Design and Analysis of Rectangular Microstrip Antenna for Radar Applications

A MINOR PROJECT - III REPORT

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BONAFIDE CERTIFICATE

Certified that this **18ECP105L - Minor Project - III** report "**Design and Analysis of Rectangular Microstrip Antenna for Radar Applications"** is the bonafide work of "JEGATHEESWARAN.K (927621BEC070), KARTHICK.C (927621BEC072), KARTHIKRAJA.M (927621BEC076), KISHORE.R (927621BEC096) who carried out the project work under my supervision in the academic year **2023 -2024 - ODD SEMESTER**.

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This report has been submitted for the **18ECP105L – Minor Project - III** final review held at M. Kumarasamy College of Engineering, Karur on ____________________

PROJECT COORDINATOR

INSTITUTION VISION AND MISSION

Vision

To emerge as a leader among the top institutions in the field of technical education.

Mission

M1: Produce smart technocrats with empirical knowledge who can surmount the global challenges.

M2: Create a diverse, fully -engaged, learner -centric campus environment to provide quality education to the students.

M3: Maintain mutually beneficial partnerships with our alumni, industry and professional associations

DEPARTMENT VISION, MISSION, PEO, PO AND PSO

Vision

To empower the Electronics and Communication Engineering students with emerging technologies, professionalism, innovative research and social responsibility.

Mission

M1: Attain the academic excellence through innovative teaching learning process, research areas & laboratories and Consultancy projects.

M2: Inculcate the students in problem solving and lifelong learning ability.

M3: Provide entrepreneurial skills and leadership qualities.

M4: Render the technical knowledge and skills of faculty members.

Program Educational Objectives

PEO1: **Core Competence:** Graduates will have a successful career in academia or industry associated with Electronics and Communication Engineering

PEO2: **Professionalism:** Graduates will provide feasible solutions for the challenging problems through comprehensive research and innovation in the allied areas of Electronics and Communication Engineering.

PEO3: **Lifelong Learning:** Graduates will contribute to the social needs through lifelong learning, practicing professional ethics and leadership quality

Program Outcomes

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

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

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6: 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 engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long 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.

Program Specific Outcomes

PSO1: Applying knowledge in various areas, like Electronics, Communications, Signal processing, VLSI, Embedded systems etc., in the design and implementation of Engineering application.

PSO2: Able to solve complex problems in Electronics and Communication Engineering with analytical and managerial skills either independently or in team using latest hardware and software tools to fulfil the industrial expectations.

Abstract	Matching with POs, PSOs
Rectangular Microstrip Antenna for Radar Applications	**PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2**

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ABSTRACT

Radar-based microstrip antennas have gained significant attention in recent years due to their versatility and Performance in various applications, including aerospace, defense, and remote sensing. This abstract Provides an overview of the design and analysis of radar-based microstrip antenna systems. This study Explores the fundamental design principles, electromagnetic characteristics, and performance parameters of Microstrip antennas specifically tailored for radar applications. The research delves into the selection of Suitable materials, geometry, and feeding techniques to optimize antenna performance. Moreover, advanced Simulation and modeling tools are employed to predict and analyze the antenna's radiation patterns, gain, and bandwidth.

Keywords – RADAR, Rectangular Microstrip Antenna

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LIST OF ABBREVIATIONS

ACRONYM	ABBREVIATION
HIS	High Impedance Surfaces
EBG	Electromagnetic Band Gap
SRR	Split ring Resonators
IMO	International Maritime Organization

