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DESIGN AND SIMULATION OF COMPACT MONOPOLEANTENNA FOR UAV APPLICATION

A MINOR PROJECT-III REPORT

Submitted By

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BONAFIDE CERTIFICATE

Certified that this **18ECP105L - Minor Project - III** report "**DESIGN AND SIMULATION OF COMPACT MONOPOLE ANTENNA FOR UAV APPLICATION"** is the bonafide work of "**KARTHIKA R(927621BEC074), KEERTHI P (927621BEC085), MADHUMITHA SRI R(927621BEC108)"** 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

Vision of the Institution

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

Mission of the Institution

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

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

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

Vision of the Department

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

Mission of the Department

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 (PEOs):

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 (POs):

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 teamwork: 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 (PSOs):

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 expecta

MAPPING OF PROJECT WITH POs AND PSOs

Abstract	Matching with POs , PSOs
Unmanned Aerial Vehicle, Coplanar Wave Guide, Monopole Antenna	PO1, PO3, PO9, PSO1

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ABSTRACT

A Compact planar monopole antenna with Coplanar Wave Guide (CPW) feed for Unmanned Aerial Vehicle (UAV) applications is presented. This micro strip-fed antenna consisting of a square slot patch with a vertical coupling strip only occupies 15(L) × 15(W) ×1.6mm^3. By properly designing the strip placed at thecenter of the patch good frequency rejection performance of the antenna with a 4.3 GHz can be obtained. Compared to other designs the antenna has a quite simple structure to make the band notched property to reduce the effect caused by frequency interference. Furthermore, fairly good omnidirectional radiation patterns and transmission responses both indicate that the proposed antenna is well suited to be integrated withunmanned Aerial Vehicles.

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Acronyms/List of Abbreviations

Acronyms	Abbreviations
HFSS	Higher Frequency Structure Simulator
CPW	Coplanar waveguide
UAV	Unmanned aerial vehicles
VSWR	Voltage standing wave ratio

1.INTRODUCTION

1.1 Antenna:

Antennas are key components of any wireless system. An Antenna is a device that receives or transmits electromagnetic waves. An Antenna is one type of transducer that converts electric energy into electromagnetic energy in the form of electromagnetic waves. Recently, Unmanned Aerial Vehicles (UAV) have attracted lots of attentions for scientific, industrial and military applications. Generally, the antenna should be compact in sizes to satisfy the highly limited space in UAV and low profile to minimize the air resistance for aerodynamics requirements. A monopole like omnidirectional radiation pattern in the horizontalplane is preferable, since it can enhance the communication link between the UAV and the ground base stations.

Types of Antenna:

There can be different types of antenna. Such as monopole antenna, dipole antenna, directional antenna, semi directional antenna and Omni directional antenna.

1.2 Patch Antenna:

Patch antennas come in various shapes and sizes and consist of a patch of metal directly above a groundplane. The main disadvantage of these antennas is their relatively large size compared to other type of antennas. For example, some patch antennas are approximately half a wavelength on each side. Thepolarization can be either circular or linear depending on the design of the patch. In a patch antenna, most of the propagation is above the ground plane and can have high directional gain.

1.3 Performance Parameters

Radiation Pattern:

The radiation pattern is a three-dimensional graphical representation of the radiation of the antenna asthe function of direction. It is actually the plot of the power radiated from an antenna per unit's solid angle. Isotropic antennas do not exist in reality but are generally used as a reference to compare the performance ofother antennas. The radiation pattern provides all the required information on antenna beam-width, side lobesand resolution of the antenna [1].

Gain:

It is the ratio of the maximum radiation intensity at the peak of the beam to the radiation intensity in the same direction produced by an isotropic radiator having same input power is known as the gain of theantenna.

Directivity:

The ratio of normalized power density at the peak of the main beam of the three-dimensional antennapattern to the average density is known as directivity.

Band Width:

Bandwidth is the range of usable frequencies with in which the performance of the antenna with respective designed character, meets the specific standards. Bandwidth ranges across a central frequency and within this range all the other antenna parameters like radiation pattern, input impedance, beam-width, polarization, gain, directivity or with in the tolerable limits from there corresponding values at the central frequency.

