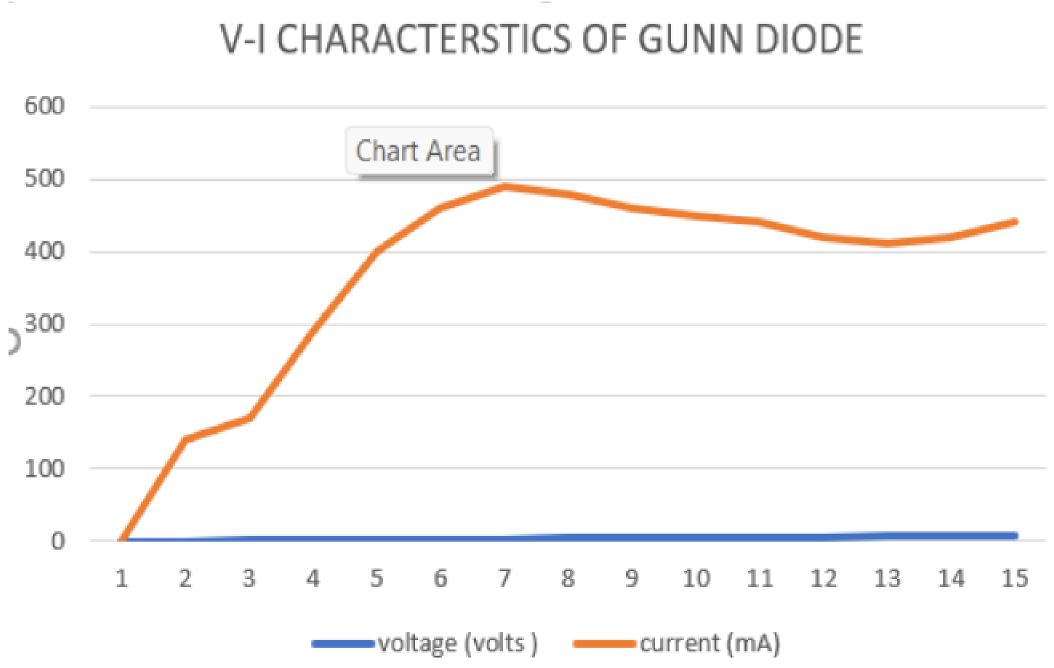
Procedure:

- Set the components and equipment as shown in the Fig 2.
- Initially set the variable attenuator for maximum attenuation.
- Keep the control knobs of Gunn power supply as below Meter switch – 'OFF' Gunn bias knob – Fully anticlockwise Pin bias knob – Fully anti-clockwise Pin mod frequency – Any position.
- Keep the control knobs of VSWR meter as below Meter switch – Normal Input switch – Low Impedance Range dB switch – 40 dB Gain control knob – Fully clockwise.
- Set the micrometre of Gunn oscillator for required frequency of operation.
- Switch 'ON' the Gunn power supply, VSWR meter and Cooling fan.
- Measure the Gunn diode current corresponding to various voltages from the panel meter by turning meter switch to voltage and current positions. Do not exceed the bias voltage above 10Volts.
- Plot the voltage and current readings on the graph as shown in Fig 1.
- Measure the threshold voltage which corresponds to maximum current.

Observation: -

voltage (volts)	current (mA)
0	0
0.5	140
1	170
1.5	290
2	400
2.5	460
3	490
3.5	480
4	460
4.5	450
5	440
5.5	420
6	410
6.5	420
7	440

Output graph: -



Precautions: -

- make sure to set the values in gun power supply to default.
- make sure that the output is connected to the oscilloscope.

Result: -

The I-V characteristics of Gunn diode are obtained. Inference: For the given Gunn diode the threshold voltage is V and the threshold current is mA. The negative resistance of the Gunn diode is observed between I= 0mA to 500mA.