CHAPTER 1

INTRODUCTION

Currently, radar is one of the emerging technologies. This technology can replace the function of the human eye to monitor objects at long distances. Radar is a system of electromagnetic waves that useful to detect, measure distances and create a map of objects [1]. Today's modern ships are equipped with the navigation radar to detect other vessels, weather encountered at the front so that it can avoid the dangers that exist in front of the ship. In applications on maritime navigation radar, based on the International Maritime Organization (IMO), maritim radar should use a frequency-band (8 to 12 GHz), where the mobility of ships requires a very small antenna size and light weight. The higher the work frequency the radar will become lighter and smaller antenna size [2]. One of important component on system radar is na antenna system, if analogous to the human body, the antenna systems as na eye which is very vital. Due to the high price of imported of a radar set, Indonesia is required to develop radar. Therefore, in this paper will discuss the making of one of its component, that is radar antenna using microstrip technology and array methods with a material such as a dielectric substrate Duroid / RT5880, Computer Simulation Technology (CST□) simulator software was used on simulation process. Microstrip technology is used so the antenna which is implemented has small dimensions, light weight and easy in fabrication and low cost [3]. Other than that, concerning the synthesis of aperture fields suitable for radar [4]. Design, rectangular shape patch is used with a modified form using a slot as a direction modifier of polarization resulting from vertical to horizontal [5]. The Designed Radar antenna consisting of 1x16 patch microstrip antenna in-array with uniform power distribution (uniform array), the working frequency of 9.4 GHz and a gain of > 12 dB.

1.1 Project description

The project will commence with a comprehensive literature review. This will provide insights into the state-of-the-art in radar technology, the role of antennas in radar systems, and the existing body of knowledge on microstrip antennas in radar applications. The next step will involve defining the precise requirements of the radar system where the microstrip antenna will be integrated. This includes considerations such as frequency bands, gain, beamwidth, and other performance parameters specific to the radar system's operational needs.Based on the system requirements, the project will proceed to the design phase. Here, a rectangular microstrip antenna will be crafted to meet the radar system's unique demands. This will involve selecting appropriate substrate materials, optimizing dimensions, and fine-tuning feeding mechanisms. Advanced electromagnetic simulation tools, like HFSS or CST Microwave Studio, will be employed to model and analyze the antenna's performance. Key parameters, including gain, directivity, bandwidth, radiation patterns, and impedance matching, will be rigorously assessed and optimized.

1.2 Project overview

This project is designed to address the pressing need for a specialized antenna system that can enhance radar performance in various applications, including military surveillance, weather monitoring, and air traffic control. The project's primary focus is on the design and analysis of a rectangular microstrip antenna, which offers a promising blend of efficiency and compactness.

CHAPTER 2

LITERATURE SURVEY

Investigate various radar applications where microstrip antennas are used. This might include ground-based, airborne, or spaceborne radar systems. Discuss the specific requirements and challenges in these radar applications Examine the principles of microstrip antenna design, including substrate materials, feeding techniques, and radiation patterns.Identify different design configurations (rectangular, circular, etc.) and their trade-offs in terms of performance. Explore the key performance metrics for radar antennas, such as gain, bandwidth, directivity, and impedance matching Investigate how these metrics relate to the design of microstrip antennasSearch for recent research papers and articles on rectangular microstrip antennas for radar applications. Highlight any novel design techniques or innovations in this area.Identify the challenges and limitations associated with using microstrip antennas in radar systems. This might include issues related to size, bandwidth, and integration Compare the performance of rectangular microstrip antennas with other antenna types commonly used in radar applications, such as horn antennas or phased arrays**.**