Return Loss:

Return loss or reflection loss is the signal power's reflection from the insertion of a device in a transmission line. It is expressed as ratio in decibels (dB) relative to the

transmitted signal power. The return loss should be restricted to less then – 10 dB, show that the antenna can radiate effectively.

VSWR:

Voltage Standing Wave Ratio (VSWR) is the wave in the transmission line where distribution of electric parameters like current, voltage or field strength is formed by superposition of two waves of same frequency that propagate in the opposite direction. This voltage standing wave along the line producers a series of nodes and anti-nodes at fixed positions. VSWR is a measure of how efficiently radio frequency power is transmitted from a power source, through a transmission line into a load the smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is deliver to the antenna. The minimum VSWR is 1.0, no power is reflected from the antenna. A VSWR value under 2 is considered suitable for mostantenna applications. VSWR is very important parameter in radio frequency transmission systems where a high VSWR can reduce the power deliver to an antenna are system significantly [1].

Geometrical Design:

Resonant Frequency: 4.3GHz (GSM Band)

Dielectric Constant: 4.4

Substrate Material: FR4 (Lossy)

Micro strip Material: Copper(Annealed)

Speed of Light: 3×10^8 m/s.

1.4 Objective:

The main objective of this project is to understand the working and the design of the antenna.

Specific Objective:

1. To design the antenna according to designed specifications.

2. To be acquainted with some of the characteristics of parasitic antenna element modelling andoperations.

3. To know the antenna radiation pattern.

4. Test antenna and verify it performs as expected.

5. The project system performance objectives are:

a)Develop large, low-cost antenna structure.

b)Validate mechanical packaging efficiency.

2.PROBLEM STATEMENT

In wireless communication, monopole antenna is vital issues these days. This paper presents the simulation analysis of UAV using CPW feed. This have brought to define bandwidth enhancement using transmission line with CPW feed. These techniques are used to reduce the physical size but to increase the bandwidth and efficiency of antenna. The effect of transmission line various antenna parameters like radiationefficiency, gain and bandwidth are discussed.

3.LITERATURE REVIEW

In order to start the project, the first is to study the research paper that has been performed previous by other researches. The paper that has related to this title are chosen and studied. With the help of this literature review, it gives more clear understanding to perform the project. In that paper, a square patch micro strip antenna design has been proposed and successfully implemented. The proposed structure has beam simulated by using the Ansys HFSS software. The square patch antenna enhances bandwidth, gain and good return loss (S11 parameters) is achieved along with broad side radiation pattern. The square patch micro strip antenna can be used for wire-less local area network (WLAN, IEEE 802.11) application. The use of thicker substrate increases the size of the patch antenna, which is the area that can be improved with the proposed design. This paper intends to propose a new and simple compact monopole antenna for ultra-wide band application the proposed antenna efficiently covers 2.4 GHz antenna which employs a vertical coupling strip to flexibly control the rejection frequency band for ultra-wide band system operation.

Those conventional designs, quite stable radiation performance of the antenna can be achieved as a major design parameter of the antenna can be achieved and the stop band are modified this make it possible for the proposed ultra-wide band notched antenna with a compact size to be integrated with in different portable devices without the need for retuning the hole design structure. The monopole is often used as a resonant antenna, the rod functions as an open resonator for radio waves, oscillating with standing waves of voltage and current along its length therefore the length of the antenna is determined by the wavelength of the radio waves. Monopole antenna is one half of a dipole antenna, almost always mounted above some sort of groundplane.

The radiation pattern of the monopole antenna above a ground plane are also known from dipole result, the impedance of the monopole antenna is halved. The directivity of the monopole antenna is directly related to that of a dipole antenna.

The monopole antennas are used in finite sized ground planes. This affects the properties of the monopole antennas,

particularly the radiation pattern. The impedance of the monopole antenna is minimally affected by a finite sized ground plane for ground planes of at least a few wave lengths in size around the monopole. However, the radiation pattern for the monopole antenna is strongly affected by a finite sized ground plane. The resulting radiation pattern for this monopole antenna is still omnidirectional. The gain given in this section are only achieved if the antenna is mounted over a perfectly conducting infinite ground pane. The monopole antenna has only vertical polarization. This antenna offers ultra-wide impedance bandwidth that is near omnidirectional [2].

