CIRCULARLY POLARIZED DUAL FEED MICROSTRIP PATCH ANTENNA USING WILKINSON POWER DIVIDER AT 5.5 GHz

by

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A project report submitted to

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BONAFIDE CERTIFICATE

Certified that this project report entitled "**CIRCULALRY POLARIZED DUAL FEED MICROSTRIP PATCH ANTENNA USING WILKINSON POWER DIVIDER"** is a bonafide work of **S SHANMATI – 22BEC1010, SANJANA A – 22BEC1013,V B VARSHINI – 22BEC1152, and K S S SARVANI – 22BEC1402** who carried out the Project work under my supervision and guidance for **BECE305L – Antenna and Microwave Engineering.**

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ABSTRACT

This project presents the design and performance evaluation of a circularly polarized dual-feed microstrip patch antenna integrated with a Wilkinson power divider (WPD). The design employs a square-shaped patch with dual orthogonal feeds to achieve circular polarization, enabling enhanced signal reception and stability for applications in wireless communication. Implemented using ANSYS software, the antenna was optimized to operate at a targeted frequency, with dimensions calculated to achieve the desired gain and bandwidth. The Wilkinson power divider was integrated to ensure equal power distribution between feeds, maintaining consistent performance. Simulation results verified the antenna's efficacy in producing circular polarization and achieving the specified performance parameters. The proposed design demonstrates improvements in bandwidth, gain, and polarization purity, making it suitable for high-frequency applications such as satellite and mobile communication.

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CHAPTER 1

INTRODUCTION

1.1 AIM

The primary objective of this project is to design and evaluate the performance of a circularly polarized dual-feed microstrip patch antenna integrated with a Wilkinson power divider (WPD) for enhanced wireless communication applications. The specific goals of this project include:

1. **Achieve Circular Polarization**: Design a square-shaped microstrip patch antenna with dual orthogonal feeds to achieve circular polarization, which improves signal stability and quality, particularly in environments prone to multipath interference.
2. **Optimize Antenna Parameters**: Determine the optimal dimensions and configuration of the antenna to meet specific frequency, gain, and bandwidth requirements, ensuring effective signal transmission and reception.
3. **Implement Wilkinson Power Divider**: Integrate a Wilkinson power divider to equally distribute power between the dual feeds, thus maintaining consistent performance and improving the efficiency of the antenna.
4. **Evaluate Performance through Simulation**: Use ANSYS software to simulate and analyze the antenna's performance in terms of return loss, axial ratio, gain, and radiation pattern to verify that it meets the targeted specifications.
5. **Suitability for High-Frequency Applications**: Ensure that the designed antenna is well-suited for high-frequency applications such as satellite communication, mobile communication, and other wireless systems requiring circular polarization.

1.2 BENEFITS

1. **Enhanced Signal Stability**: Circular polarization reduces multipath interference, ensuring reliable communication in various environments.
2. **Improved Alignment Flexibility**: Less sensitivity to orientation allows consistent performance, ideal for mobile and satellite applications.
3. **Efficient Power Distribution**: The Wilkinson power divider balances power between feeds, optimizing performance.
4. **Compact Design**: The low-profile structure makes it suitable for portable devices.
5. **High-Frequency Compatibility**: Well-suited for applications like GPS, satellite, and mobile communications, where high efficiency is required.

1.3 FEATURES

1. **Dual-Feed Configuration**: Utilizes two orthogonal feeds to achieve circular polarization, enhancing signal reception and stability in challenging environments.
2. **Wilkinson Power Divider Integration**: Ensures equal power distribution between feeds, providing balanced performance and efficient power management.
3. **Square Patch Design**: The square-shaped patch is designed for simplicity and effectiveness, optimized to operate at a specific frequency with desired gain and bandwidth.
4. **Compact and Low-Profile**: Microstrip patch antennas are inherently compact, making this design easy to integrate into various devices without adding bulk.
5. **High-Frequency Operation**: Tailored for high-frequency applications, making it suitable for systems such as satellite, GPS, and mobile communication.
6. **Optimized for Circular Polarization**: Provides consistent signal quality regardless of antenna orientation, which is beneficial in mobile or satellite communications.
7. **ANSYS Simulation**: The design was tested and optimized using ANSYS software, ensuring that it meets targeted specifications for return loss, gain, and radiation patterns.