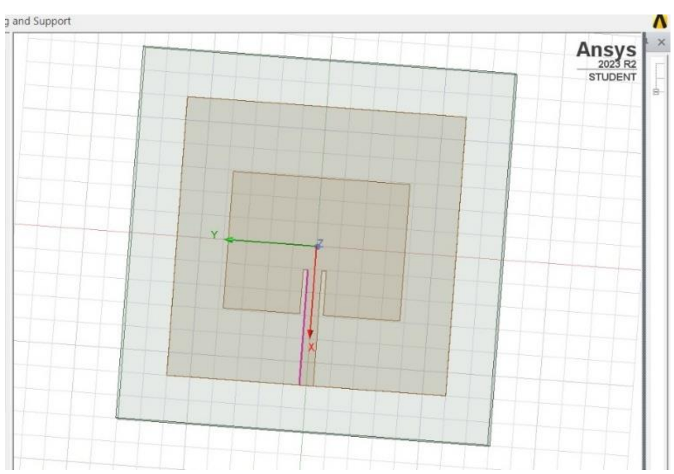


Fig 2.1

CHAPTER 3

EXISTING SYSTEM`

In the realm of radar technology, the design and analysis of antennas play a pivotal role in the effective operation of radar systems. Radar, which stands for Radio Detection and Ranging, is a technology widely employed for a range of applications, including air traffic control, weather monitoring, military surveillance, and more. It operates on the fundamental principle of emitting radiofrequency (RF) signals and capturing their reflections to derive information about objects or targets within its vicinity. Among the critical components of a radar system, the antenna assumes a significant role in transmitting and receiving RF signals. In the context of radar systems, rectangular microstrip antennas have gained prominence as a key technology. Microstrip antennas are known for their compact size, low profile, and ease of integration, making them suitable for a variety of radar applications. The rectangular microstrip antenna, in particular The use of rectangular microstrip antennas in radar systems is underpinned by their inherent advantages, including ease of fabrication, low profile, and the capability to meet various performance requirements. These antennas have found applications in a range of radar systems, such as weather radar, ground surveillance radar, and automotive radar.

3.1 DESIGN PARAMETERS

The rectangular microstrip patch antenna in this research is Designed for working at 3GHz. It is the range of S-band. This Antenna is used for radar application. The design of the Antenna is shown in Table II. This antenna use FR-4 for the Substrate and copper for patch and ground. The effective Dielectric constant of FR-4 is 4.4. It will be used in calculation Of the design parameters based on dimensions. The physical Design of the antenna in simulation is shown in Physical design of rectangular microstrip patch antenna in ANYSIS software Dimension of rectangular microstrip patch antenna using line feed.