4.PROJECT METHODOLOGY

4.1Existing Method:

The existed method is a printed monopole antenna that simply employs a vertical coupling strip to flexibly control the rejection frequency band for UWB system operation. Unlike those conventional designs,quite stable radiation performance of the antenna can be achieved as the major design parameters of the stopband are modified. This makes it possible for the proposed UWB band-notched antenna with a compact size of $15 \times 15 \times 1.6mm^3$ to be integrated with in different portable devices without the need for retuning the whole design structure [3].

4.2 Proposed Method:

In proposed method, the monopole antenna consists with CPW feed. The coplanar Wave Guide feed isinserted instead of a ground. The main purpose for inserting the CPW feed is to increase the bandwidth and high frequency. The CPW is the feeding which side plane conductor is ground and centre strip carries the signal. Hence CPW fed slot antenna is most effective and promising antenna for UAV application. A CPW fed defected substrate micro strip antenna is proposed. The proposed antenna shows UAV applications by choosing suitable defected square shaped substrate. Defected substrate also reduces the size of an antenna. Inset feeding technique of micro strip antenna is simple to implement and easy to know the behavior of the antenna, which is controlled by the inset gap and inset length. Impedance of the antenna can be controlled bythis feeding method due to planar structure. The height of substrate(H), design frequency (fr), width of CPW feed(W), length of CPW feed(L), patch length(L), patch width(W) values are shown in Table 4.1. By using this, we can design the high frequency monopole antenna for UAV application. The CPW is the feeding whichside-plane conductor is ground and Centre strip carries the signal. The advantage of CPW fed slot antenna is its wide band characteristics. Hence CPW fed slot antenna is most effective and promising

antenna for wideband wireless application. Drones are typically run by 2.4 GHz radio waves.

To communicate with theiraircraft, many drone controllers use Wi-Fi, which can be transmitted on the 2.4 GHz spectrum, and is something that smartphones and tablets can tap into without any accessories. Unmanned Aerial Vehicle, something that can fly without a pilot on board. There are two main types of UAV such as, fixed wing and multi rotor. A fixed wing UAV looks like an airplane. Since the wing provides lift, the motor doesn't have to spend all the battery power to maintain flight [4].

Table 4.1 Designed Antenna Parameters

PARAMETERS	VALUES
HIGHTOF SUBSTRATE(H)	1.6mm
DESIGN FREQUENCY (fr)	4.3GHz
WIDTH OF CPW FEED(W)	12.6 mm
LENGTH OF CPW FEED(L)	13.3mm
PATCH LENGTH(L)	15mm
PATCH WIDTH(W)	15mm

Design of the Antenna:

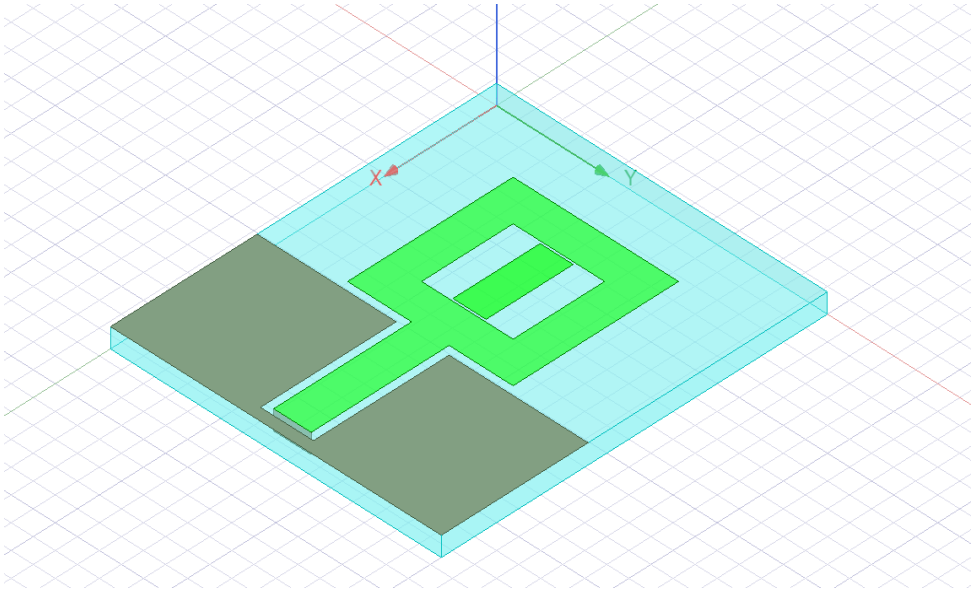

Figure 4.1 Isotropic View of the Antenna

The first step is to create the substrate. The main purpose of creating substrate is to enhance the mechanical strength of the antenna. The length and thickness of the antenna is 30mm and 1.6mm. By using the dimensions, the required antenna is designed with Coplanar Wave guide feed is shown in Figure 4.1. By inserting CPW feed, the antenna can obtain good frequency performance. Thus, the different views of antennaare shown in following figures [5].

