A

PROJECT REPORT

ON

"DESIGN AND ANALYSIS OF MICROSTRIP PATCH ANTENNA AT ISM BAND"

Submitted in partial fulfillment ofthe requirements

for the degree of

BACHELOR OF TECHNOLOGY

In

Electronics & Communication Engineering

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June 2021

DECLARATION

We hereby declare that this submission is our own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree of the university or other institute of higher learning, except where due acknowledgement has been in the text.

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CERTIFICATE

This is to certify that the project entitled "**Design and Analysis of Microstrip Patch Antenna at ISM Band"** submitted by **Ananya Shreesh , Kishore Kumar Jha , Shivam Dubey ,** and, **Shivam Kumar (1713331112)** in the partial fulfillment of the requirements for award of Bachelor of Technology in Electronics and Communication Engineering from Dr. A.P.J. Abdul Kalam Technical University, U.P., Lucknow under my supervision. The project embodies result of original work and studies carried out by the student's their self and the contents of the project do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

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ABSTRACT

The research work design, simulation, development and measurement done on the rectangular microstrip patch antenna for the ISM Band of frequencies is presentedin this paper. This rectangular patch antenna is fed by a microstrip line feed. Its resonance frequency performance is studied between 2.4-2.5 GHz.

This band of frequencies is ISM band of wireless applications .The ISM band are also frequency bands which are designated radio frequency bands defined by Telecom Regulatory Authority of India (TRAI).In simple terms it is a part of radio spectrum that can be used for any purpose at the range of 2.4 GHz to 2.4834 GHz.

The common Use of this band is for low and short range communication. The design and simulation are done on Computer Simulation Technology (CST) software with FR4 substrate.According to its application, the material, shape, and the type, the microstrip antenna is designed.

Patch antenna can be design in any shape generally takes a size as small as possible.This antenna is compact antenna.The small size patch antennas are needed because of modern telecommunication equipment whose size and weight is reduced. The size of the Antenna is calculated by the length, width expressions.Then the antenna is stimulated for the radiation parameters obtained through optimizing and matching to meet the requirements.

The parameters of antenna such as Reflection coefficient, Gain, VSWR and Band width are measured using network analyzer with simulated results.

ACKNOWLEDGEMENT

In the absence of mother, the birth of a child is not possible and in the absence of teacher the right path of knowledge is impossible. This project is by far the most significant accomplishment in our life and it would be impossible without people who supported us and believed us.

We would like to extend my gratitude and my sincere thanks to my honorable, esteemed guide **Mr. Anshu Kumar** (Assistant Professor (ECE)), Department of Electronics and Communication Engineering, NIET, Greater Noida for their immeasurable guidance and valuable time that he devoted for project. We sincerely thank for their exemplary guidance and encouragement. His trust and support inspired me in the most important moments of making right decisions and we are glad to work with him/her.

We would also like to give very special thanks to our HOD Sir **Dr. V.K.Pandey (Professor)**. Also, we would also like to give thanks to our project coordinator and my teachers for their support, help and encouragement during this work.

We would like to thank all my friends for all the thoughtful and mind stimulating discussions we had, which prompted us to think beyond the obvious.

We have enjoyed their companionship so much during my stay at NIET, Greater Noida. We would like to thank all those who made my stay in NIET, Greater Noida an unforgettable and rewarding experience.

A boat held to its moorings will see the floods pass by; but detached of its moorings, may not survive the flood. The support of all the members of our family (specially our parents, our sisters and brothers) motivated us to work even while facing the blues. We dedicate this work to them.