1.4 APPLICATIONS

Applications of Circularly Polarized Dual-Feed Microstrip Patch Antenna with WPD:

1. **Satellite Communication-** Ensures reliable uplink/downlink signals with reduced polarization mismatch.
2. **IoT Networks-** Enhances connectivity and coverage in low-power, compact IoT devices.
3. **GPS-**Improves navigation accuracy by minimizing multi-path interference.
4. **5G and 6G Communication-** Supports high-frequency bands for better bandwidth and data rates.
5. **Aerospace and Aviation-** Provides reliable communication during dynamic flight conditions.
6. **RFID Systems-** Enables efficient tag reading in complex, non-line-of-sight scenarios.
7. **Wireless Sensor Networks-**Optimizes power distribution for low-power remote sensors.
8. **Military and Defense-**Delivers secure and robust communication in challenging environments.

2. LINK OF THE PROJECT VIDEO

https://drive.google.com/file/d/1aKwwIa0u5SmgTGiVDCmbekyaqJWrTh4y/view?usp=sharing

3. LITERATURE SURVEY

1. **Design and Analysis of a Wideband Microstrip 3 dB Power Divider**

   Authors: Year: 2022

   DoI:10.1109/ISIEA54517.2022.9873715

2. **Design and Performance Evaluation of Circularly Polarized Dual Feed Microstrip Patch Antenna Using Wilkinson Power Divider**

   Year: 2021

   DoI: 10.1109/INCAP52216.2021.9726355

3. **Back-to-Back Microstrip Antenna Fed With Tunable Power Divider**

   Year: 2015

   DoI: 10.1109/TAP.2015.2407377

4. **Design of W-band Microstrip Antenna Array**

   Year: 2019

   DoI:10.1109/APMC46564.2019.9038729

5. **Millimeter-wave waveguide-based out-of-phase power divider/combiner using microstrip antenna**

   Year: 2014

   DoI: 10.1016/j.aeue.2014.07.003

6. **Side-lobe level suppression using unequal four way power divider for proximity coupled microstrip antenna.**

   Year: 2013

   DoI: 10.1109/APMC.2013.6695058

7. **A Novel Parallel-Series Feeding Network Based on Three-Way Power Divider for Microstrip Antenna Array**

   Year: 2013

   DoI: 10.1109/LAWP.2013.2270938

8. **A Novell: 19 Microstrip Radial Power Divider Design for the Application in Antenna Array**

   Year: 2013

   DoI: 10.1109/MMWCST.2013.6814601

9. **Dual-Band Shared-Aperture Base-Station Antenna Array With Dual Polarization Using Filtering Magnetoelectric Dipole Antenna**

   Year: 2024

   DoI: 10.1109/OJAP.2023.3333905

10. **A Wideband Tunable Power Divider for SWIPT Systems**

    Year: 2020

    DoI: 10.1109/ACCESS.2020.2970781

11. **Compact Quasi-Planar Four-Way Power Divider With Wide Isolation Bandwidth**

    Year: 2019

    DoI: 10.1109/ACCESS.2019.2919124

12. **A Microwave/Millimeter Wave Dual-Band Shared Aperture Patch Antenna Array**

    Year: 2021

    DoI: October 2021

13. **A Microstrip line three-way power divider**

    Year: 2011

    DoI: 10.1109/MAPE.2011.6156248

14. **Complementary phase power divider feed for dipole antenna specific to GSM 900 Base station Applications**

    Year: 2015

    DoI: 10.1109/CACC.2015.26

15. **A Millimeter-Wave Differential Filtering Dual-Patch Antenna Based on Coupling Power Divider Feeding**

    Year: 2020

    DoI:10.1109/APMC47863.2020.9331475

16. **Integrated Waveguide-to-Microstrip Transition with Power Divider at W-band**

    Year: 2020

    DoI:10.23919/ACES

Key Observations:

- Circular polarization enhances signal robustness and mitigates fading issues in dynamic environments.
- Dual-feed configurations significantly improve bandwidth and axial ratio performance.
- Wilkinson power dividers are crucial for efficient and balanced power distribution to ensure optimal antenna operation.
- Applications span across satellite communication, 5G networks, IoT, and RFID systems, reflecting versatility in wireless technologies.

4. DIELECTRIC USED

Rogers RO4003C

Permittivity – 3.5

5. WORKFLOW

Design a circularly polarized dual feed microstrip patch antenna using Wilkinson power divider at frequency of 5.5Ghz.