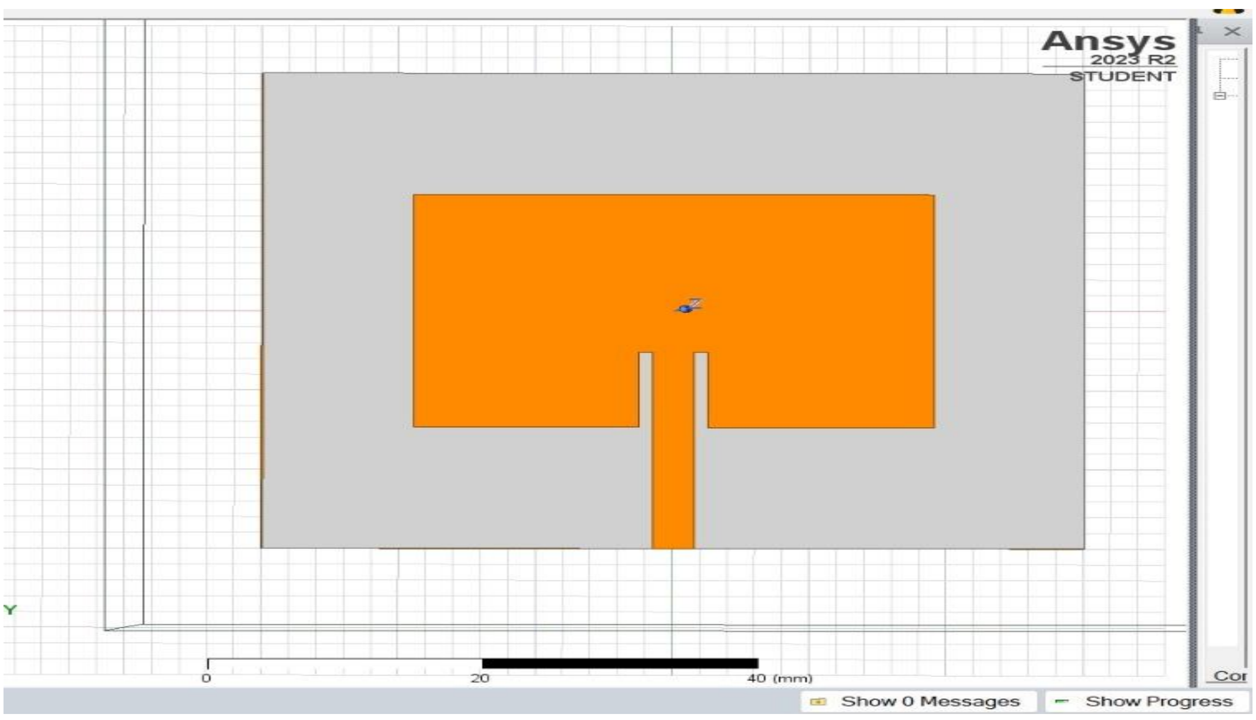


Fig3.1

CHAPTER 4

PROPOSED SYSTEM

In the pursuit of designing and analyzing a rectangular microstrip antenna for radar applications within a proposed system, a comprehensive literature survey is imperative to inform and guide the development process. The success of this endeavor relies on a deep understanding of existing radar technologies, the role of antennas, and the unique requirements of the forthcoming system.The foundation for such a project lies in a holistic comprehension of radar systems. Radar, an acronym for “Radio Detection and Ranging,” encompasses a wide spectrum of applications, from military surveillance and weather monitoring to automotive safety. These systems rely on a set of essential components, including transmitters, receivers, signal processing units, and, critically, the antenna. The antenna serves as the bridge between the electromagnetic realm and data acquisition, playing a pivotal role in transmitting and receiving radar signals.

Microstrip antennas, known for their compact and lightweight nature, have emerged as a notable choice for radar applications. Their adaptability to various frequency bands and ease of fabrication make them an appealing option for the proposed system. However, the exact design of the rectangular microstrip antenna must be meticulously tailored to align with the specific needs of the new radar application.This process involves an in-depth analysis of the proposed system’s requirements, taking into consideration factors such as frequency bands, bandwidth, beamwidth, radiation patterns, and other performance metrics. Furthermore, this literature survey should explore the potential challenges and limitations inherent in employing microstrip antennas for radar in the context of the forthcoming system.

CHAPTER 5

MICROSTRIP FEED LINE

A microstrip line feed is a type of transmission line used in microwave and RF engineering. It consists of a conducting strip placed on a dielectric substrate and is widely used for feeding electromagnetic signals to antennas, as well as for connecting various microwave components in integrated circuits and high-frequency systems. The design and performance of microstrip line feeds are crucial for the overall operation of these syste .Microstrip line feeds are fundamental components in RF and microwave engineering. Their design and implementation are critical to the performance of antennas, filters, and various RF components. A thorough consideration of design parameters, substrate materials, and manufacturing processes is imperative to ensure efficient signal transfer and system performance in high-frequency applications. These versatile transmission lines continue to be at the forefront of modern RF and microwave technology, contributing to advancements in wireless communication, radar systems, satellite technology, and numerous other fields.

