DESIGN OF TRIBAND ANTENNA FOR UWB APPLICATION

A MINOR PROJECT - II REPORT

Submitted by

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BACHELOR OF ENGINEERING

in

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BONAFIDE CERTIFICATE

Certified that this **18ECP104L - Minor Project II** report "**DESIGN OF TRIBAND ANTENNA FOR UWB APPLICATION"** is the bonafide work of KIRUTHIGA.M (972621BEC090) who carried out the project work under my supervision in the academic year 2022-2023.

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This Minor project-II report has been submitted for the **18ECP104L – Minor Project-II** 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**
Tri-band antenna, UWB,WIMAX,WLAN Aircraft, Mobile application	**PO1, PO2, PO3, PO5, PO6, PO7, PO8, PO9, PO10, PO11, PO12, PSO1, PSO2**

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ABSTRACT

Antennas are the most crucial components which needed to build a communication link in today's modern wireless sector. Because of its compact profile, less weight, and limited power handling capacity, microstrip antennas are suitable for aircraft and mobile applications. To achieve increased gain and bandwidth for dual band and tri-band operation, these antennas can be constructed in a wide range of configurations. This paper introduces a compact tri-band antenna with microstrip inset feeding for UWB applications. The basic structure of the proposed antenna dimensions 17.25mm x 21.69mm x 1.6mm. The designed antenna exhibits multiband behavior and produces three distinct resonant frequency bands. The antenna's first band resonates at 5.962GHz with a return loss of -15.28dB, while its second band operates at resonating frequency 7.643 GHz with a return loss of -27.78dB. The suggested antenna also supports WiMAX standards because it resonates at 9.48 GHz in its third band with a return loss of about -32.49dB. FR4 works as the substrate material for the proposed triple band antenna.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

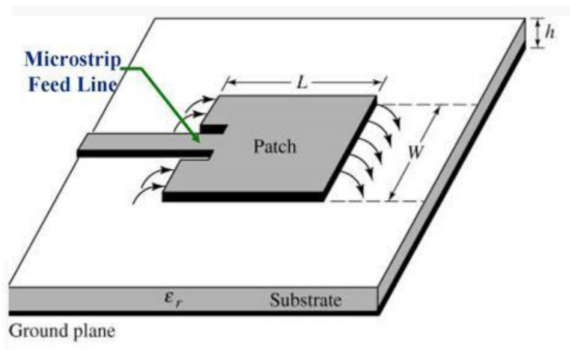
CHAPTER 1

INTRODUCTION

1.1 TRIBAND ANTENNA

An antenna is a metallic structure that captures and/or transmits radio electromagnetic waves. Antenna can also be termed as an Aerial. Plural of it is, antennae or antennas. Antennas come in all shapes and sizes from little ones that can be found on your roof to watch TV to really big ones that capture signals from satellites millions of miles away. The word 'antenna' is from Guglielmo Marconi's test with wireless equipment in 1895. The length of the antenna is inversely proportional to the frequency and directly proportional to the wavelength. The higher the frequency and the shorter the wavelength, the shorter the antenna can be made. The antennas primary function is to transmit and receive clear signals between multiple wireless points. It is safe to say that an effective and efficient wireless network will require antennas to operate properly. This is mostly because high-quality substrates are readily available. Since then, in-depth study and development of microstrip antenna and arrays, utilizing the many benefits like light weight, low volume, low cost, planar configuration, and compatibility with integrated circuits, have resulted in a variety of applications and the topic's establishment as a distinct entity within the larger field of microwave antennas . Microstrip antennas have emerged as one of the most cutting-edge areas of antenna theory and design in recent years. Utilizing printed circuit technology for both the radiating components of an electronic system as well as the circuit components and transmission lines gave rise to the fundamental concept of the microstrip antenna. Because of their ease of usage and compatibility with printed-circuit technology, they are used in a variety of contemporary microwave applications. In its most basic form, a microstrip antenna is simply a rectangular shape (or other forms like circular, triangular, etc.) on top of a substrate with a ground plane backing it. Commercial ultra-wideband (UWB) communication systems must operate between. and. GHz, according to the Federal Communication Commission (FCC). Since then, a number of UWB application antennas have been reported. The WiMAX band, the WLAN band, and the downlink of X-band satellite communication systems are all included in the UWB system's spectrum, which could cause interference with the UWB system. It is therefore preferable to construct UWB antennas with band-notch features. Using parasitic elements, inserting a slit in the feed line, or creating various types of slots in the radiation patch and ground plane are the traditional ways to produce band-notched function.