Experiment 8

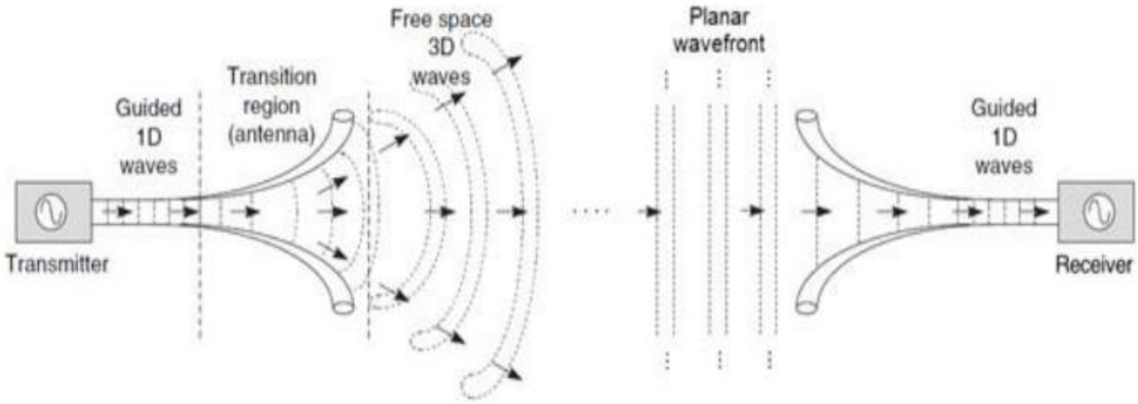
Aim: -

To demonstrate that the transmitting and receiving radiation patterns of an antenna are equal and hence confirm the reciprocity theorem of antennas.

THEORY: -

When an antenna is rotated around its axis its radiation pattern can be plotted. So whether the antenna is rotated while being connected at receiver or transmitter makes no difference.

Sources of error could be stray reflections and wire leakages and should be accounted for. The transmitting and receiving radiation patterns of an antenna are equal and hence the reciprocity theorem of antennas is proved.



EQUIPMENT REQUIRED: -

ATS04 with stepper motor controller, Dipole & Yagi antenna, Antenna pod and stepper pod with connecting cables

PROCEDURE: -

1. Connect the Yagi Antenna to receiver stepper pod and set the frequency to 3.8GHz. Keep

the antenna in horizontal plane.

2. Now connect a dipole antenna to the transmitter pod.

3. Point the Yagi antenna is the direction of dipole with their elements parallel to each other

as per figure.

4. Set the distance between the antennas to be around 1m. Remove any stray object fromaround the antennas, especially in the line of sight. Avoid any unnecessary movement while taking the readings.

5. Now rotate the Yagi antenna around its axis in steps of 5 degrees using stepper motor controller. Take the readings in ATS04 receiver at each step and note down. Plot the readings on the graph paper provided at back.

6. Now without disturbing the setup, connect the antenna at stepper pod to the transmitter. Do not disturb their directions. Now Yagi is connected to transmitter and dipole at receiver. Take another set of readings by rotating the transmitter stepper pod from the controller every 5 degrees.

7. Keep in mind that it is antenna that is being rotated is plotted in reception and transmission mode both for proving the reciprocity theorem.

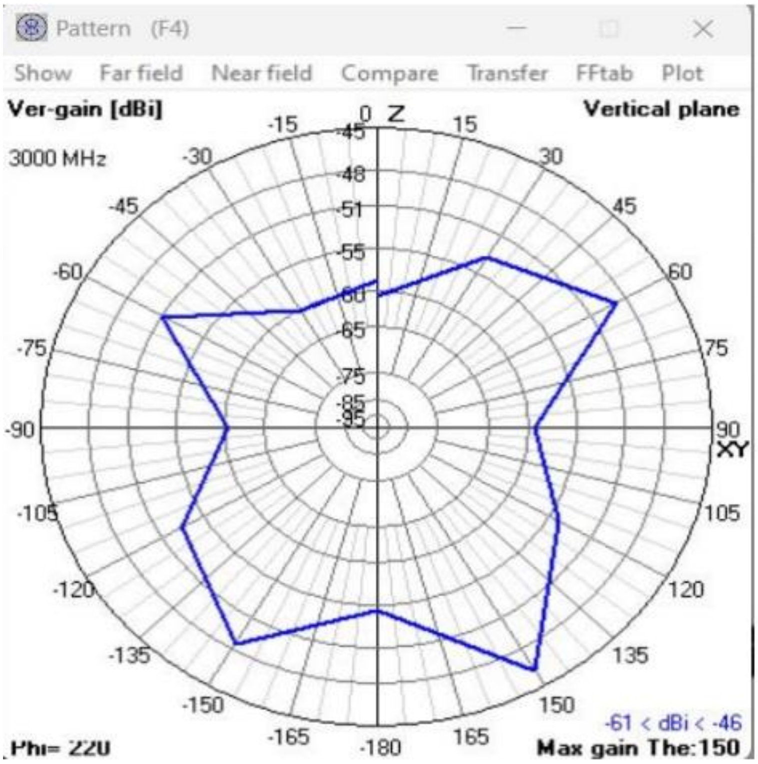
8. Observe the two plots and find if they are any different from each other.