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ABBREVIATIONS

Abbreviations	Full Form	Page No.
UWB	Ultra Wideband	15
MMR	Multiple mode resonator	15
VSWR	Voltage standing wave ratio	16
UHF	Ultra high frequency	18
CST	Circuit simulation technology	23

LIST OF SYMBOLS

G	Gain
E	Efficiency
D	Directivity
λ	Wavelength in free space
R	Distance from antenna
F_H	Upper frequency
F_L	Lower frequency
F_C	Centre Frequency or Resonant Frequency
m and n	Modes
ε_{reff}	Effective dielectric constant
ε_r	Relative Permittivity or dielectric constant of substrate
μ_r	Relative Permeability
Γ	Reflection coefficient
W	Width of patch
L	Length of patch
h	Thickness or height of substrate

CHAPTER-1

Introduction

Communication between humans was first by sound through voice. With the desire for slightly more distance communication came, devices such as drums, then, visual methods such as signal flags and smoke signals were used. These optical communication devices, of course, utilized the light portion of the electromagnetic spectrum. It has been only very recent in human history that the electromagnetic spectrum, outside the visible region, has been employed for communication, through the use of radio. One of humankind's greatest natural resources is the electromagnetic spectrum and the antenna has been instrumental in harnessing this resource.

1.1 Antenna

Antenna is one of the critical components in any wireless communication system. The word 'antenna' is derived from Latin word '**antenna**.' Since the first demonstration of wireless technology by Heinrich Hertz and its first application in practical radio communication by Guglielmo Marconi, the antenna has been a key building block in the construction of every wireless communication system. IEEE defines an antenna as "a part of a transmitting or receiving system that is designed to radiate or receive electromagnetic waves[1].

Antenna is a device which transforms the Radio frequency signal in either transmitting or receiving mode of operation. The antennas are frequency dependent device and every antenna is designed for certain frequency band .Antenna is an important part of any wireless communication system as it converts the electrical signals into Electromagnetic waves efficiently with minimum loss.

In a typical wireless communication system increasing the gain of antennas used for transmission increases the wireless coverage range, decreases errors, increases achievable bit rates and decreases the battery consumption of wireless communication devices. One of the main factors in increasing this gain is matching the polarization of the transmitting and receiving antenna. To achieve this polarization matching the transmitter and the receiver should have the same axial ratio, spatial orientation and the same sense of polarization.

In mobile and portable wireless application where wireless devices frequently change their location and orientation it is nearly impossible to constantly match the spatial orientation of the devices .Circularly polarized antennas could be matched in wide range of orientations because the radiated waves oscillate in a circle that is perpendicular to the direction of propagation.

Microstrip patch antenna used to send onboard parameters of article to the ground while under operating conditions. The aim of the thesis is to design and fabricate Microstrip Patch Antenna and study the effect of antenna dimensions Length (L), and substrate parameters relative Dielectric constant (ε_r), substrate thickness (t) on the Radiation parameters of Bandwidth and Beam-width [2].

A microstrip antenna consists of conducting patch on a ground plane separated by dielectric substrate. Microstrip patch antenna is a sandwich of two parallel conducting layers. This concept was undeveloped until the revolution in electronic circuit miniaturization and large-scale integration in 1970. After that many authors have described the radiation from the ground plane by a dielectric substrate for different configurations.

Flush mounted antennas on rockets and missiles showed that this was a practical concept for use in many antenna system problems. Various mathematical models were developed for this antenna and its applications were extended to many other fields. The number of papers, articles published in the journals for the last ten years, on these antennas shows the importance gained by them [3]. The micro strip antennas are the present day antenna designer's choice. Low dielectric constant substrates are generally preferred for maximum radiation. The conducting patch can take any shape but rectangular and circular configurations are the most commonly used configuration. Other configurations are complex to analyze and require heavy numerical computations. A microstrip antenna is characterized by its Length, Width, Input impedance, and Gain and radiation patterns. Various parameters of the microstrip antenna and its design considerations were discussed in the subsequent chapters. The length of the antenna is nearly half wavelength in the dielectric; it is a very critical parameter, which governs the resonant frequency of the antenna. There are no hard and fast rules to find the width of the patch. The microstrip antenna is one of the most commonly used antennas in applications that require circular polarization. A Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane another side.