There have been a number of UWB antennas described recently featuring single, dual, and multiple notched band functionalities. In this study, we suggest a straightforward triband-notched UWB antenna that is microstrip inset-fed. The computer stimulation technique simulates and optimises the planned antenna.



Antenna design model

FEEDING TECHNIQUES

There are four fundamental ways to feed a microstrip patch antenna: edge feeding, probe feeding, aperture coupling, or proximity coupling. The first is one of the earliest techniques for microstrip excitation. This places the patch and microstrip line in close proximity. The key advantage of this feeding technique is how straightforward it is to construct because the microstrip line and patch may both be etched on the same piece of wood. One major drawback is unwanted radiation from the feed, which changes the radiation pattern of the antenna. In the simple process known as "probe feeding," the inner conductor of a coaxial cable is extended through the ground plane and connected to the patch. The limited bandwidth is still present, though. Changing the aperture is the next method of commenting. It is the first non-contact method created to get over direct input technology's drawbacks of surface waves and a narrow bandwidth. Via a void in the backplane that divides the power substrates and position, the power of the power supply is connected. The antenna and power substrates can be independently optimized using this technology, which also makes production simpler. The final technique described in this appendix is proximity switching. The dot is etched on top of another substrate that is above the grounded substrate, which is where the microstrip line is positioned. Because the two substrates are not connected, current from the power source can couple the spot electromagnetically.

CHAPTER 2

OBJECTIVE

Designing and analyzing a rectangular microstrip patch antenna for UWB applications is the primary goal of this effort. the CST microwave studio suite is being utilized The main emphasis will be on minimizing patch antenna size for UWB applications with resonance frequencies of at 5.962GHz, 7.643 GHz & 9.48 GHz. The attenuation of microstrip patch antennas in various UWB applications has increased during the preceding two decades. The study of microstrip antennas is a rapidly growing topic with potential uses in satellite communication and mobile electronics. In this paper, a rectangular patch antenna is examined, designed, and validated. A specific frequency band's reflection coefficient reduction is the primary goal of antenna design. It will be challenging to simultaneously arrive at the best option because the various signs would have collided. The design must also adhere to a challenging constraint on the far-field pattern in addition to the three goals of return loss minimization, cross polarization minimization, and mutual coupling between the ports.

CHAPTER 3

LITERATURE REVIEW

When Guglielmo Marconi transmitted the letter "S" in three-dot Morse code across a three-kilometer distance using electromagnetic waves in 1895, he created wireless communications. Starting with this, wireless communications has developed into a significant aspect of modern society. Wireless communications, from satellite transmission through radio and television broadcasting to the now-ubiquitous cell phone, have changed how civilizations function (Schiller, 2000). In 1901, Guglielmo Marconi travelled 1800 miles across the Atlantic Ocean, from Cornwall to St. Johan's, Newfoundland, to relay telegraphic signals. His invention allowed two people to communicate by sending and receiving alphanumeric characters encoded in analogue impulses via (Stalling, 2004). Wireless communications have seen their fastest growing era in history throughout the last century. An expanding set of IEEE standards called 802.16. The Federal Communications Commission (FCC) claims that Ultra-Wide Band (UWB) technology, which operates in the frequency range of 3.1-10.6 GHz, is a possible contender for high-speed communication applications for short distances. Patch antennas are being extensively researched in order to deploy UWB communication for portable and handheld devices. Microstrip line or CPW feeds have both been used to build UWB antennas. Wide bandwidth, cheap cost, and simple integration with radio frequency front end circuitry are all benefits of CPW supplied planar antennas. There are still several difficulties in designing antennas for UWB applications, including consistent gain, good omnidirectional radiation pattern, small size, and electromagnetic interference (EMI). EMI is a significant concern, no doubt. Other narrowband standards that coexist in the designated UWB band include WiMAX, which operates at 9.48 GHz, WLANs that operate at 5.962GHz, and satellite communication systems that operate at 7.643GHz. These standards could interfere with UWB systems. In order to reduce interference from these narrowband transmissions, UWB antenna designs with band-notched characteristics must be created. The most popular methods for achieving frequency notches in a UWB-printed antenna involve making modifications to the ground and radiator planes in the form of slots, stubs and slits.