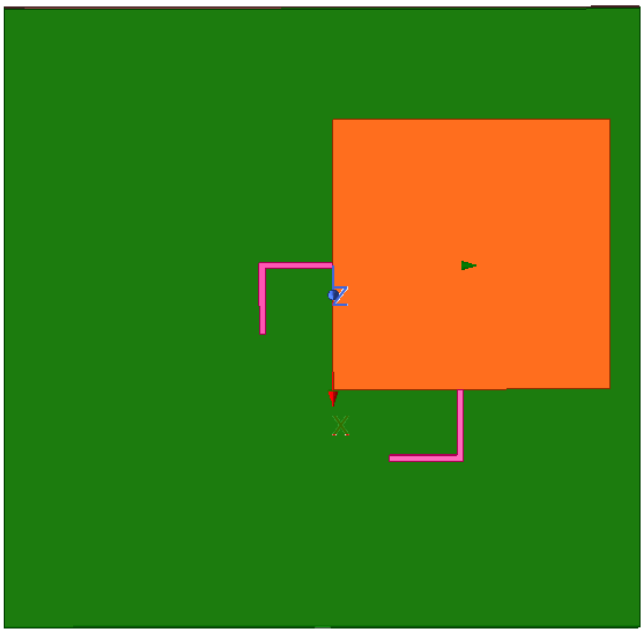
Design Antenna in ANSYS HFSS

a. Geometry Creation

- Create the rectangular microstrip patch geometry.

- Add dual-feed points for circular polarization.

- Define the ground plane and substrate material as Rogers RO4003C.

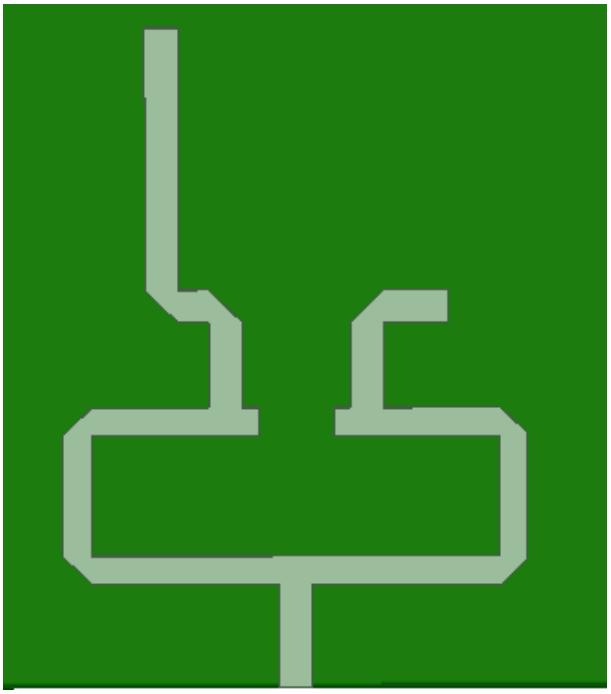


b. Feed Network Design

- Design the Wilkinson Power Divider (WPD) in HFSS:

  - Include input and dual output ports.

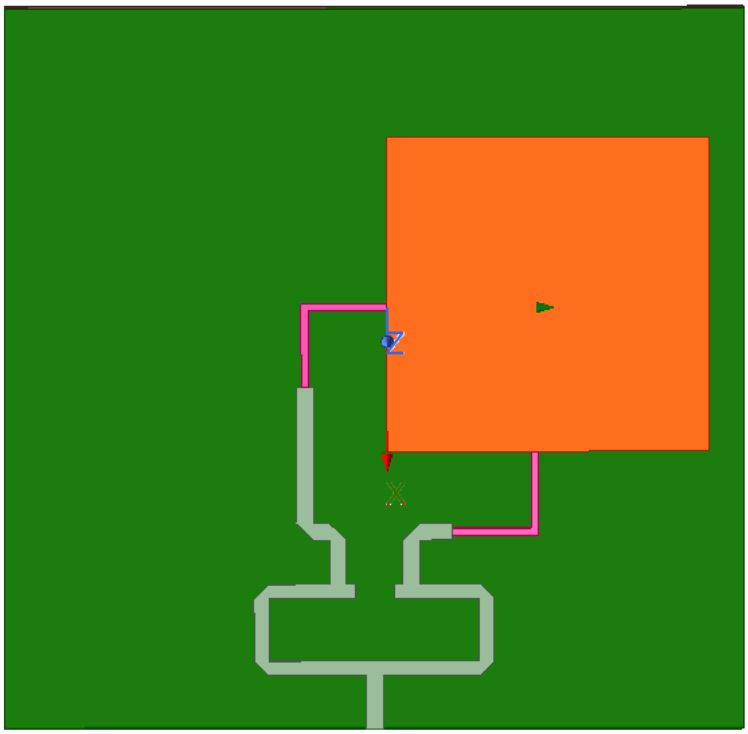
  - Set line impedances and isolation resistors for even power distribution.