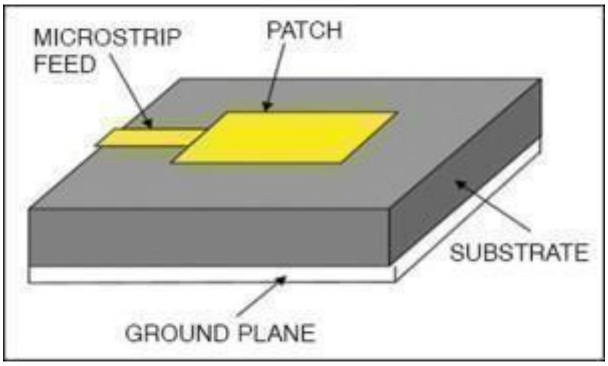

Fig. 1.1: Physical geometry of microstrip antenna

1.2 Classification of Antenna

Antennae could be broadly classified as wire antennae, aperture antennae, printed antennae, array antennae, reflector antennae and lens antennae.

Wire Antenna

This is the basic type of an antenna, widely used on top of the buildings, automobiles, ships and spacecrafts. These antennae are made into different shapes such as a straight wire (dipole), loop and helix.

Apperture Antenna

These antenna are in the form of a slot or aperture in a metal plate and commonly used at higher frequencies (3-30 GHz). Typical examples are slotted waveguide antenna and horn antenna.

These antennae are very useful for aircraft and spacecraft applications, because they can be conveniently flush mounted on the surface of the aircraft or spacecraft.

In practice, these antennae are covered with a dielectric material to protect them from hazardous environmental conditions[4].

Printed Antenna

By definition, a printed antenna is one that is fabricated using standard photolithography technique. The most common version of printed antenna is microstrip antenna, which consists of a metallic patch above a ground plane. The shape and size of patch determine the frequency of operation of the antenna and its performance.

These antennae are more popular because of their low cost and ease of fabrication, and easy integration with circuit components. Printed antennae are inexpensive to fabricate using modern printed circuit technology, and are conformal to planar and non-planar surfaces. These antennae can be easily mounted on the surface of aircrafts, spacecrafts, satellites, missiles and even on handheld mobile devices[4].

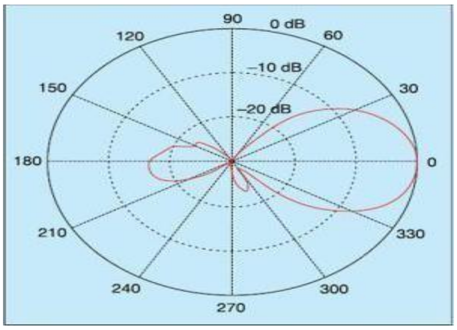

Fig. 1.2: Typical Radiation Pattern of Microstrip antenna

Array Antenna

In an array antenna, several radiators separated from each other are geometrically arranged to give desired radiation characteristics that are not possible to achieve with a single independent radiating element.The arrangement of array elements is such that radiation from individual elements adds up to give the maximum radiation in a particular direction or directions, and minimum radiation in other directions. In practice, individual radiators are arranged in linear or planar grid depending on the application.

Reflector Antenna

These antennae are specifically used in applications requiring communication over long distances, such as outer space exploration and satellite communication. They are built with large diameters in order to achieve the high gain required to transmit or receive signals over very long distances. The reflector antenna usually uses a smaller antenna as the feed[5].

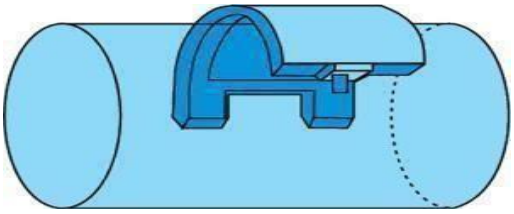

Fig.1.3: Flexible microstrip applicator for hyperthermia medicinal applications

Lens Antenna

In these antennae, lenses are used to collimate the incident divergent energy to prevent it from spreading in undesired directions. By choosing the appropriate material and setting the geometrical configuration of lenses, they can transform various forms of divergent energy into plane waves. Lens antennae are classified according to the material from which they are constructed or their geometrical shapes.