The literature suggests numerous arrangements involving planar monopole antennas, which have a modified radiator characteristic. In printed antennas, these designs are frequently used to change the current route, which influences the input impedance of the antenna. By altering the current distribution on the radiator of a UWB antenna, the aforementioned various geometrical structures of differing sizes produced various notching effects. The ultra-wideband (UWB) antennas have extremely wide operating bands. Low signal distortion, adequate stability of the group delay, the antenna gain, and the angular behavior of the radiation patterns are all requirements in these bands for the antennas. In order to accomplish this, the UWB antennas and appropriate design solutions necessary to increase the antenna bandwidth are discussed in this section. Many of UWB's current applications can be seen as early iterations of the technology's position in the wireless industry because UWB technology is still relatively new. Pioneers in the UWB space include the automotive, smartphone, and smart home industries, which are laying the groundwork for its use in upcoming technologies. Automotive Well-known automakers already include UWB connectivity in their designs, including BMW. Physical or digital car keys that communicate with a vehicle based on proximity can incorporate the precise distance measurement provided by UWB. Without ever having to take the key or smartphone out of their pocket, a user can approach their car and unlock it with just a few steps. Additionally providing an additional layer of security, UWB uses radio signals. Resonators inspired by metamaterials (MTM) have recently been used to achieve notching in the UWB operating band. The evolution of consumer electronics necessitates that the antenna-on-demand have high channel capacity, gain, bandwidth, and compact size. Over the past ten years, numerous methods have been suggested to boost antenna performance. Metamaterials is one of these methods. The antenna design comprises a FR-4 substrate with a copper tape for the radiator patch and the ground plane. The proposed antenna showcases an optimum S11 value and radiation pattern under various bending conditions. The efficiency of the antenna in terms of return loss has been tested for planar and bending configurations.

CHAPTER 4

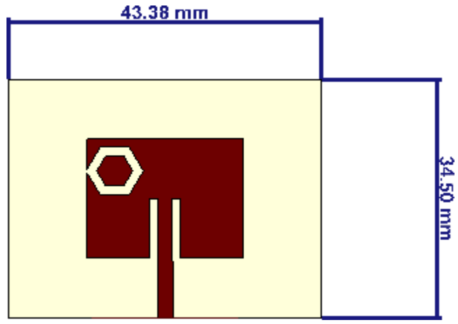
TOOLS USED

CST SOFTWARE

CST Studio Suite is used in leading technology and engineering companies around the world. A high performance 3D EM analysis software suite called CST Studio Suite is used to design, analyze, and optimize electromagnetic (EM) systems and components. Solvers for electromagnetic fields used in a variety of applications. In CST Studio Suite, the entire spectrum is housed behind a single user interface. The solvers can be connected to generate hybrid simulations, providing engineers the freedom to quickly and effectively assess entire systems made up of several components. EM simulation may be integrated into the design flow and drives the development process from the very beginning by co-designing with other SIMULIA products. It facilitates quicker product development cycles and lower development costs, providing significant product to market advantages. the number of physical prototypes required can be reduced, device performance may be maximized, potential compliance issues can be discovered and managed early in the design process, and decreased, and the likelihood of test failures and recalls was decreased For engineers, designers, and researchers working in a variety of domains, such as microwaves, RF & optical, EDA & electronics, electromagnetic compatibility (EMC), particle dynamics, statics, and low frequency, CST Studio Suite offers quick, accurate, and accessible electromagnetic modelling.