c. Integration of WPD with Antenna

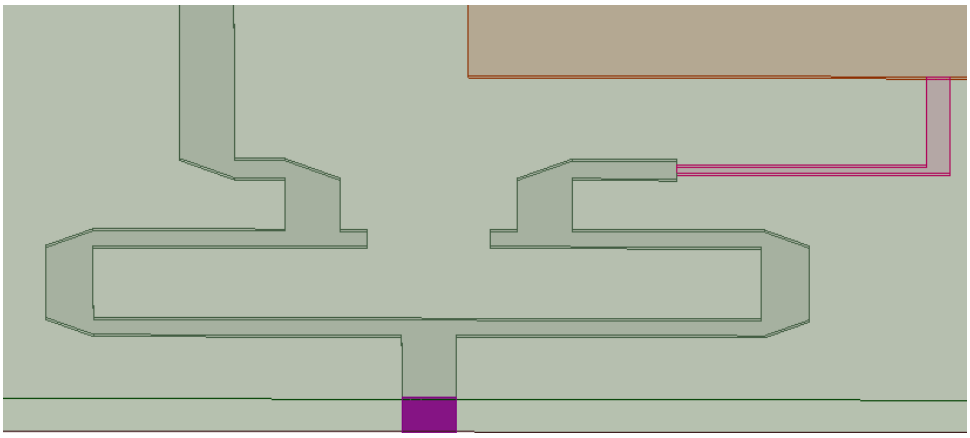
- Connect the WPD output ports to the dual feeds of the patch antenna.

- Ensure proper phase difference (e.g., 90°) between feed points to achieve circular polarization.

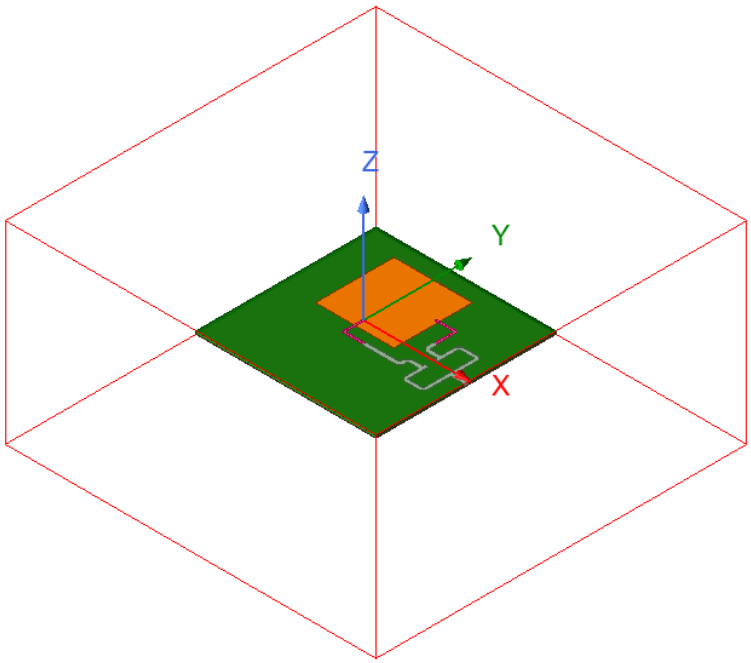


d. Boundary Conditions and Excitations

- Apply wave ports for excitation.



- Define radiation boundaries to simulate an open environment.



Simulate the Design

a. Run S-Parameter Analysis

- Analyze return loss (S11), input impedance, and isolation between ports.

b. Radiation Pattern

- Simulate the far-field radiation pattern for gain, directivity, and polarization performance.

c. LHCP and RHCP Analysis

- Plot RHCP and LHCP and determine the direction of circular polarization.

Optimization – Parametric Analysis

- Adjust patch dimensions, feedline parameters, or substrate properties to meet design goals.

