MARRI LAXMAN REDDY
INSTITUTE OF TECHNOLOGY AND MANAGEMENT
(AN AUTONOMOUS INSTITUTION)
(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)
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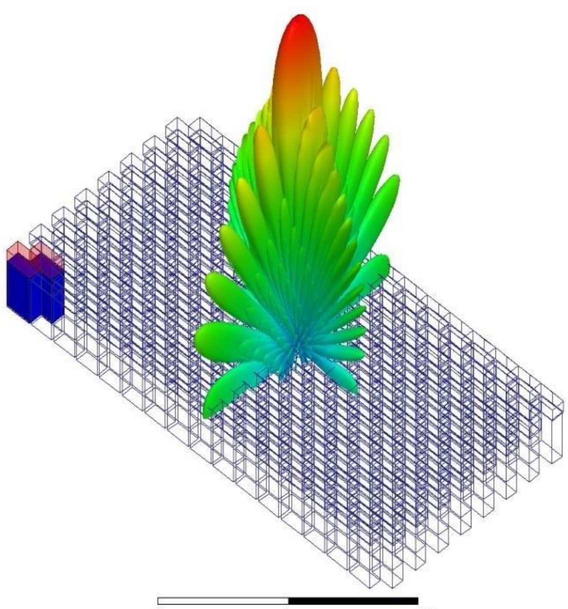
Department of Electronics & Communication Engineering

Computational Electromagnetics and Antenna Laboratory Manual (2460480)

III B.TECH-ISEMESTER-

ECE&EEE MLRS-R24

REGULATION



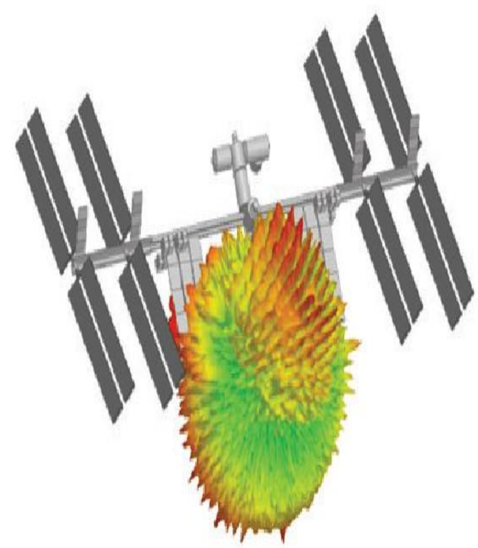


Figure 8. PO example showing antenna pattern of an antenna on

CERTIFICATE

This is to certify that this manual is a Bonafide record of practical work in the **Computational Electromagnetics And Antenna Laboratory** in **Second Semester of III-year B. Tech (ECE) SEM-II Programme** during the academic year **2026-27.** This Lab Manual is prepared Dr.R. Prabhakar **(Associate Professor)** Department of Electronics and Communication Engineering.

Head of the Department

PREFACE

This foundation for the Electronics and Communication Engineering and Electrical and Electronics Engineering students during Second year of their course.

In this course students will know how to design, simulate and layout design of Electronic Circuits and functional checks using HFSS software tools.

By,

Dr.R. Prabhakar

ACKNOWLEDGEMENT

It was really a good experience, working with **Computational Electromagnetics and Antenna Laboratory,**. First, we would like to thank Dr. N. Srinivas Assoc. Professor, HOD of Department of Electronics and Communication Engineering, Marri Laxman Reddy Institute of technology & Management for his concern and giving the technical support in preparing the document.

We are deeply indebted and gratefully acknowledge the constant support and valuable patronage of Dr. Ravi Prasad, Dean, Marri Laxman Reddy Institute of technology & Management for giving us this wonderful opportunity for preparing the **Computational Electromagnetics And Antenna Laboratory** in **Second Semester**

We express our hearty thanks to Dr. R. Murali Prasad, Principal, Marri Laxman Reddy Institute of technology & Management, for timely corrections and scholarly guidance.

We express our hearty thanks to Dr. P. Sridhar, Principal, Marri Laxman Reddy Institute of technology & Management, for timely corrections and scholarly guidance.

At last, but not the least I would like to thanks the entire ECE Department faculty those who had inspired and helped us to achieve our goal.

By,

Dr.R. Prabhakar

GENERALINSTRUCTIONS

1. Students are unstructured to come to HFSS Lab. Late comers are not entertained in the lab.
2. Student should be punctual to the lab. If not, then conducted experiments will not be repeated.
3. Students are expected to come prepared at home with the experiments which are going to be per formed.
4. Students are instructed to display the identity cards before entering in to the lab.
5. Students are instructed not to bring mobile phones to the lab.
6. Any damage/loss of equipment like mouse, keyboard, CPU etc., during the lab session, it is student's responsibility and penalty or fine will be collected from the student.
7. Students should update the records and lab observation books session wise. Before leaving the lab, the student should get his lab observation book signed by the faculty.
8. Students should submit the lab records by the next lab to the concerned faculty members in the staffroom for their correction and return.
9. Students should not move around the lab during the lab session.
10. If any emergency arises ,the student should take the permission from faculty member concerned in written format.
11. Thefacultymembersmaysuspendanystudentfromthelabsessionondisciplinary grounds.
12. Never copy the output from other students. Write down your own outputs.

SAFETYPRECAUTIONS

1. No horse play or running is allowed in the labs.

2. No bare feet or opens and also are permitted.

3. Before energizing any equipment, check whether anyone is in apposition to be injured

bifurcations.

4. Readtheappropriateequipmentinstructionmanualsectionsorconsultwithyourinstru

ctor.

5. Beforeapplyingpowerorconnectingunfamiliarequipmentorinstrumentsintoanycircui

ts.

6. Position all equipment on benches in a safe and stable manner.

7. Do not make circuit connections by hand while circuits are energized. This is especially.

8. Dangerous with high voltage and current circuits.

INSTITUTE VISION AND MISSION

Vision of the Institute

To be a globally recognized institution that fosters innovation, excellence, and leadership in education, research, and technology development, empowering students to create sustainable solutions for the advancement of society.

Mission of the Institute

To foster a transformative learning environment that empowers students to excel in engineering, innovation, and leadership.
To produce skilled, ethical, and socially responsible engineers who contribute to sustainable technological advancements and address global challenges.
To shape future leaders through cutting-edge research, industry collaboration, and community engagement.

Quality Policy

The management is committed in assuring quality service to all its stakeholders, students, parents, alumni, employees, employers, and the community.
Our commitment and dedication are built into our policy of continual quality improvement by establishing and implementing mechanisms and modalities ensuring accountability at all levels, transparency in procedures, and access to information and actions.