CHAPTER 5

ANTENNA DESIGN



5.1 Design of microstrip patch

The proposed antenna is designed by using CST studio suite software. For the better performance of the patch antenna, it requires impedance matching circuits. Input impedance of the patch antenna is associated with (w/l) ratio. A microstrip feed line of width 2.11mm has been used in order to achieve a characteristic impedance of 89.48Ω. The applied feeding technique is inset feeding. The planar antenna which is fed directly by the microstrip inset feed line and placed on the top section of the dielectric substrate and the bottom is directly connected to the ground. The proposed antenna having dimensions 17.25mm x 21.69mm x 1.6mm. The antenna has been designed on a dielectric substrate with a relative permittivity of 3.8 and a loss tangent of 0.02. Three distinct resonant frequency bands were indeed obtained by the designed antenna, which displays multiband behavior. The antenna's first band runs at a resonating frequency of 5.962 GHz with a return loss of -15.28 dB and its second band at a frequency of 7.643 GHz with a return loss of -27.78 dB. Because the suggested antenna resonates at 9.48 GHz in its third band with a return loss of roughly -32.49dB, it also complies with WiMAX specifications. The given dimensions of the antenna are calculated using following formulas.

A. Width of patch

$$W = \frac{c}{2 f_r \sqrt{\frac{\varepsilon_r + 1}{2}}}$$

B. Dielectric constant

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + \frac{12h}{W}}} \quad \text{F/m}$$

C. Effective length

$$L = \frac{c_0}{2 f_r \sqrt{\varepsilon_{re}}} \quad \text{mm}$$

Table:5.1 parameters of antenna

GROUND PLANE WIDTH(Wg)	43.38mm
GROUND PLANE LENGTH(Lg)	34.5mm
PATCH LENGTH(L)	17.25mm
PATCH WIDTH(W)	21.69mm

Table:5.2 substrate of antenna

Material	FR4
Dielectric constant	3.8
Loss Tangent	0.02
Substrate Thickness	1.6mm

Table:5.3 results of antenna design

FREQUENCY RANGE	RESONATING FREQUENCY	S11	VSWR
[5.86-6.07] GHz	5.96GHz	-15.28dB	1.41
[7.42-7.88] GHz	7.64GHz	-27.78dB	1.08
[9.31-9.65] GHz	9.48GHz	-32.49dB	1.05

CHAPTER 6

RESULTS & DISCUSSION

RETURN LOSS (S11)

The percentage of a signal that is reflected as a result of an impedance mismatch is known as the return loss. In the field of communications, return loss is the measurement of the relative power of the signal reflected by a break in an optical fiber or transmission line. This discontinuity could be caused by a mismatch between the termination or load connected to the line and the characteristic impedance of the line. most often expressed as a decibel (dB) ratio. Return loss should be smaller than -10dB in order to obtain the effective output. The designed antenna exhibits multiband behavior and produces three distinct resonant frequency bands. The antenna's first band resonates at 5.962GHz with a return loss of -15.28dB, while its second band operates at resonating frequency 7.643 GHz with a return loss of -27.78dB. The suggested antenna also supports WiMAX standards because it resonates at 9.48 GHz in its third band with a return loss of about -32.49dB. FR4 works as the substrate material for the proposed triple band antenna.