CHAPTER 6

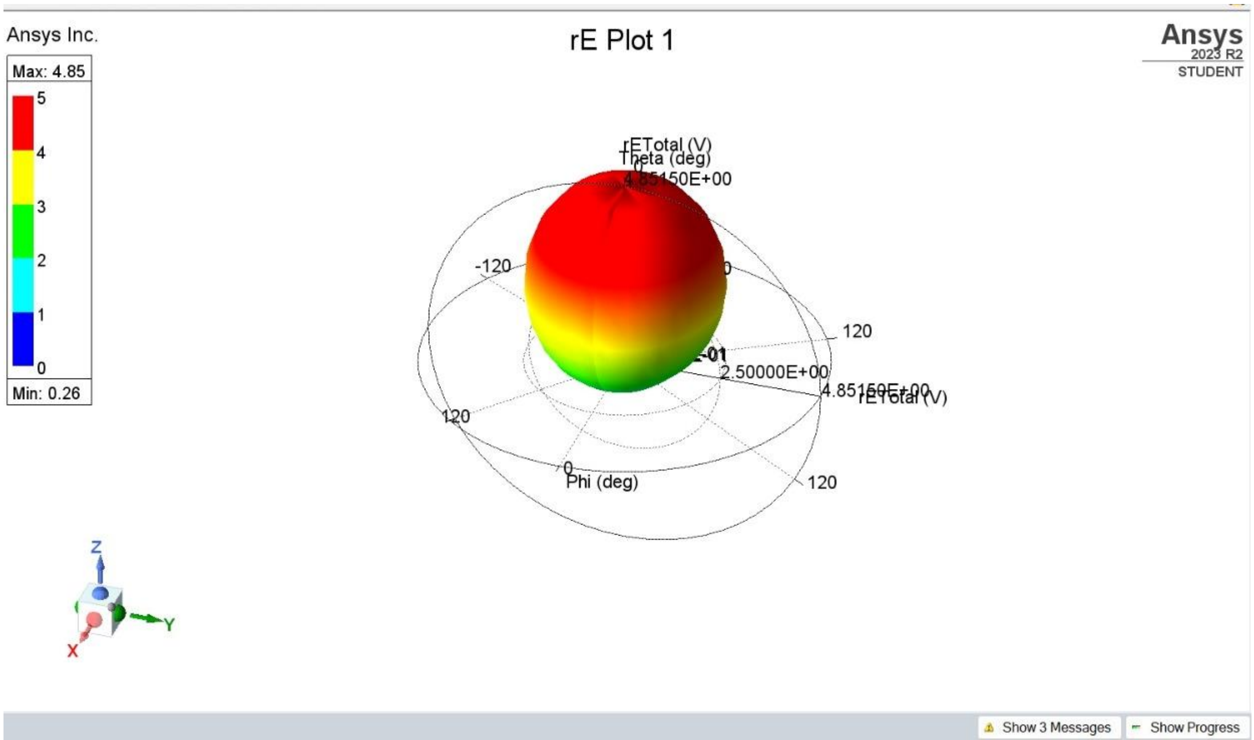
SOFTWARE REQUIRED

Ansys High-Frequency Structure Simulator (HFSS) is a general-purpose full-wave 3D electromagnetic (EM) simulation software for simulating and optimizing high-frequency electronics products like antennas, antenna arrays, high-speed interconnects, and printed circuit boards to name a few. Using Ansys HFSS allows engineers to accurately evaluate the performance of complex designs before the prototype phase. Many antenna design application calculations cannot be done by hand, making this high-frequency software extremely valuable

CHAPTER 7

RESULT AND DISCUSSION

In designing a rectangular microstrip patch antenna, achieving the desired performance metrics while maintaining a compact form factor is often a trade-off. The choice of substrate material and feed mechanism is crucial in this regard. High dielectric constant substrates allow for smaller antenna dimensions, but they may increase losses. Proper impedance matching techniques, such as using a matching network or a quarter-wavelength transformer, are necessary to optimize performance. Additionally, while rectangular patches are straightforward to design, they have certain limitations. They are typically linearly polarized, and achieving circular polarization or dual polarization often requires more complex structures like stacked patches or the use of a feed network. Overall, the design of a rectangular microstrip patch antenna involves a balance between trade-offs in terms of size, bandwidth, and performance metrics. The choice of design parameters depends on the specific application requirements. Through simulations, prototyping, and iterative design, engineers and researchers can tailor the antenna to meet the needs of various wireless communication systems and other applications.