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Department of Electronics and Communication Engineering

Vision of the Department

To provide quality technical education in Electronics and Communication Engineering through research, innovation, striving for global recognition in specified domain, leadership, and sustainable societal solutions.

Mission of the Department

- To create a transformative learning environment that empowers students in electronics and communication engineering, fostering excellence in technical skills and leadership.
- To drive innovation through research, deliver a transformative education grounded in ethical principles, and nurture the development of professionals
- To cultivate strong industry partnerships, and engaging actively with the community for societal and technological progress.

Program educational Objectives (PEOs)

PEO 1: Have Successful career in Industry

Graduates will excel in the Electronics and Communication industry with a strong foundation in technical expertise, continuous learning, and innovation.

PEO 2: Show Excellence in higher studies/Research

Graduates will excel in higher studies and research in Electronics and Communication Engineering (ECE) through a combination of rigorous academic dedication, cutting-edge innovation, and a deep understanding of emerging technologies.

PEO 3: Show Good Competency towards Entrepreneurship

*Graduates will have t*o show good competency towards entrepreneurship in the field of Electronics and Communication Engineering, one must demonstrate an in- depth understanding of emerging technologies, market trends, and the ability to innovate within this rapidly evolving industry.

Program Specific Outcomes (PSOs)

1. Analyze and design analog & digital circuits or systems for a given specification and function.
2. Implement functional blocks of hardware-software co-designs for signal processing and communication applications.

Department of Electronics and Communication Engineering
Program Outcomes (POs)

Engineering Graduates will be able to:

PO1: Engineering knowledge:Apply the knowledge of mathematics, science, engineering fundamentals, and engg. Specialization to the solution of complex engineering problems.

PO2: Problemanalysis:Identify,formulate,researchliterature,andanalyzeengineeringproblemsto arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components, processes to meet the specifications with consideration for thepublichealthandsafety,andthecultural,societal,andenvironmentalconsiderations.

PO 4: Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Moderntoolusage:Create,select,andapplyappropriatetechniques,resources,andmodernengineeringandITtoolsincludingpredictionandmodelingtocomplexengineeringactivitieswithanunderstandingofthelimitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and sustainability: Understand the impact of the professional engineeringsolutionsinsocietalandenvironmentalcontexts,anddemonstratetheknowledgeof,andneedforsustainabledevelopment.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individualandteamwork:Functioneffectivelyasanindividual,andasamemberorleaderinteams,andinmultidisciplinarysettings.

PO10: Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

PO12: Lifelong learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMSPECIFICOUTCOMES

PSO1: Analyze and design analog &digital circuits or systems for a given specification and function.

PSO2: Implement functional blocks of hardware-software co-designs for signal processing and communication applications.

. COURSE CONTENT

COMPUTATIONAL ELECTROMAGNETICS AND ANTENNA LABORATORY									
VI Semester: ECE									
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**			
2460480	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**	
		0	0	2	1	40	60	100	
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 30**				**Total Classes: 30**			
Prerequisites: Electromagnetics and Electromagnetic Wave Theory, familiarity with antenna fundamentals and radiation concepts.									

Couse Overview:

This course introduces the fundamentals of antennas, wave propagation, and waveguide structures. Students will gain hands-on experience with ANSYS HFSS for designing and simulating various antenna types and arrays. The course also covers practical applications through the modeling of coaxial cables, waveguides, and striplines.

Course Objectives:

The students will try to learn

- Fundamentals of antennas, types, and key performance parameters
- Basics of electromagnetic wave propagation and different propagation models
- Proficiency in using ANSYS HFSS for 3D antenna modeling and simulation
- Designing and simulation of various antennas including dipole, microstrip patch, and waveguides
- Antenna arrays and stripline structures with a focus on their design and analysis in HFSS

Course Outcomes:

After successful completion of the course, students shall be able to

CO1: Explain antenna fundamentals and wave propagation concepts

CO2: Use HFSS software to model and simulate basic and advanced antenna structures

CO3: Design and analyze dipole, microstrip, and circular patch antennas

CO4: Simulate and evaluate waveguide structures such as coaxial, rectangular, and circular waveguides

CO5: Design and simulate antenna arrays and straplines for real-world applications

List of Experiments:

Use ANSYS High-Frequency Structure Simulator (HFSS) software to model, design, and simulate both basic and advanced antenna structures through the following experiments.

1. Design and Simulate Dipole Antenna
2. Design and Simulate Rectangular Microstrip Patch Antenna
3. Design and Simulate Circular Patch Antenna
4. Design and Simulate Coaxial Cable.
5. Design and Simulate Rectangular Waveguide
6. Design and Simulate Circular Waveguide
7. Design and Simulate Rectangular slotted Waveguide

8. Design and Simulate Circular Waveguide Array
9. Design and Simulate strip line.
10. Design and Simulate Rectangular Array Waveguide
11. Design and Simulate Yagi–Uda Antenna
12. Design and Simulate Horn Antenna
13. Design and Simulate Frequency Selective Surface (FSS)
14. Design and Simulate Dual-Band Microstrip Patch Antenna

NOTE: The minimum 12 experiments to be conducted

.

ELECTRONIC RESOURCES:

1. https://nptel.ac.in/courses/108/104/108104078
2. https://nptel.ac.in/courses/108/104/108104115
3. https://nptel.ac.in/courses/108/105/108105039
4. https://nptel.ac.in/courses/108/106/108106151
5. https://nptel.ac.in/courses/117/105/117105070
6. https://nptel.ac.in/courses/108/107/108107114
7. https://nptel.ac.in/courses/108/108/108108076
8. https://nptel.ac.in/courses/108/109/108109093

MAPPING OF EACH CO WITH PO(s), PSO(s):

Course Outcomes	PROGRAM OUTCOMES												PSOs	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	✓	✓	-	-	-	-	-	-	-	-	-	-	✓	✓
CO2	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓
CO3	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓
CO4	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓
CO5	✓	✓	✓	✓	✓	-	-	-	-	-	-	-	✓	✓

Simple-1 **Moderate-2** **High-3vi**

TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

Course Outcomes	PROGRAM OUTCOMES												PSOs	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
	4	**10**	**10**	**10**	**4**	**5**	**4**	**4**	**10**	**5**	**10**	**8**	**4**	**4**
CO1	4	5	-	-	-	-	-	-	-	-	-	4	3	2
CO2	4	5	4	4	3	-	-	-	-	-	-	4	2	3
CO3	4	6	6	4	3	-	-	-	-	-	-	4	3	3
CO4	4	6	4	6	3	-	-	-	-	-	-	4	3	3
CO5	4	6	6	6	3	-	-	-	-	-	-	4	3	3

TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

Course Outcomes	PROGRAM OUTCOMES												PSOs	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
No .of key competence	4	10	10	10	4	5	4	4	10	5	10	8	4	4
CO1	100	50	-	-	-	-	-	-	-	-	-	50	75	50
CO2	100	50	40	40	60	-	-	-	-	-	-	50	50	75
CO3	100	60	60	40	60	-	-	-	-	-	-	50	75	75
CO4	100	60	40	60	60	-	-	-	-	-	-	50	75	75
CO5	100	60	60	60	60	-	-	-	-	-	-	50	75	75

COURSE ARTICULATION MATRIX (PO – PSO MAPPING):

CO'S and PO'S, CO'S and PSO'S on the scale of 0 to 3, 0 being no correlation, 1 being the low correlation, 2 being medium correlation and 3 being high correlation.