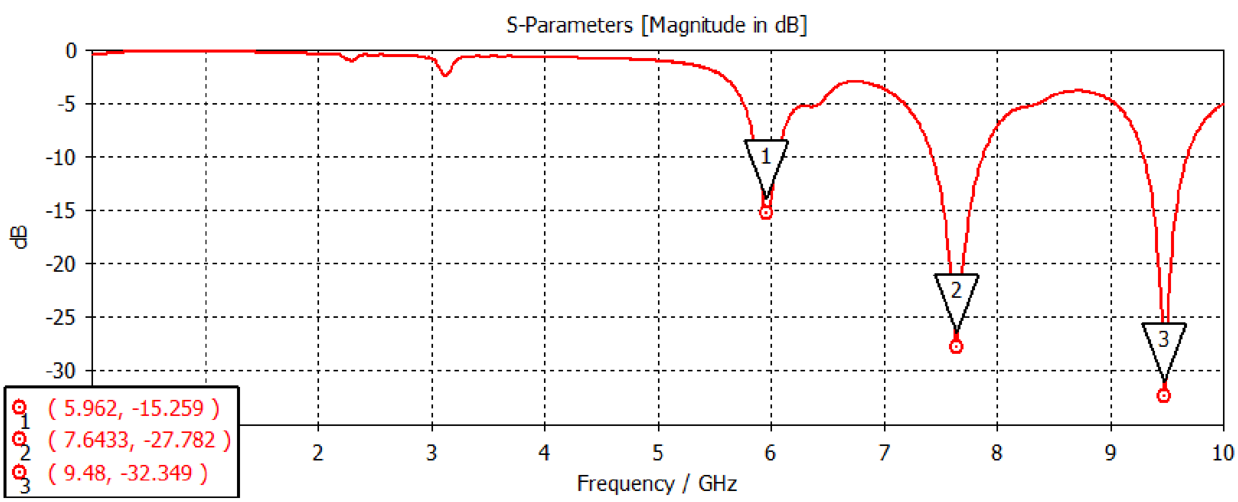


Fig:6.1 S11(Return Loss)

VOLTAGE STANDING WAVE RATIO (VSWR)

VSWR stands for Voltage Standing Wave Ratio. “The ratio of the maximum voltage to the minimum voltage in a standing wave is known as Voltage Standing Wave Ratio.” It is also called as SWR. The impedance of the radio and transmission line must be properly matched to the impedance of the antenna for a radio (transmitter or receiver) to supply power to an antenna. The impedance matching performance of the antenna with respect to the radio or transmission line it is linked to is quantified by the VSWR parameter. Voltage Standing Wave Ratio, commonly known as Standing Wave. The reflection coefficient, which specifies the power reflected from the antenna, is a function of VSWR. The higher the impedance mismatch, the higher will be the value of VSWR. Voltage standing wave ratio for three distinct frequencies 5.962GHz, 7.644GHz & 9.4861GHz were 1.41, 1.08 & 1.05 respectively.