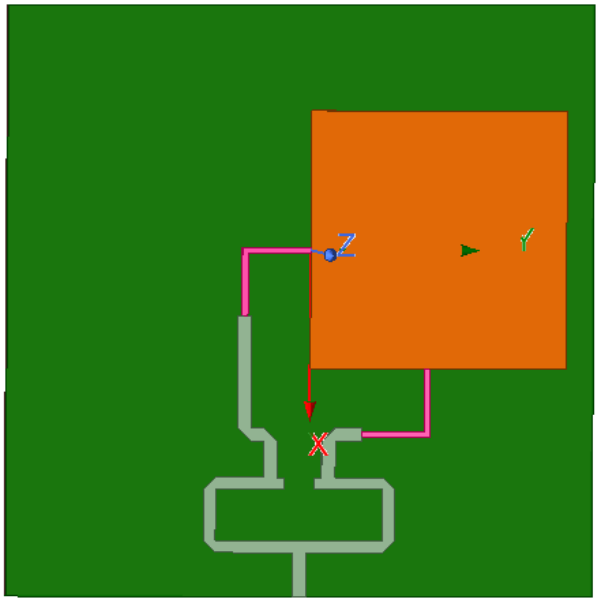
- Optimize WPD for minimal insertion loss and high isolation.

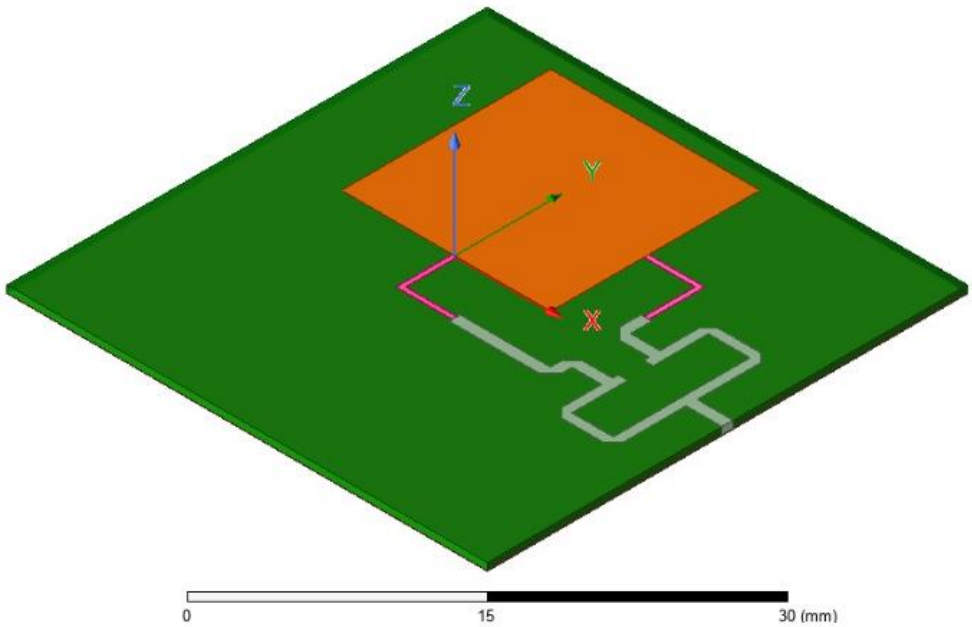
Documentation and Reporting

- Prepare a report with simulation results, design parameters, and performance evaluation.

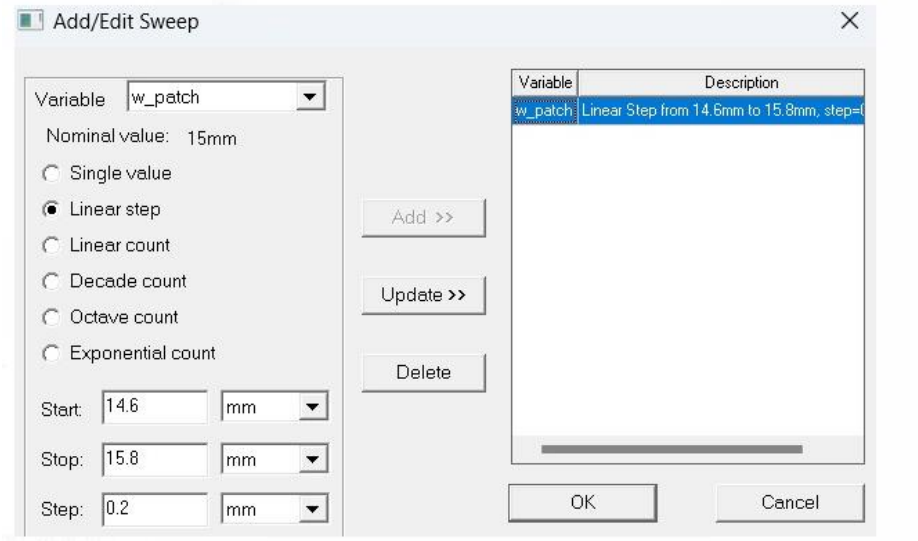
- Include graphs for S-parameters and radiation patterns.