Microstrip Antenna: The most common printed antenna

Microstrip antennas are one of the most popular types of printed antenna. These play a very significant role in today's wireless communication systems. Micro strip patch antennas have found extensive application in wireless communication system owing to their advantages such as:

• Conformability,

• Low-cost fabrication

• Ease of integration with feed-networks.

• Light in weight, small in size.

• Low profile planar configuration.

• Low fabrication cost.

• Can be easily mounted onto missiles, rockets andsatellites.

Micro strip patch antennas also suffer from drawbacks as compared to conventional antennas. Some of their major disadvantages are-:

• Narrow bandwidth

• Low efficiency

• Low Gain

• Extraneous radiation from feeds andjunctions

• Poor end fire radiator except tapered slot antenna

• Low power handling capacity.

• Surface wave excitation

Microstrip antennae are very simple in construction using a conventional fabrication technique side of a dielectric substrate (FR4) that has a ground plane (Cu) on the other [6].

The patch is generally made up of a conducting material such as copper or gold and take any possible shape like rectangular, circular, triangular, elliptical or some other common shape. The radiating patch and the feed lines are usually photo-etched on the dielectric substrate

Microstrip patch antennae radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant (<6) is desirable since it provides higher efficiency, larger bandwidth and better radiation. However, such a configuration leads to a larger antenna size.

In order to design a compact microstrip patch antenna, a substrate with a higher dielectric constant (<12) must be used, which results in lower efficiency and narrower bandwidth. Hence a compromise must be reached between antenna dimensions and antenna performance. Excitation guides the electromagnetic energy source to the patch, generating negative charges around the feed point and positive charges on the other part of the patch. This difference in charges creates electric fields in the antenna that are responsible for radiations from the patch antenna[6].

Three types of electromagnetic waves are radiated. The first part is radiated into space, which is 'useful' radiation. The second part is diffracted waves, which are reflected back into space between the patch and the ground plane, contributing to the actual power transmission. The last part of the wave remains trapped in the dielectric substrate due to total reflection at the air-dielectric separation surface. The waves trapped in the substrate are generally undesirable.

Different types of antennae have many different shapes and dimensions. Few samples shapes of Microstrip patch antennas used in wireless communication system are as shown in Figure 1.4

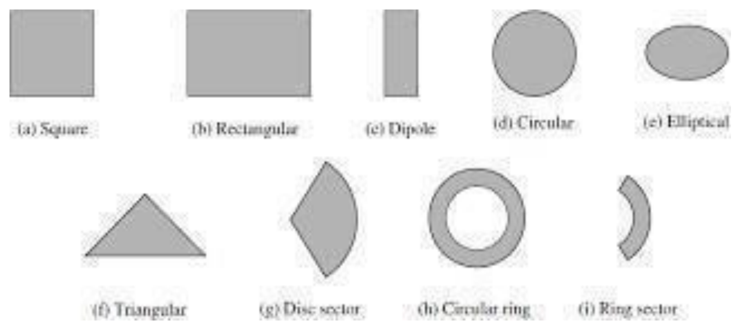

Figure1.4: Typical shapes of Microstrip patch antennas

Microstrip antennae can be classified into four subtypes: microstrip patch antenna microstrip dipoles, printed slot antennae and microstrip travelling-wave antennae.

1.3 Feeding techniques of Antenna

Microstrip patch antennas can be powered by a variety of techniques by two main types of contacting type and non- contacting type. The RF current is given to the radiating patch by connecting a microstrip line and probe in contacting type. The common feeding techniques utilized are the coaxial probe, microstrip line, through aperture coupling and by proximity coupling.