9.Plot these readings on Cartesian plane with distance between antennas on X axis and signal

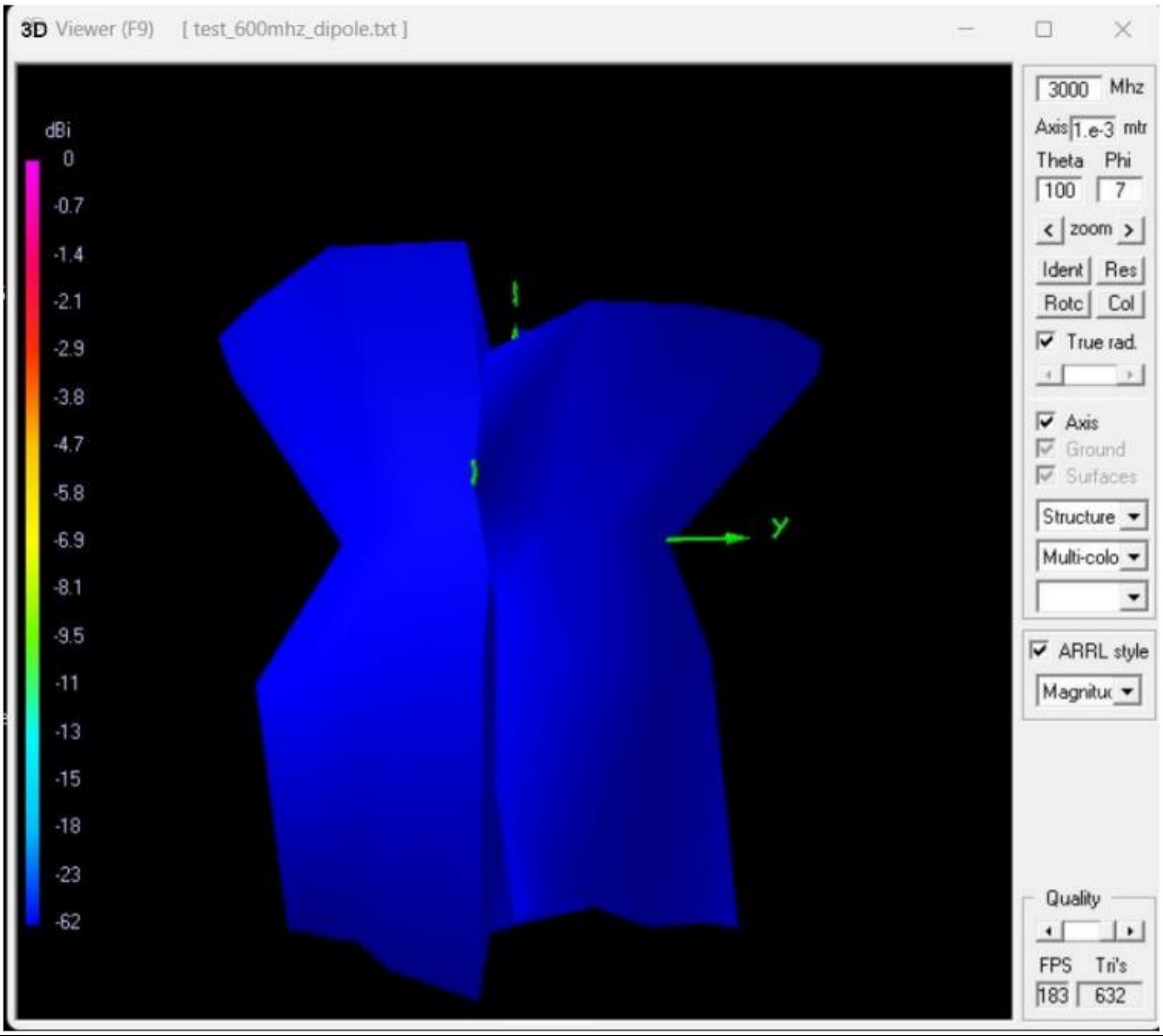
level in dB as Y-axis.

Observation: -

Radiation Pattern: -



3D Model radiation pattern: -



Precautions: -

- Never go between the antennas while they are operating.
- Make sure that the circuit is working fine with all connections correct.

Result: Upon observing the patterns i have observed that there are some places where the magnitude is very high and very low this is due to the strength of the antenna transmitting and receiving. the 3-d diagram is not complete because we have started from 0 and end at 180 this process is not continuous, so we get a dip line.