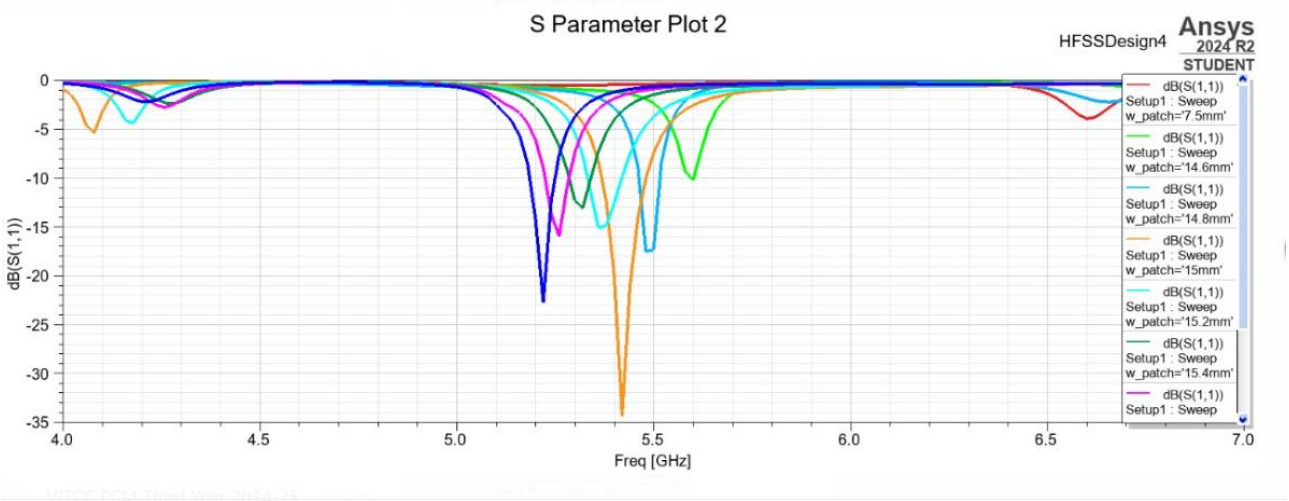
6. FINAL DESIGN



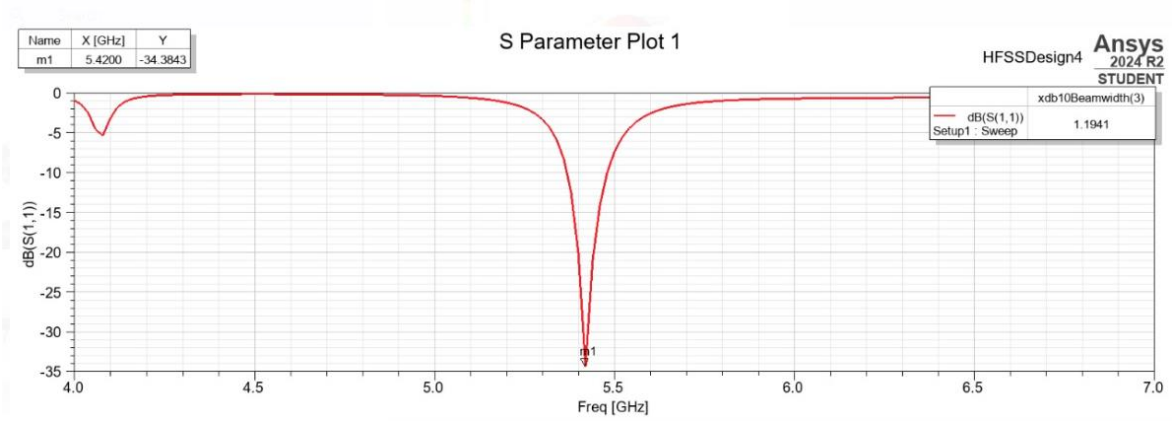


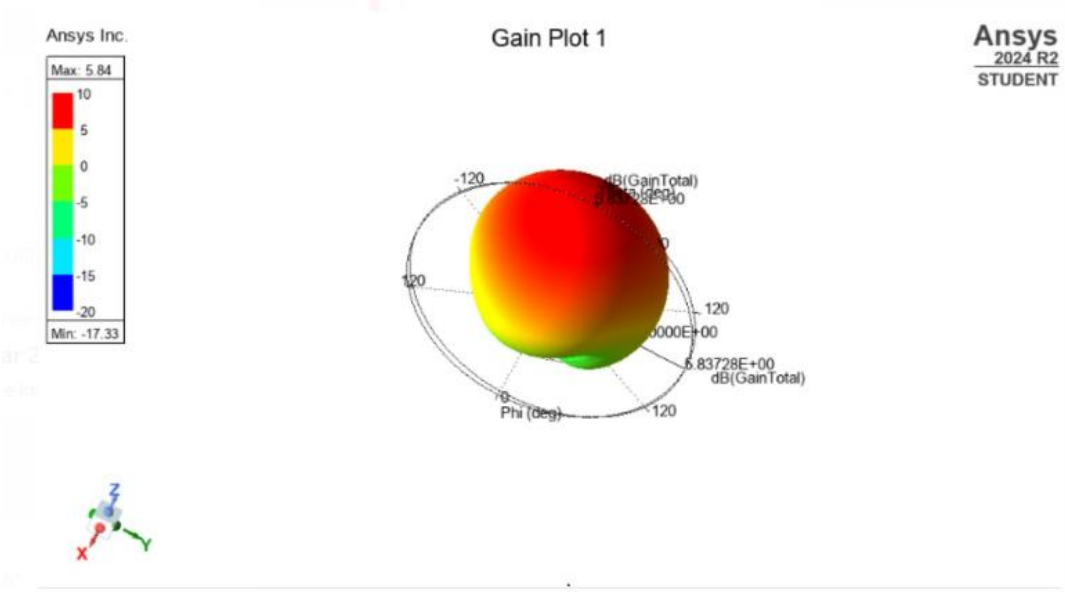
8. PARAMETRIC ANALYSIS





8. GAIN AND RETURN LOSS

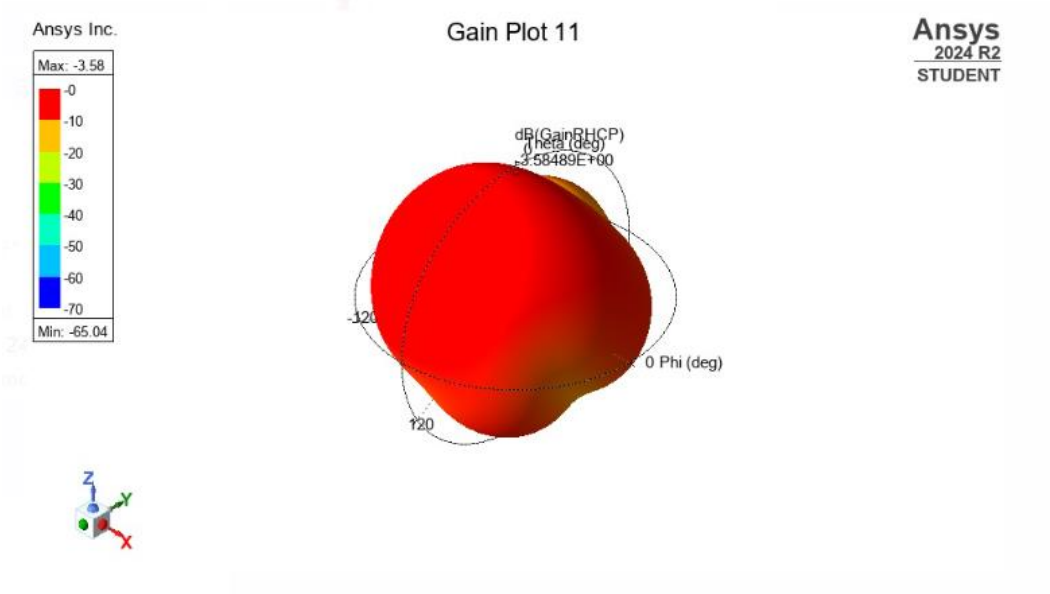




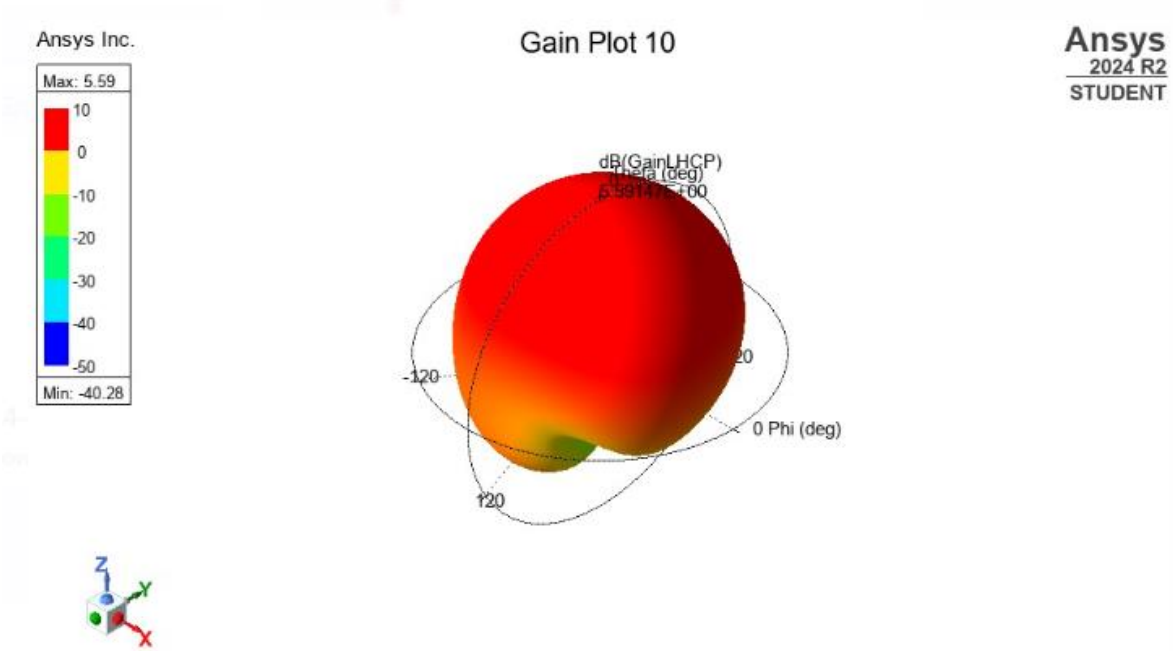
Gain(dB): S11= 5.84 dB

Return Loss: -S11= 34.38 dB

RHCP Analysis:



LHCP Analysis:



Inference: Antenna is Left Hand Circularly Polarized

9. FUTURE WORK

1. Multi-Band Extension: Extend the design to support multi-band operations for emerging 5G/6G and IoT applications.

2. Miniaturization: Explore novel substrate materials and patch designs to reduce antenna size while maintaining performance.

3. Advanced Feeding Networks: Investigate hybrid power dividers or differential feeding techniques for improved efficiency and bandwidth.