0 - 0≤ C≤ 5% – No correlation,
1-5 <C≤ 40% – Low/ Slight
2 - 40 % <C< 60% –Moderate
3 - 60% ≤ C < 100% – Substantial /High

Course Outcomes	PROGRAM OUTCOMES												PSOs	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3	2
CO2	3	2	2	2	3	-	-	-	-	-	-	2	2	3
CO3	3	3	3	2	3	-	-	-	-	-	-	2	3	3
CO4	3	3	2	3	3	-	-	-	-	-	-	2	3	3
CO5	3	3	3	3	3	-	-	-	-	-	-	2	3	3
Total	15	13	10	10	12	-	-	-	-	-	-	2	14	14
Average	3	2.6	2.5	2.5	3	-	-	-	-	-	-	2	2.8	2.8

List of Experiments:

1. Design and Simulate Coaxial Cable
2. Design and simulate strip line
3. Rectangular Waveguide.
4. Circular Waveguide.
5. Dipole Antenna
6. Slotted rectangle waveguide
7. Circular Array
8. Micro strip Patch Antenna.
9. Circular Patch Antenna
10. Rectangular patch array

Experiment 1: Design and Simulation of Coaxial Cable

Aim To design and simulate a coaxial cable using HFSS and analyze its electromagnetic characteristics.

Software :Ansys HFSS

Theory

A **coaxial cable** consists of: Inner conductor Dielectric insulator Outer conductor (shield)

It supports **TEM mode propagation** and is widely used in RF communication systems.

A coaxial cable is a type of transmission line used to carry high-frequency electrical signals with minimal loss and interference. It consists of a central conductor surrounded by a dielectric insulating layer, which is enclosed by a cylindrical outer conductor or shield. The outer conductor helps prevent electromagnetic interference and signal leakage, making coaxial cables highly suitable for high-frequency communication systems. The structure supports the propagation of electromagnetic waves in the transverse electromagnetic (TEM) mode.

The characteristic impedance of a coaxial cable depends on the ratio of the inner conductor radius to the outer conductor radius and the dielectric constant of the insulating material. Coaxial cables are widely used in television distribution, RF communication systems, internet connections, and measurement equipment. In HFSS simulation, the coaxial structure is modeled to analyze parameters such as return loss, insertion loss, impedance, and electric field distribution.

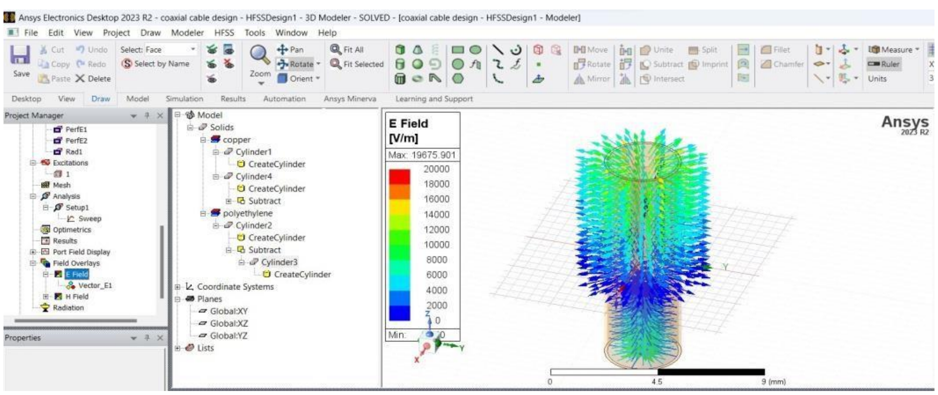
Procedure

1. Open HFSS and create a **new project**.
2. Draw the **inner conductor (cylinder)**.
3. Create **dielectric insulation** around the conductor.
4. Design the **outer conductor**.
5. Assign material properties (Copper, Teflon).
6. Assign **wave ports** at both ends.
7. Set **solution frequency**.
8. Run simulation.
9. Observe **S-parameters and field distribution**.

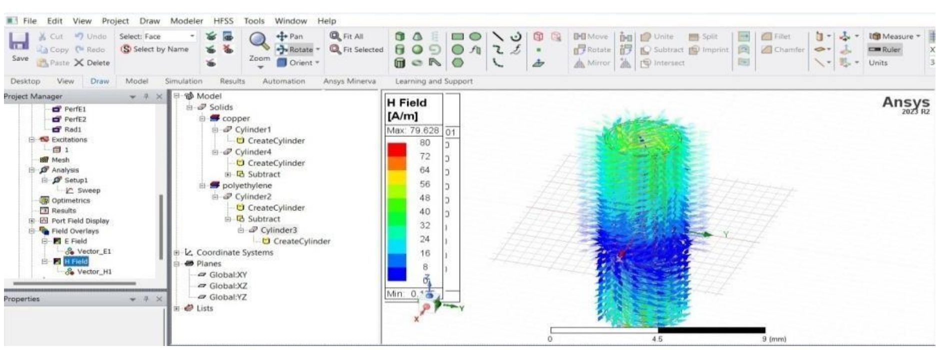
Result

The coaxial cable model is simulated and **return loss, impedance, and field distribution** are analyzed.

E-PLANE



H-PLANE



Viva Questions

1. What is a coaxial cable?
2. What are the main parts of a coaxial cable?
3. What type of mode propagates in coaxial cable?
4. What is characteristic impedance?
5. What is the formula for characteristic impedance of coaxial cable?
6. What materials are used for inner conductor?
7. What is the role of dielectric material?
8. What are the advantages of coaxial cable?
9. What are the disadvantages of coaxial cable?
10. What are common applications of coaxial cable?
11. What is return loss?
12. What is insertion loss?
13. What are S-parameters?
14. What port is used in coaxial cable simulation in HFSS?
15. What is shielding in coaxial cable?
16. What is impedance matching?
17. What happens when impedance is mismatched?
18. What is attenuation in coaxial cable?
19. Why is copper used in coaxial cables?
20. What are typical frequency ranges for coaxial cables?