Microstrip Line Feeding: In this technique, a conducting microstrip line is attached directly to the center edge of the microstrip patch[7]. The feeding strip thickness is less than width dimension. This feeding gives a planar structure.

Aperture Coupled Feeding: In this type of non-contact, the feed is given as microstrip line to patch through aperture made centered on ground plane. Coupling is done on waves[7]. The coupling amount depends on the shape, size and location of the aperture. This method increases the antenna thickness and also provides shortbandwidth.

Coaxial Feeding: The microstrip antennas are energized by Coaxial probe feed technique normally. In this, the inner conductor of the coaxial probe is connected to the radiating patch, while the outer conductor is soldered to the ground plane[7].

The design of a rectangular microstrip patch antenna has the following parameters:

(i) Operating Frequency (fo): The antennas operating frequency is taken considerably. The Mobile CommunicationSystems uses the frequency range from 1800-5600 MHz. Hence these antennas resonant frequency is selected as 2.4 GHz for this design.

(ii) Substrate Dielectric constant (εr): The dielectric material selected for this design is FR4 of dielectric constantof 4.6. This one is easily available low-cost lossy substrate.

Dielectric substrate thickness or height (h): For the microstrip patch antenna to be used in cellular phones, it should not be bulky[1]. Hence, the essential parameters are taken for the design: fo= 2.4 GHz, εr = 4.6, h = 1.6mm.

Step 1: Patch width Calculation (W): It is expressed by the as:

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon r+1)}{2}}}$$

By Substituting c = 3x10^8 m/s, εr = 4.6 and fo = 2.46GHz, width is got as W = 36.5

mm Step 2: Effective dielectric constant Calculation (εreff): Itgives the value as:

$$\varepsilon_r = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_{r-1}}{2} + [1 + 12\frac{h}{W}]^{\frac{1}{2}}$$

By Substituting εr = 4.6, width as 36.5 mm and thickness as1.6 mm it is got as

εreff=6.12 Step 3: Calculation of the Effective length (Leff):gives the effective length as

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}}$$

By Substituting εreff = 6.12, c = 3x10^8 m/s and fo = 2.46GHz it is got as Leff = 24.64

mm Step 4: Length extension Calculation (ΔL): gives the length extension as:

$$\Delta L = 0.412h\,\frac{(\varepsilon_{reff+0.3})\frac{W}{H}+0.264}{(\varepsilon_{reff-0.258})\frac{W}{H}+0.8}$$

By Substituting εreff = 6.12, W = 36.5 mm and H = 1.6mm it is got as ΔL=1.09mm

Step 5: Actual length of patch Calculation (L): The lengthis obtained by re-writing by Substituting Leff =24.64 mm and ΔL =1.09 mm it is calculated as

L =23.55 mm

Step 6: The ground plane dimensions Calculation (Lg and Wg): Infinite ground is assumed in the method of transmission line model. However, for practical purpose, it is essential to have a finite ground plane. It has been obtained by approximately six times the substrate thickness in addition to length [2]. It is shown below in the following expression.

Lg=L+6*h =23.55+6*1.6=33.15mm

Wg=W+6*h =36.5+6*1.6=46.1mm

Step 7: Determination of feed points. The feed point location is denoted as (Xf ,Yf). That must be located on the patch, where the 50 ohms input impedance is achieved. According to the existing point along the length of the patch where the return loss is minimum. Hence in this design, Yf will be zero and only Xf will be varied to locate the optimum feed point.

Step 8: Microstrip line calculation

$$Z_o = \frac{87.0}{\sqrt{\varepsilon_r + 1.41}} \times \ln\left(\frac{5.98h}{0.8W + t}\right)$$

It is calculated that W=2.95 mm and L 5.22 mm for Z0=50 ohm, Electrical length =28.1mm Dimensions for designed Antenna is calculated and Patchantenna dimensions are presented after the calculations in tabular form.