4. Integration with Systems: Implement and test the antenna in real-world applications, such as wearable devices or smart home systems.

5. Energy Harvesting: Integrate the antenna with RF energy harvesting systems for low-power IoT devices.

6. Circular Polarization Diversity: Develop techniques for dynamic polarization switching to handle varying communication requirements.

10. CONCLUSION

The designed circularly polarized dual-feed microstrip patch antenna integrated with a Wilkinson Power Divider demonstrates significant potential for enhanced wireless communication applications. By achieving circular polarization, the antenna minimizes signal degradation due to polarization mismatch and multipath fading, ensuring reliable communication across diverse scenarios. The integration of a Wilkinson Power Divider ensures uniform power distribution with minimal loss, further improving efficiency.The simulation results from ANSYS HFSS validate the design's ability to meet performance requirements such as low axial ratio, acceptable return loss (S11), and a well-defined radiation pattern. This project highlights the scalability of microstrip patch antennas for emerging technologies like 5G, IoT, and satellite communications.

11. REFERENCES

- Richa, M. M. Sharma, I. B. Sharma, Jaiverdhan, P. Kaith and J. Garg, "Design and Performance Evaluation of Circularly Polarized Dual Feed Microstrip Patch Antenna Using Wilkinson Power Divider," *2021 IEEE Indian Conference on Antennas and Propagation (InCAP)*, Jaipur, Rajasthan, India, India, 2021, pp. 12-14, doi: 10.1109/InCAP52216.2021.9726355.

- Wilkinson Power Divider - https://youtu.be/goka75ko6AI?si=YYGZ5EFp_ITMUEZP

- Microstrip Patch Antenna – https://youtu.be/vHUbV_7f_dE?si=NtnagnKKJdo9DEAb

- Parametric Analysis – https://youtu.be/wX-YGzVZ2YM?si=z0-rlBIgzZJOlzl8