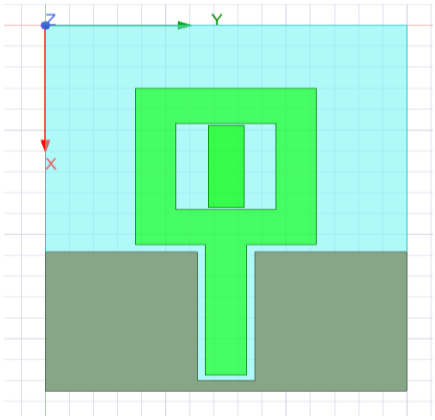

Figure 4.2 Top View of the Antenna

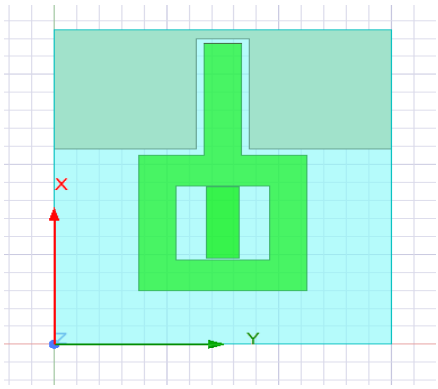

Figure 4.3 Bottom View of the Antenna

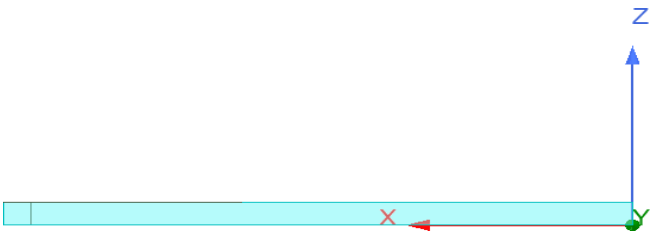

Figure 4.4 Right View of the Antenna

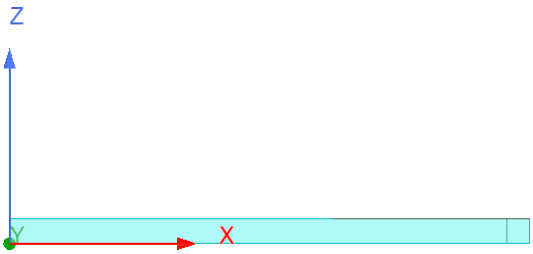

Figure 4.5 Left View of the Antenna

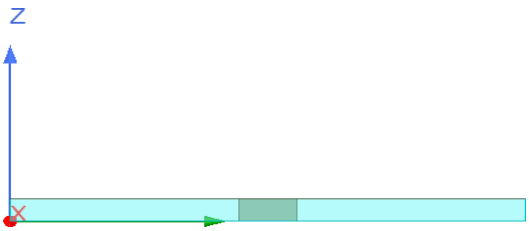

Figure 4.6 Front View of the Antenna

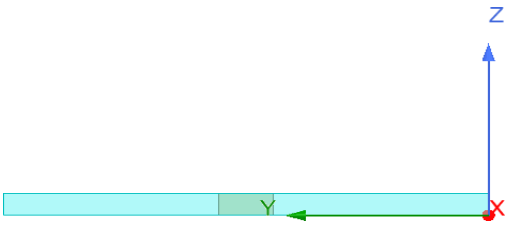

Figure 4.7 Back View of the Antenna

5.SIMULATION SOFTWARE

Ansys HFSS (High Frequency Structure Simulator), is a commercial finite element method solver forelectromagnetic (EM) structures from Ansys that offers multiple state-of-the-art solver technologies. It is a 3D electromagnetic (EM) simulation software for designing and simulating high frequency electronic products such as antennas, antenna arrays, radio frequency or microwave components, high speed interconnects, filters, connectors, IC packages and printed circuit boards. The HFSS software from Ansys is an adaptive meshing technology-based software used for simulating 3D full wave electromagnetic fields. It is one of the most powerful used software tools in the radio frequency and micro wave industry. Windows 11 and Windows 10 are supported for the Ansys software for installation and to design the required antenna in HFSS. Ansys consist of HFSS, Q3D, Icepacks, Maxwell. Maxwell is mainly used for to design the capacitor. Used by millions aroundthe world, students can take advantage of our free engineering software for homework, capstone projects and student competitions. Our renewable products can be downloaded at no cost by students across the globe and installed on Windows 11 and 10.

6.APPLICATION

Antennas are the most important electronic components of any UAV for they allow the vehicle to transmit information and to receive information from other systems as well as the people on the ground. Unmanned aerial vehicles (UAVs), also known as drones, have come in a great diversity of several applications such as military, construction, image and video mapping, medical, search and rescue, parcel delivery, hidden area exploration, oil rigs and power line monitoring, precision farming, wireless communication. Drones are small remotely controlled aerial vehicles, i.e., they are unmanned aerial vehicles. They look like helicopters or reconnaissance aircraft and, without a doubt, one of their strengths is the many different applications for which they can be used [6].

Advantages of UAV:

- Reduced volume and lighter structures.
- Suitable for using planar arrays.
- Easy to adapt to different surfaces for mounting, if the substrate is flexible.
- It monitors area that do not necessarily pose a risk to human workers.
- Makes delivery easier.

7.RESULTS AND DISCUSSIONS

S PARAMETER:

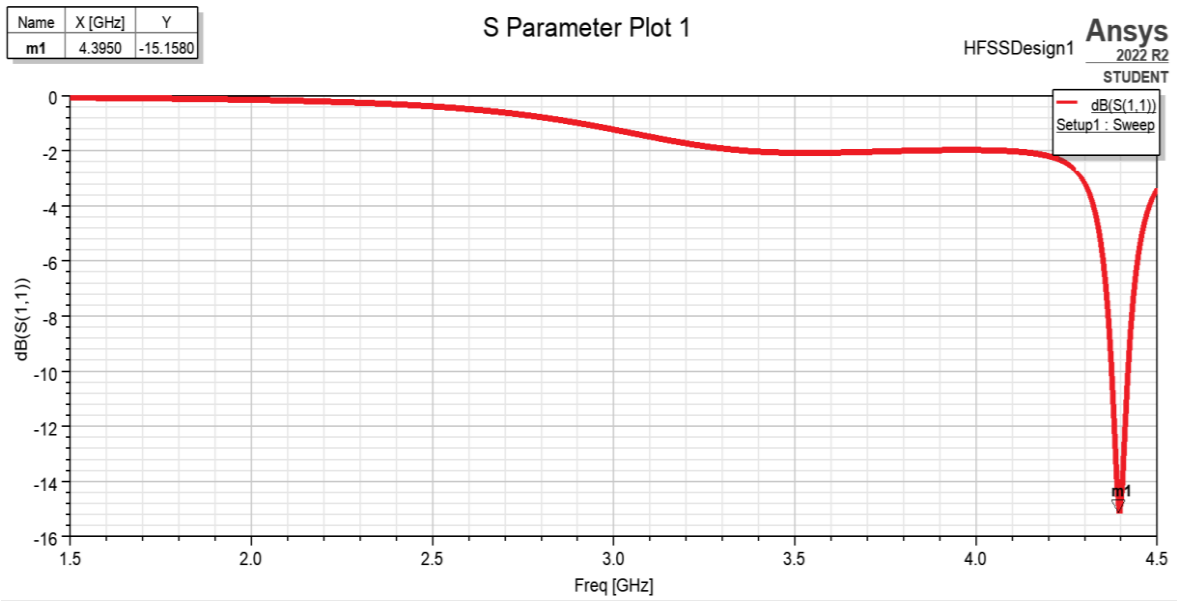

Figure 7.1 S Parameter of the Antenna

VSWR:

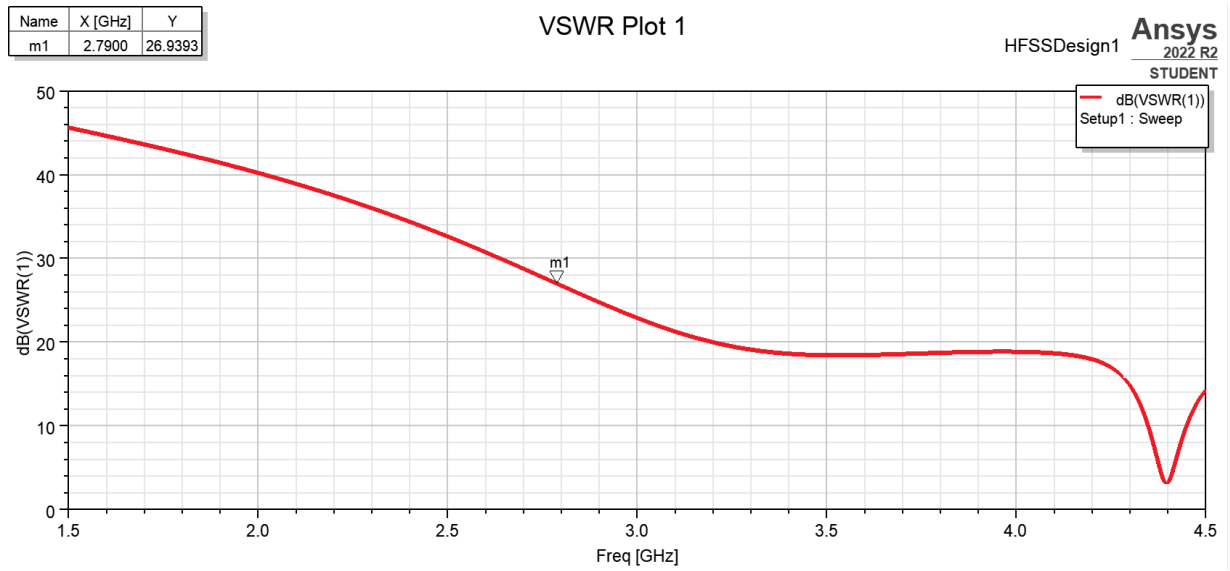

Figure 7.2 VSWR of the Antennas

GAIN:

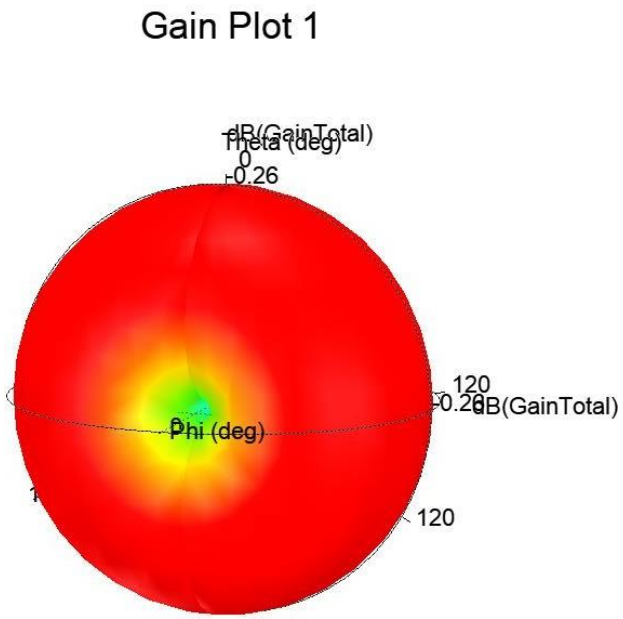

Figure 7.3 Gain of the Antenna

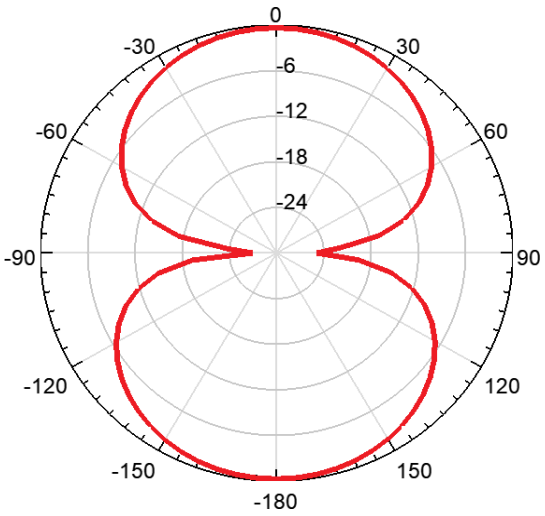

Figure 7.4 Radiation pattern of the Antenna

The proposed antenna with CPW feed has a low profile with monopole-like radiation characteristics and omnidirectional radiation pattern can be fulfilled through this method, it can be applied to various aircrafts, including UAV. Fairly, good agreements between the stimulations and measurements have been achieved. As observed, the measured impedance bandwidth 15 dB return loss for the proposed antenna is from 3.05 to 11.15GHz, rejecting the frequency band of about 5.12 – 6.08 GHz, so the effects due to frequency interference can be avoided well. To further analyze the band notched property, the surface current distribution of the antenna at the Centre rejected frequency of 5.6 GHz has been simulated. We can see that compared to the square slot patch, a stronger resonance surrounding. The CPW feed line has occurred apparently. This results in a good frequency rejection property for our design with the help of simulated HFSS. S Parameter with -15dB is attained as a result is shown in Figure7.1 which is a good return loss. VSWR is a measure of how efficiently radio frequency power is transmitted from a power source, through a transmission line into a load antenna is shown in Figure7.2. Gain of the antenna in a given direction is defined as the ratio of the intensity, it defines as the degree to which an antenna concentrates radiated power in the given direction is shown in Figure7.3. A radiation pattern defines the variation of the power radiated by an antenna as a function of the direction away from the antenna. This power variation as a function of the arrival angle is observed in the antenna's far field. As an example, consider the 3-dimensional radiation pattern in Figure7.4, plotted in decibels (dB).

8.SCOPE FOR IMPROVEMENT

- The experimental radiation patterns of the constructed antennas could not be obtained and comparedwith the theoretical patterns.
- Though we were able to simulate several patch antennas, we were unable to fabricate one andcompared the practical and simulated results.
- A more complete study of different field solvers and simulators (such as sonnet, AWR, etc.) could notbe made we were only able to focus on HFSS.

9.CONCLUSION

A compact planar band notched monopole antenna is suitable for UAV application has been presentedand studied in this project. Compared with prior designs, the proposed antenna can easily and flexibly adjustits stopband property so that better radiation performance can be achieved. Issues with frequency interferencemay also be more effectively handled with the use of this stopband. Additionally, it has qualities like good omnidirectional energy and is ideally suited for the integration of UAV equipment. As a result, the structure of the antenna with band notches and notch strips is very straightforward. The design and analysis of UAV applications in the finished product. The suggested antenna was etched on a flame retardant (FR4) substrate and designed with Ansys HFSS. This modality operates in nearly all commercial wireless applications and isobserved to have gain efficiency in those bands. The S parameter, VSWR, and gain that was determined. It can therefore be applied to UAV drones.