Ansys Inc.
rE Plot 1
Ansys
2023 R2
STUDENT
Max: 4.85
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4
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Theta (deg)
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120
2.50000E+00
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Phi (deg)
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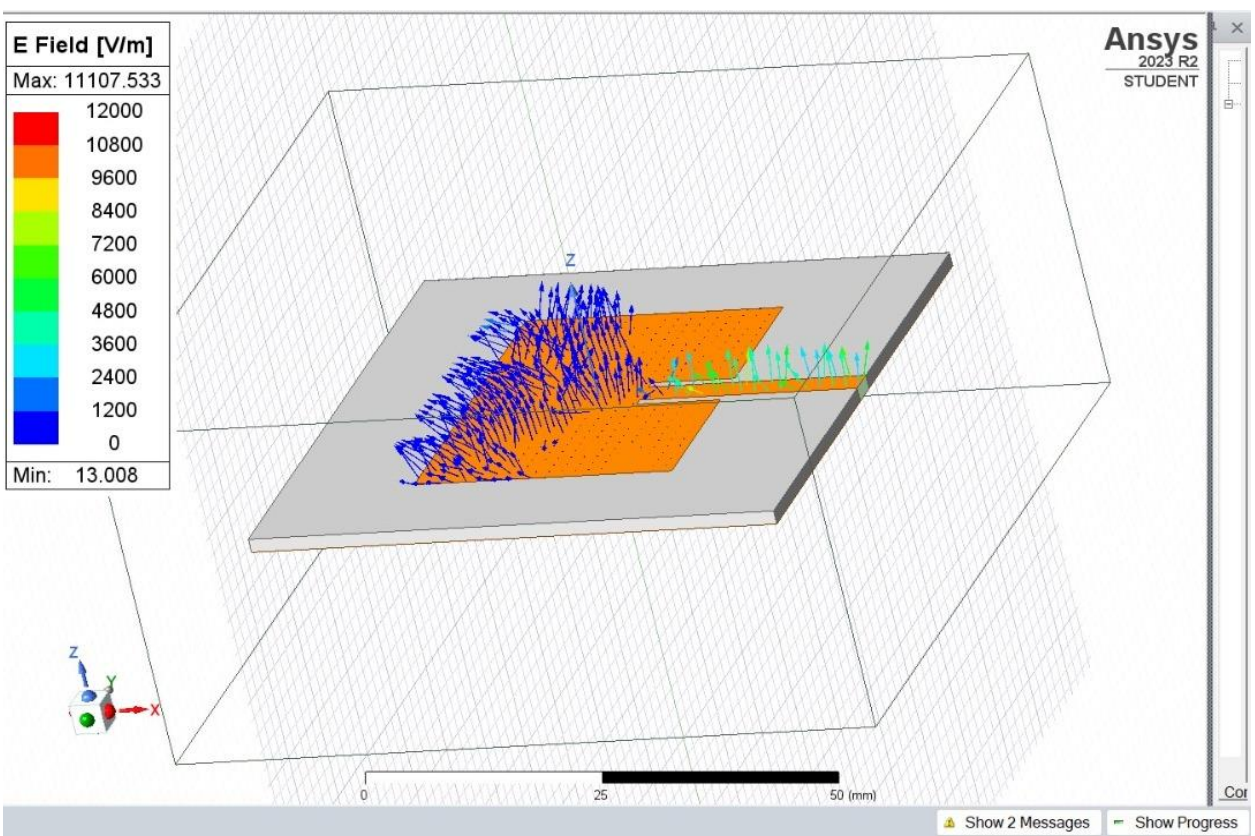
Z
Y
X
Show 3 Messages
Show Progress