Experiment 2: Design and Simulation of Strip line

Aim: To design and simulate a strip line transmission line using HFSS.

Software :Ansys HFSS

Theory

A **strip line** consists of a conducting strip sandwiched between **two ground planes** separated by dielectric material. It supports **TEM mode propagation** and provides excellent shielding.

A strip line is a type of planar transmission line widely used in microwave and RF circuits. It consists of a flat conducting strip placed between two parallel ground planes and separated by a dielectric material. Because the conductor is completely enclosed by dielectric material and ground planes, the electromagnetic fields are confined within the structure. This configuration allows the strip line to support pure transverse electromagnetic (TEM) mode propagation.

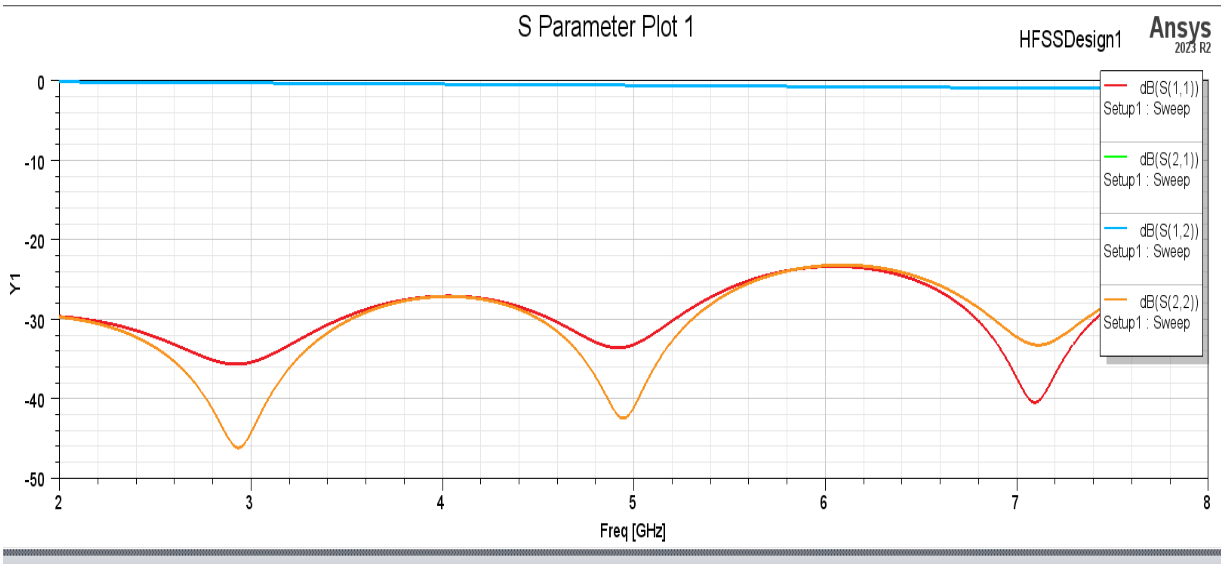
Strip lines are commonly used in microwave integrated circuits due to their excellent shielding and low radiation losses. The characteristic impedance of a strip line depends on the width of the conducting strip, thickness of the dielectric substrate, and dielectric constant of the material. In HFSS, strip line structures are simulated to study signal transmission characteristics, impedance matching, and electromagnetic field distribution.

Procedure

1. Create **dielectric substrate**.
2. Draw **center conductor strip**.
3. Add **top and bottom ground planes**.
4. Assign **wave ports**.
5. Define **boundary conditions**.
6. Run simulation.
7. Analyze **S11 and S21 parameters**.

Result

The strip line is successfully simulated and its **transmission characteristics** are obtained.



Viva Questions

1. What is strip line?
2. What is the structure of strip line transmission line?
3. What is the difference between strip line and micro strip line?
4. What propagation mode exists in strip line?
5. Why are two ground planes used in strip line?
6. What are advantages of strip line?
7. What are disadvantages of strip line?
8. What substrate materials are used in strip line?
9. What is characteristic impedance of strip line?
10. What parameters affect impedance?
11. What are applications of strip line?
12. What is dielectric constant?
13. What is propagation delay?
14. What is wave port in HFSS?
15. What is signal integrity?
16. What is crosstalk?
17. What is conductor loss?
18. What is dielectric loss?
19. What is dispersion in transmission lines?
20. What are advantages of strip line shielding?

Experiment 3: Design and Simulation of Rectangular Waveguide

Aim: To design and simulate a rectangular waveguide using HFSS.

Software: Ansy HFSS

Theory

A rectangular waveguide is used to transmit **microwave signals** and supports **TE and TM modes**. The dominant mode is **TE10**.

A rectangular waveguide is a hollow metallic structure used for transmitting microwave signals from one point to another. Unlike transmission lines, waveguides guide electromagnetic waves through reflections from the metallic walls. Rectangular waveguides support transverse electric (TE) and transverse magnetic (TM) modes but do not support TEM mode propagation. The most dominant mode in a rectangular waveguide is the TE10 mode.

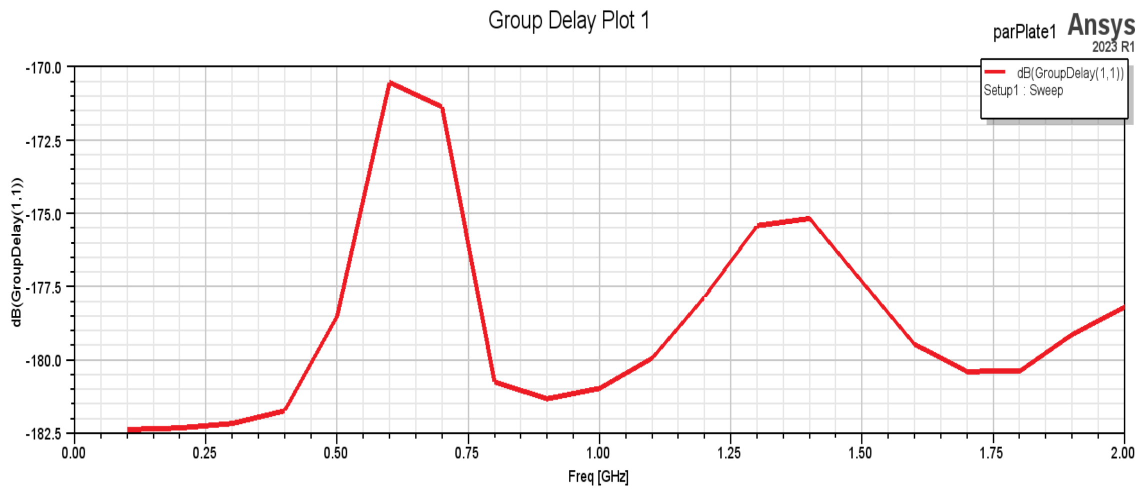
The propagation of waves in a waveguide depends on the operating frequency and the physical dimensions of the guide. If the operating frequency is below the cutoff frequency, the wave cannot propagate through the waveguide. Rectangular waveguides are widely used in radar systems, satellite communications, and microwave transmitters. HFSS simulation helps visualize electric field patterns and analyze propagation characteristics.