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National Conference on Innovative Research in
Electrical, Electronics and Communication Engineering

ELECTROX'23

CERTIFICATE OF PARTICIPATION

This is to certify that Dr./Mr./Ms. **Karthika R** of **M. Kumarasamy College of Engineering** has participated and presented a paper titled **Design and Simulation of Compact Monopole Antenna for UAV Applications** in the IETE sponsored National Conference on Innovative Research in Electrical, Electronics and Communication Engineering (ELECTROX'23) organized by Department of ECE & EEE, Karpagam Institute of Technology, Coimbatore held on October 28, 2023.

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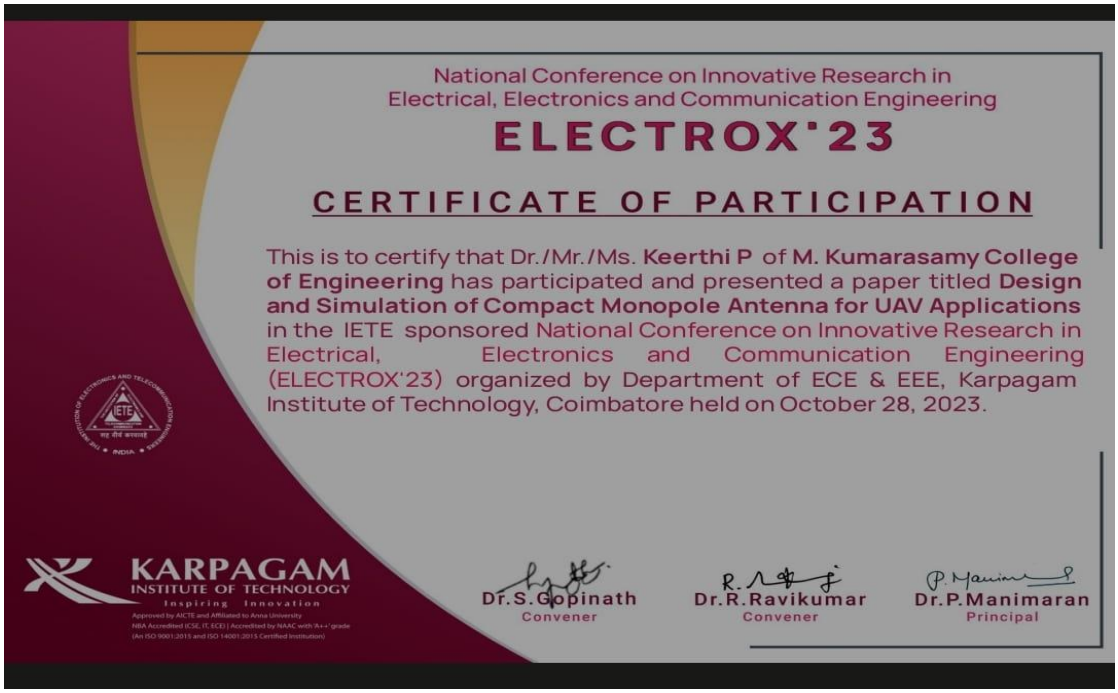

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This is to certify that Dr./Mr./Ms. **Keerthi P** of **M. Kumarasamy College of Engineering** has participated and presented a paper titled **Design and Simulation of Compact Monopole Antenna for UAV Applications** in the IETE sponsored National Conference on Innovative Research in Electrical, Electronics and Communication Engineering (ELECTROX'23) organized by Department of ECE & EEE, Karpagam Institute of Technology, Coimbatore held on October 28, 2023.

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Principal

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This is to certify that Dr./Mr./Ms. **Madhumitha Sri R** of **M. Kumarasamy College of Engineering** has participated and presented a paper titled **Design and Simulation of Compact Monopole Antenna for UAV Applications** in the IETE sponsored National Conference on Innovative Research in Electrical, Electronics and Communication Engineering (ELECTROX'23) organized by Department of ECE & EEE, Karpagam Institute of Technology, Coimbatore held on October 28, 2023.

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