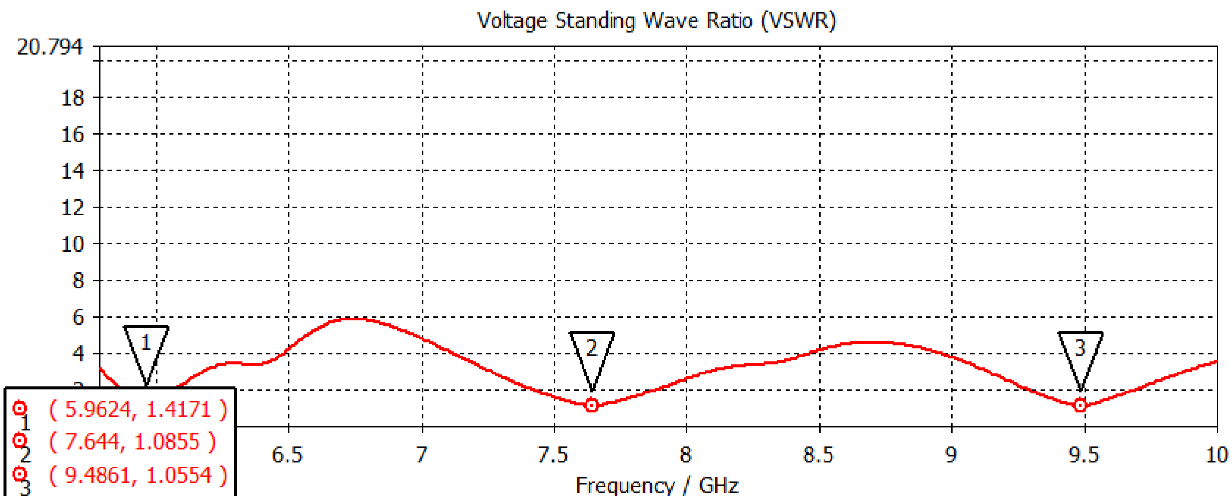


Fig: 6.2 VSWR

FARFIELD PATTERN

The field, which is far from the antenna, is called as far-field. It is also called as radiation field, as the radiation effect is high. The radiation intensity when measured nearer to the antenna, differs from what is away from the antenna. Though the area is away from the antenna, it is considered effective, as the radiation intensity is still high there. The field, which is nearer to the antenna, is called as near-field. It has an inductive effect and hence it is also known as inductive field, though it has some radiation components. The field, which is far from the antenna, is called as far-field. It is also called as radiation field, as the radiation effect is high in this area. Many of the antenna parameters along with the antenna directivity and the radiation pattern of the antenna are considered in this region only.

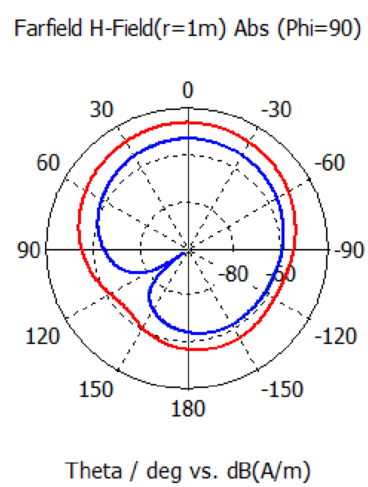


Fig 6.3: far fields

CHAPTER 7

CONCLUSION

Wireless technology for transmitting and receiving electromagnetic waves wirelessly Consider that effective antenna design has recently introduced a new dimension to research and development, and that scientific community has long considered it to be a desirable research topic. A new tri-band notched UWB patch antenna has been proposed and implemented. According to the results of the simulation, the antenna can operate over a frequency range of 3.5 GHz to 18.9 GHz with a |S11|< -10 or VSWR2 and three bands notched. To verify the effectiveness of the suggested antenna, simulation results and an explanation of the antenna design in detail are offered. With band-notched characteristic at WiMAX (9.48 GHz), WLAN (5.962GHz), and Satellite connection (7.64 GHz) have been successfully designed and simulated. The antenna has a simple fabricated structure and merely uses hexagonal slot and a inset feed to generate three stop bands. Simulated results demonstrate that the stop bands can be adjusted flexibly and independently. This antenna provides low VSWR in the frequency band from 3.5 to 18GHz with triple band-notching effect at the frequency bands [5.86-6.07], [7.42-7.88] and [9.31-9.65]. The stable gain variation behavior for our proposed antenna with and without band-notched characteristic has been examined. Based on other works, the proposed antenna combines both tri-band notched antenna and compact size.

FUTURE SCOPE

The performance of the antenna is also impacted by the placement of the feed line termination. In the future, array antennas and other input methods might make it possible to boost the gain. Because of the significant growth in demand for wireless communication and information transmission via smartphones and personal communications (PCS) devices, antenna design advancements are now crucial parts of any wireless system. One form of antenna that can meet the bulk of the requirements of wireless systems is the microstrip antenna. These antennas are widely used by portable devices as well as base stations. Microstrip antennas, which are available in a variety of sizes, are currently the subject of the most active antenna research and development. Input technology, impedance, and substrate should be taken into account as critical characteristics.

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