Procedure

1. Draw a **rectangular hollow structure**.
2. Assign **perfect electric conductor (PEC)** material.
3. Assign **wave ports** on both sides.
4. Set **frequency range**.
5. Run simulation.
6. Observe **electric field distribution**.

Result

The rectangular waveguide is simulated and **dominant TE10 mode propagation** is verified.



Viva Questions

1. What is a waveguide?
2. What is the dominant mode in rectangular waveguide?
3. What does TE mode mean?
4. What does TM mode mean?
5. What is cutoff frequency?
6. What is TE10 mode?
7. Why is TE10 dominant mode?
8. What happens below cutoff frequency?
9. What materials are used for waveguides?
10. What are advantages of waveguides?
11. What are disadvantages of waveguides?
12. What are applications of rectangular waveguides?
13. What is guide wavelength?
14. What is phase velocity?
15. What is group velocity?
16. What is attenuation in waveguide?
17. What are higher order modes?
18. What is wave port in HFSS?
19. What is boundary condition in waveguide simulation?
20. What frequency ranges use waveguides?

Experiment 4: Design and Simulation of Circular Waveguide

Aim: To simulate a circular waveguide using HFSS.

Theory

Circular waveguides support **TE and TM modes**, and the dominant mode is **TE11**.

A circular waveguide is a cylindrical metallic tube used to transmit microwave signals efficiently at high frequencies. Similar to rectangular waveguides, circular waveguides support TE and TM modes but do not support TEM mode propagation. The dominant mode in a circular waveguide is the TE11 mode, which allows efficient signal transmission with minimal loss.

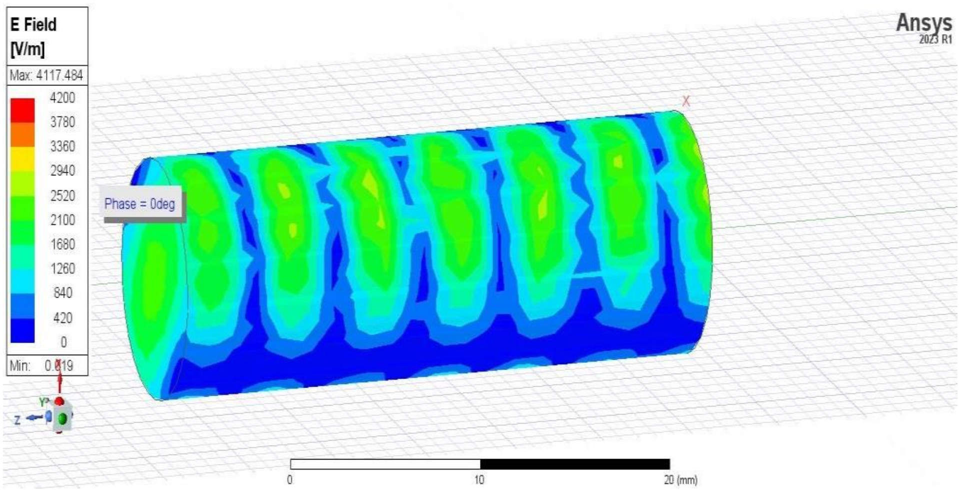
Circular waveguides are preferred in certain microwave applications because they can handle higher power levels and exhibit lower attenuation compared to rectangular waveguides. They are often used in radar systems, satellite communication systems, and microwave antennas. Using HFSS simulation, the electric and magnetic field distributions inside the circular waveguide can be analyzed to understand its propagation characteristics.

Procedure

1. Draw a **cylindrical hollow structure**.
2. Assign **PEC boundary**.
3. Apply **wave ports**.
4. Set **operating frequency**.
5. Run simulation.
6. Observe **field patterns**.

Result

Circular waveguide operation and **mode propagation characteristics** are analyzed.



Viva Questions

1. What is a circular waveguide?
2. What is the dominant mode of circular waveguide?
3. What modes exist in circular waveguides?
4. What is cutoff frequency?
5. What are advantages of circular waveguide?
6. What are disadvantages of circular waveguide?
7. What is mode degeneracy?
8. What materials are used in waveguides?
9. What is wave impedance?
10. What is guide wavelength?
11. What is attenuation?
12. What is dispersion?
13. What are applications of circular waveguides?
14. What is mode conversion?
15. What is field distribution in circular waveguide?
16. What are TE modes?
17. What are TM modes?
18. What type of port is used in HFSS?
19. What is PEC boundary condition?
20. What frequency ranges use circular waveguides?

Experiment 5: Design and Simulation of Dipole Antenna

Aim

To design and simulate a **half-wave dipole antenna**.

Theory

A dipole antenna consists of **two conductive elements** with length approximately **λ/2**.

Key parameters:

- Radiation Pattern
- Gain
- Return Loss

A dipole antenna is one of the simplest and most widely used antennas in wireless communication systems. It consists of two conductive elements arranged in a straight line and fed at the center by a transmission line. The total length of the dipole antenna is typically half the wavelength of the operating frequency, which is why it is called a half-wave dipole antenna.