Fig 7.1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7200
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4800
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1200
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Ansys
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25
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Show 2 Messages
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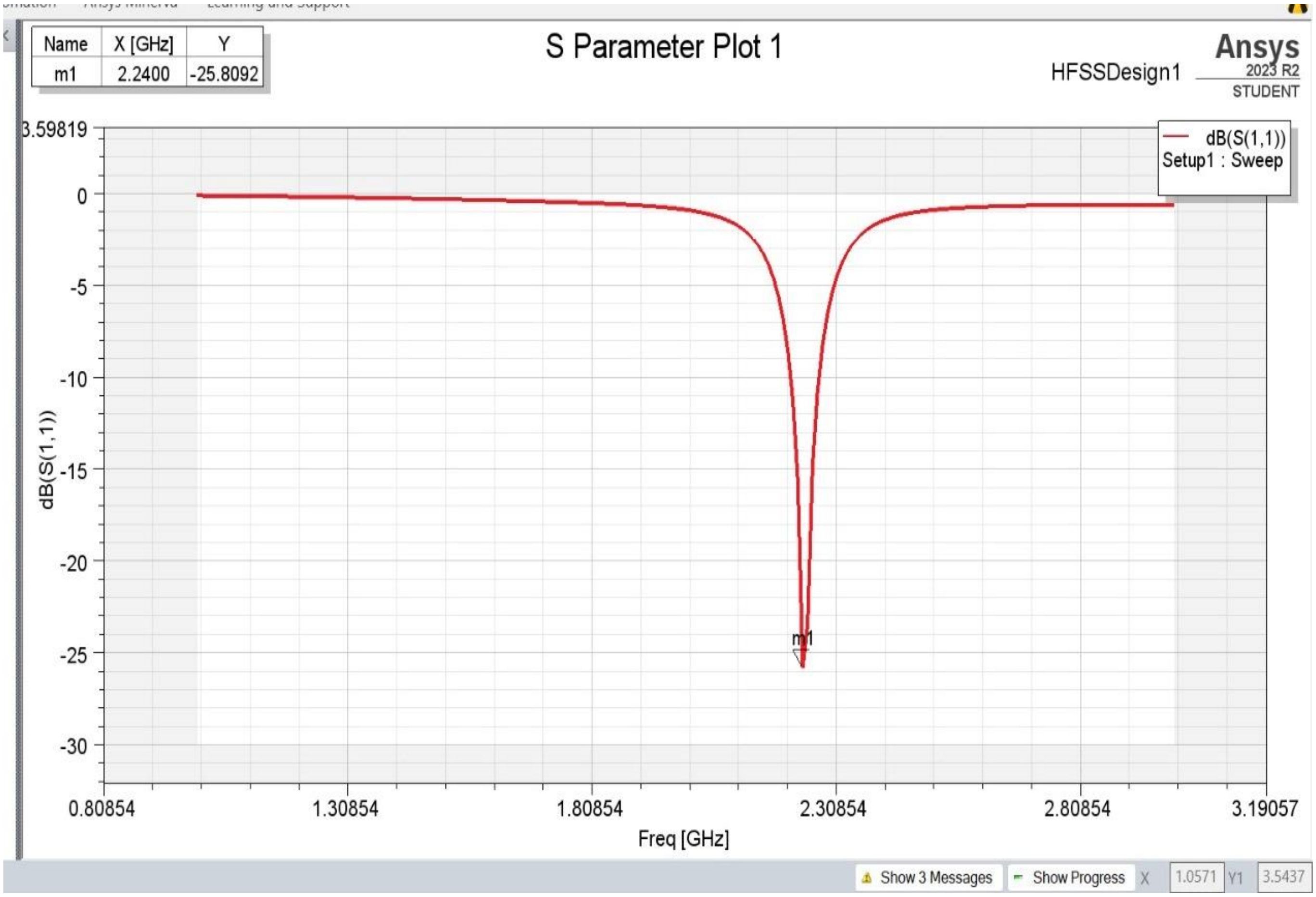
Fig 7.2


Name
X [GHz]
Y
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-25.8092
S Parameter Plot 1
HFSSDesign1
Ansys
2023 R2
STUDENT
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Setup1 : Sweep
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0
-5
-10
-15
-20
-25
-30
dB(S(1,1))
m1
0.80854
1.30854
1.80854
2.30854
2.80854
3.19057
Freq [GHz]
Show 3 Messages
Show Progress
X
1.0571
Y1
3.5437

Fig 7.3

CHAPTER 8

CONCLUSION

From this research, researchers have successfully designed and investigate the performance of a dipole antenna using Aluminum and iron. After doing performance investigation From the result of simulation it can be conclude that Iron is Better to be used for large bandwidth with value of directivity And gain is bigger than aluminum except for upper frequency. On the other hand, aluminum is better to be used for higher Frequency with the small bandwidth since the directivity and The gain of aluminum in upper frequency is bigger than iron. Both of aluminum and iron has no significant difference for HPBW but in the center frequency.

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