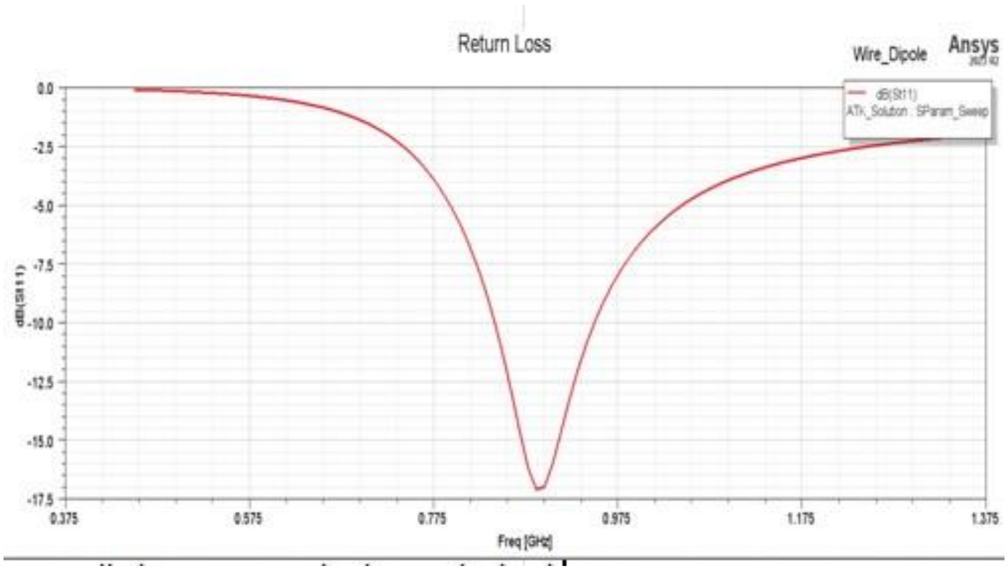
Dipole antennas radiate electromagnetic waves in an unidirectional pattern in the horizontal plane. Important parameters of dipole antennas include radiation pattern, gain, input impedance, and bandwidth. Dipole antennas are used in radio broadcasting, television transmission, and wireless communication systems. HFSS simulation helps analyze the radiation characteristics and electromagnetic field distribution of the antenna.

Procedure

1. Draw **two cylindrical conductors**.
2. Add **feed gap** between them.
3. Assign **lumped port**.
4. Surround with **radiation boundary**.
5. Run simulation.
6. Observe **radiation pattern and gain**.

Result

The dipole antenna radiation pattern and gain are obtained.



Viva Questions

1. What is a dipole antenna?
2. What is the length of half-wave dipole antenna?
3. What is antenna radiation pattern?
4. What is antenna gain?
5. What is antenna directivity?
6. What is radiation resistance?
7. What is polarization?
8. What feeding method is used in dipole antenna?
9. What is input impedance of dipole antenna?
10. What is bandwidth of antenna?
11. What is VSWR?
12. What is return loss?
13. What is radiation efficiency?
14. What is antenna aperture?
15. What is radiation boundary in HFSS?
16. What are applications of dipole antenna?
17. What is omni-directional radiation pattern?
18. What is near field and far field?
19. What is antenna matching?
20. What materials are used for dipole antennas?

Experiment 6: Design of Slotted Rectangular Waveguide

Aim:

To design and simulate a slotted waveguide antenna**.**

Theory

Slots cut in the waveguide wall radiate electromagnetic waves, forming an **antenna array**.

A slotted waveguide antenna is formed by cutting slots on the surface of a rectangular waveguide. These slots act as radiating elements that allow electromagnetic energy to radiate into free space. The spacing and orientation of the slots determine the radiation pattern and direction of the antenna. This structure essentially behaves like an array antenna.

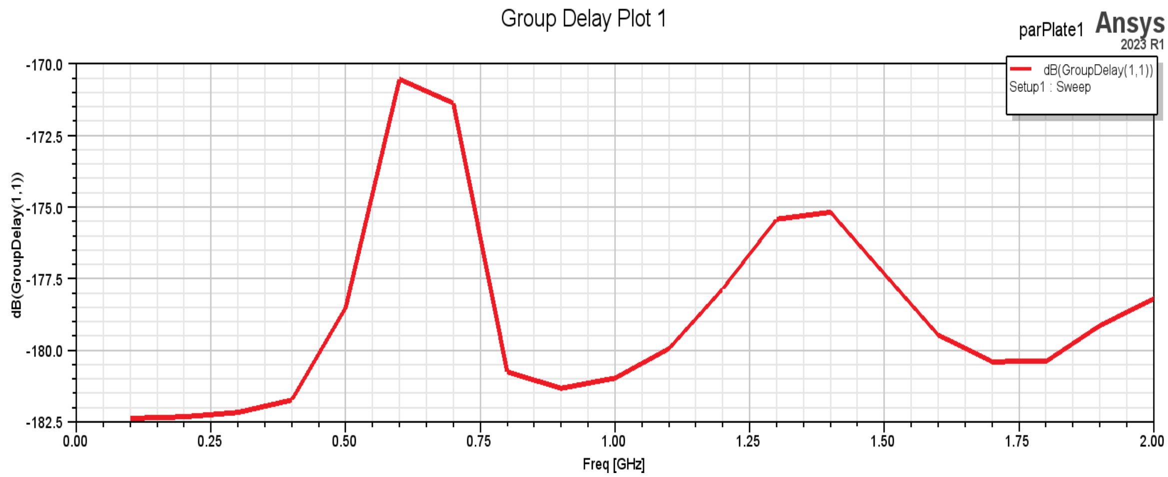
Slotted waveguide antennas are widely used in radar and microwave communication systems due to their high efficiency and directional radiation patterns. The waveguide acts as a feeding structure that distributes power to the slots along its length. HFSS simulation helps analyze the radiation pattern, gain, and field distribution produced by the slotted waveguide.

Procedure

1. Design a **rectangular waveguide**.
2. Create **slots on the top surface**.
3. Assign **wave ports**.
4. Define **radiation boundary**.
5. Run simulation.
6. Observe **radiation characteristics**.

Result

The slotted waveguide antenna radiation characteristics are analyzed.



Viva Questions (20)

1. What is a slotted waveguide antenna?
2. Why are slots introduced in waveguides?
3. What is slot antenna?
4. What is slot spacing?
5. What is radiation mechanism of slot?
6. What mode is used in slotted waveguide?
7. What are advantages of slotted antennas?
8. What are applications of slotted waveguide antennas?
9. What is beam steering?
10. What is array antenna?
11. What is radiation pattern?
12. What is side lobe?
13. What is beamwidth?
14. What is gain of antenna?
15. What is slot coupling?
16. What materials are used in waveguides?
17. What boundary condition is used in HFSS?
18. What is PEC boundary?
19. What parameters are measured in simulation?
20. What is antenna efficiency?

Experiment 7: Design and Simulation of Circular Antenna Array

Aim

To simulate a **circular antenna array**.

Theory

A circular array consists of **multiple antennas arranged in a circular configuration** to improve **directivity and gain**.

A circular antenna array consists of multiple antenna elements arranged in a circular configuration. Each antenna element is fed with a specific amplitude and phase so that their combined radiation produces a desired radiation pattern. Circular arrays are used to improve the directivity, gain, and beam steering capability of antenna systems.

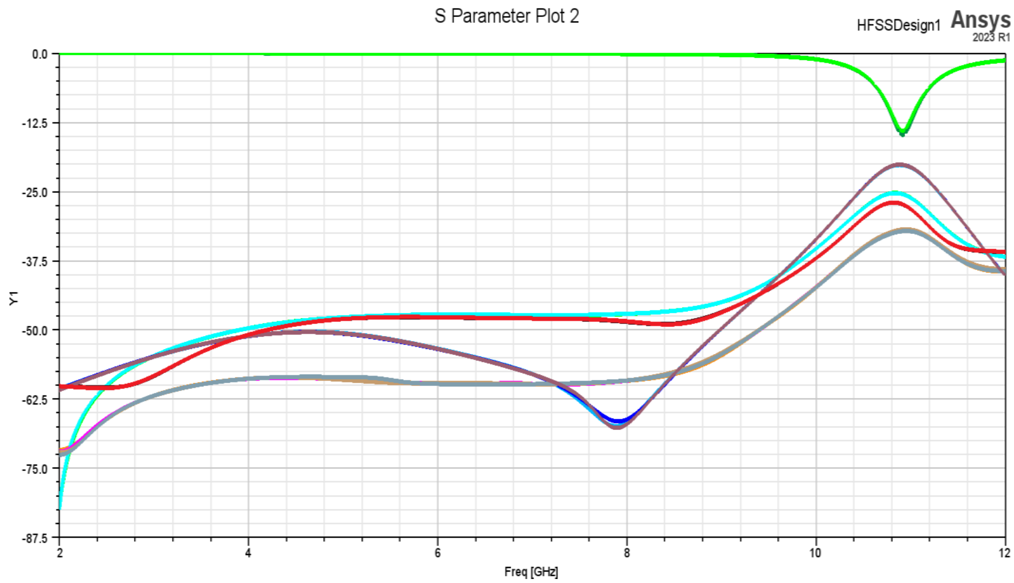
The radiation pattern of an antenna array depends on the number of elements, spacing between them, and phase excitation. Circular arrays are commonly used in radar, satellite communication, and wireless communication systems. HFSS simulation helps visualize the combined radiation pattern and analyze parameters such as beamwidth and side lobe levels.

Procedure

1. Design a **single antenna element**.
2. Replicate elements in **circular pattern**.
3. Apply **phase excitation**.
4. Set radiation boundary.
5. Run simulation.
6. Observe **array radiation pattern**.

Result

Improved antenna gain and directional radiation pattern are observed.



Viva Questions (20)

1. What is an antenna array?
2. What is circular array antenna?
3. Why are arrays used in antennas?
4. What is array factor?
5. What is element spacing?
6. What is beamwidth?
7. What is side lobe level?
8. What is directivity?
9. What is gain?
10. What is phase excitation?
11. What is amplitude distribution?
12. What is beam steering?
13. What is radiation pattern?
14. What are advantages of circular arrays?
15. What are disadvantages of arrays?
16. What is mutual coupling?
17. What is pattern multiplication?
18. What are applications of antenna arrays?
19. What is HFSS radiation boundary?
20. What happens when element spacing increases?

Experiment 8: Design and Simulation of Micro strip Patch Antenna

Aim

To design a **rectangular micro strip patch antenna**.

Theory

A micro strip patch antenna consists of:

- Patch
- Dielectric substrate
- Ground plane

Used widely in **wireless communication systems**.

A micro strip patch antenna is a type of planar antenna widely used in modern wireless communication systems. It consists of a metallic patch placed on a dielectric substrate with a ground plane on the opposite side. Micro strip antennas are lightweight, low-profile, and easy to fabricate using printed circuit board technology.

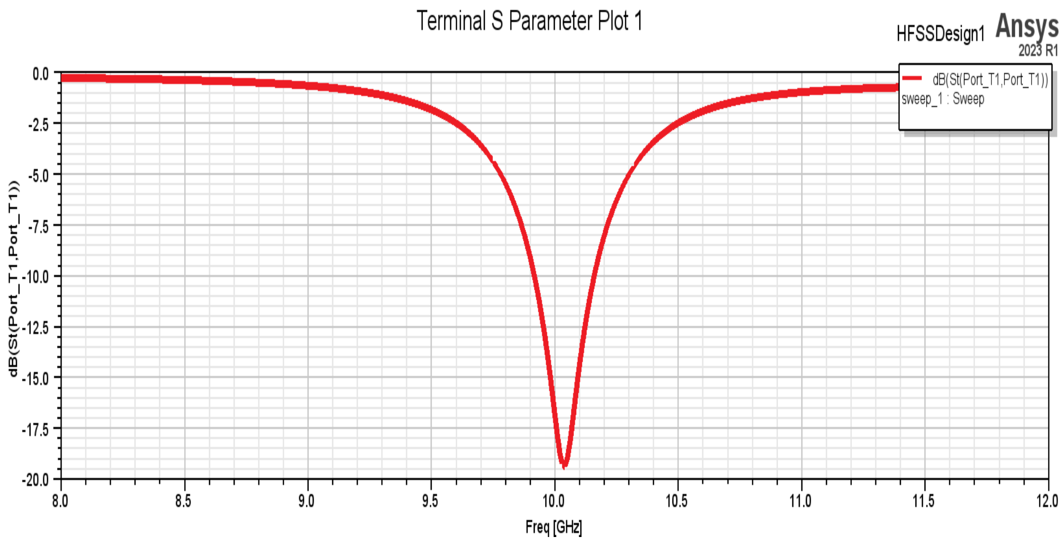
The operating frequency of a micro strip antenna depends on the dimensions of the patch and the dielectric constant of the substrate. Although micro strip antennas have advantages such as compact size and low cost, they generally have limited bandwidth and lower efficiency compared to other antenna types. HFSS simulation is used to analyze parameters such as return loss, radiation pattern, and gain.

Procedure

1. Create **dielectric substrate**.
2. Draw **rectangular patch**.
3. Add **ground plane**.
4. Provide **microstrip feed**.
5. Assign radiation boundary.
6. Run simulation.

Result

The antenna radiation pattern and return loss are analyzed.



Viva Questions

1. What is micro strip patch antenna?
2. What are the components of patch antenna?
3. What substrate materials are used?
4. What are advantages of micro strip antennas?
5. What are disadvantages of micro strip antennas?
6. What is dielectric constant?
7. What is resonant frequency?
8. What is return loss?
9. What is bandwidth?
10. What is gain?
11. What is radiation efficiency?
12. What feeding methods are used?
13. What is micro strip line feed?
14. What is coaxial feed?
15. What is VSWR?
16. What is ground plane?
17. What is fringing effect?
18. What are applications of patch antennas?
19. What is radiation pattern?
20. What is antenna polarization?

Experiment 9: Design and Simulation of Circular Patch Antenna

Aim

To design and simulate a **circular micro strip patch antenna**.

Theory

A circular patch antenna is similar to a rectangular patch but provides **better bandwidth and compact size**.

A circular patch antenna is a variation of the micro strip antenna where the radiating element has a circular shape. It consists of a circular metallic patch placed on a dielectric substrate above a ground plane. Circular patch antennas are preferred in some applications due to their symmetrical radiation characteristics and compact design.

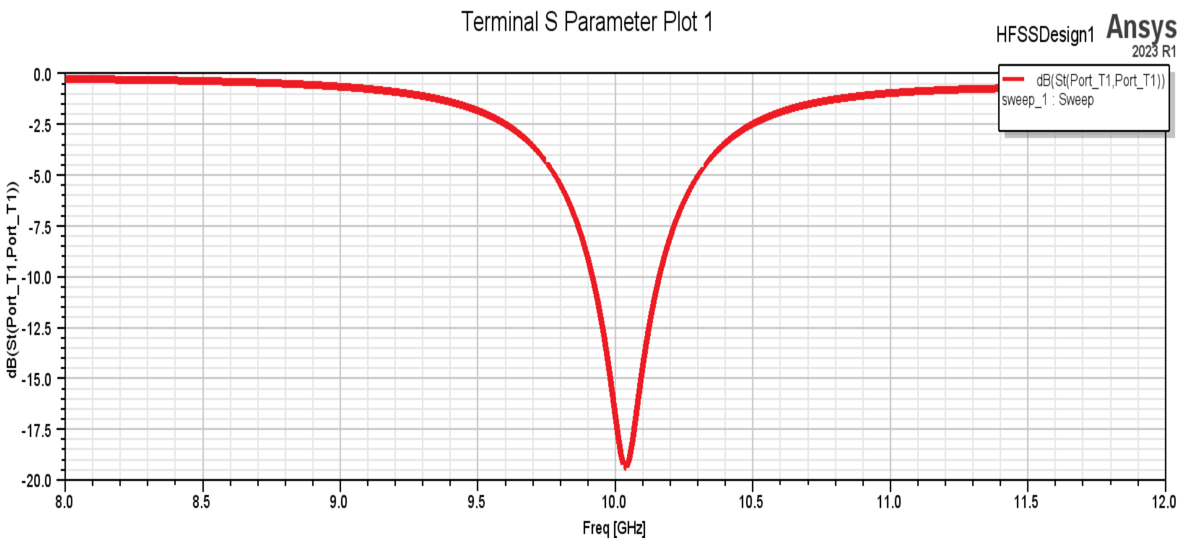
The resonant frequency of a circular patch antenna is determined by the radius of the patch and the dielectric constant of the substrate material. These antennas are widely used in wireless communication systems, satellite communication, and GPS devices. HFSS simulation allows the analysis of radiation patterns, gain, and impedance matching of the antenna.

Procedure

1. Create **substrate**.
2. Draw **circular patch**.
3. Add **ground plane**.
4. Provide **coaxial feed**.
5. Assign radiation boundary.
6. Run simulation.

Result

Circular patch antenna radiation characteristics are obtained.



Viva Questions

1. What is circular patch antenna?
2. How is it different from rectangular patch antenna?
3. What is resonant frequency?
4. What are feeding techniques?
5. What substrate materials are used?
6. What is dielectric constant?
7. What is radiation pattern?
8. What is gain of antenna?
9. What is bandwidth?
10. What is return loss?
11. What is VSWR?
12. What is antenna efficiency?
13. What is fringing field?
14. What are applications of circular patch antennas?
15. What is polarization?
16. What is ground plane?
17. What is patch radius?
18. What is impedance matching?
19. What is radiation boundary?
20. What is antenna directivity?

Experiment 10: Design and Simulation of Rectangular Patch Antenna Array

Aim

To simulate a **rectangular patch antenna array**.

Theory

An antenna array improves:

- Gain
- Directivity
- Radiation efficiency

A rectangular patch antenna array is formed by arranging multiple rectangular micro strip patch antennas in a systematic pattern. The purpose of using an array is to improve antenna gain, directivity, and radiation efficiency compared to a single antenna element. Arrays are commonly used in communication systems that require highly directional signals.

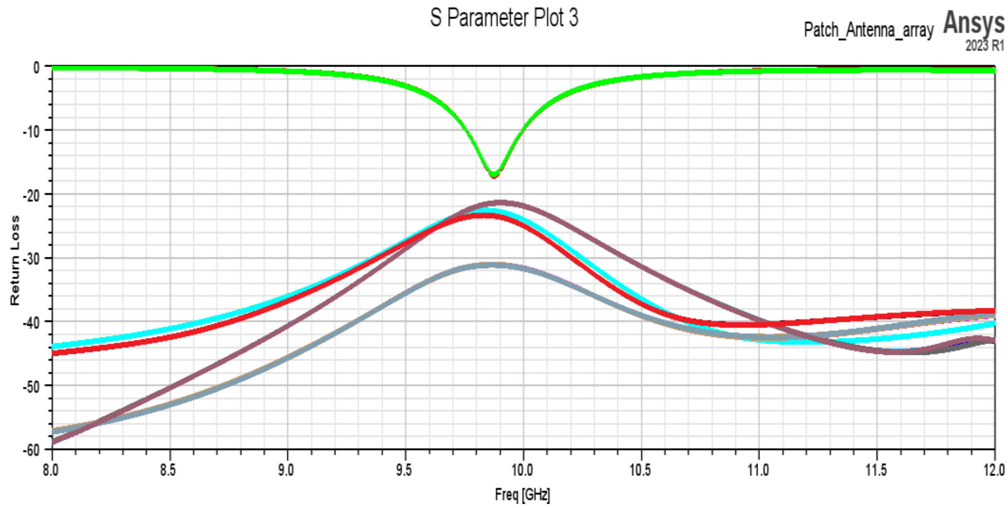
The performance of an antenna array depends on factors such as element spacing, feed network design, and phase excitation between elements. Rectangular patch arrays are widely used in radar systems, satellite communication, and wireless base stations. HFSS simulation helps analyze the radiation pattern, array gain, and beam steering capability.

Procedure

1. Design **single rectangular patch**.
2. Replicate patches to form **array structure**.
3. Add **corporate feed network**.
4. Assign radiation boundary.
5. Run simulation.

Result

The rectangular patch array shows **higher gain and directional radiation pattern**.



Viva Questions

1. What is rectangular patch antenna array?
2. Why are arrays used instead of single antennas?
3. What is array gain?
4. What is directivity?
5. What is beam width?
6. What is side lobe level?
7. What is element spacing?
8. What is mutual coupling?
9. What is corporate feed network?
10. What is series feed network?
11. What is radiation pattern?
12. What is array factor?
13. What is beam steering?
14. What is antenna efficiency?
15. What is return loss?
16. What is VSWR?
17. What are applications of patch arrays?
18. What is bandwidth?
19. What is impedance matching?
20. What is antenna polarization?