The layout overview of patch antenna is following below. Designing the antenna with appropriate dimensions, Simulate the antenna, Analyse the design in layout view, Evaluate the performance measure of frequency, return loss, power, gain, Fabrication, Measuring[8]. In order to have the desired resonance at more than one frequency generally we can go for multi band techniques.

TABLE 1. Dimensions of Antenna

Plane	Dimension	Measurement values(mm)
Radiating patch	W	36.50
Length	L	23.55
Ground plane	Wg	46.10
Length	Lg	33.15

1.4 Motivation

The extensive demand for mobile communication and information exchange through wireless devices has led to major achievements in antenna designing. In the era of this wireless communication, antenna makes it easy for communication at wider range of frequencies that present few physical challenges like bandwidth and radiation efficiency etc[9]. The aim of using micro strip antenna is to overcome the de-merits such as easy to design, light weight etc.

Micro strip antennas are rapidly developing for the past few decades due to their small size, low cost, low weight, and they are easily fabricated on the substrate. Since basic microstrip antenna shapes produce linear polarization there must be some deviation in the patch design to produce circular polarization.

Antennas produce circularly polarized waves when two orthogonal field components with equal amplitude but in phase quadrature are radiated. Various antennas are capable of satisfying these requirements. They can be classified as a resonator and traveling-wave types. A resonator-type antenna consists of a single patch antenna that is capable of simultaneously supporting two orthogonal modes in phase quadrature or an array of linearly polarized resonating patches with proper orientation and phasing. A traveling-wave type of antenna is usually constructed from a microstrip transmission line. It generates circular polarization by radiating orthogonal components with appropriate phasing along discontinuities is the travelling-wave line[10].

Our task is to design and analysis of Microstrip Patch Antenna because they are able to reduce the loss caused by the polarization misalignment between the transmitting antennas and the receiving antennas

1.5 Objectives

The objective of this project is to design and analysis of Microstrip patch antenna.To calculate return loss **S11, VSWR, Gain** and **Axial ratio** of the proposed antenna.

1.6 Structure of Report

The chapters provides a complete review of the methods for Design and Analysis of Microstrip Patch antenna. The content of this report is divided into five chapters.

Chapter-1 is devoted to the background of meta materials, development of meta material antennas for wireless communication. The objective and motivation are also included in this chapter.

Chapter-2 of this report gives a detailed literature review on the various reference papers included for the study and design of the microstrip antenna.

Chapter-3 tells the fundamentals of the project work. The radiation properties, bandwidth, efficiency and gain at different modes are analyzed. The simulated results are validated through experimental verification. The reference research paper supported by the structure is also discussed and implemented.

Chapter-4 The bandwidth, gain, radiation pattern and efficiency of the antenna structure are investigated Methodologies adopted in these designs are introduced. The simulated results are validated through experimental verification.

Chapter-5 Optimization process is carried out through CST software to achieve optimum antenna design with enhanced bandwidth and gain Summary and suggested.

CHAPTER 2

Literature Survey

2.1 Introduction

By surveying it is planned to design and implement rectangular microstrip patch antenna resonating at ISM band of 2.4 GHz frequency. This chapter extensively details the state of the art research on implantable antennas and ways to improve their performance.

Nowadays, with the development of the healthcare life, more and more importance have been attached to the study of medical implantable devices. Painless, real-time, high efficiency has become basic performance of those devices that researchers pursue. Implantable medical devices can transmit in-body physical information to outer receivers wirelessly, and they have been employed in several biomedical telemetries, such as glucose monitoring, neural recording[11-12,13] , RFID-inspired brain caring . For implants, numerous characteristics such as impedance bandwidth, miniaturization, polarization matching, radiated safety and radiation efficiency are worthy of noting.

2.2 Titles

- A new H-Slot coupled microstrip filter antenna for wireless communication system, Zhouyun Chen, Xiwang Dai, Guoqing Luo 2019 Key Laboratory of RF Circuits & system of ministry of education , Sotheast University Nanjing,310018 China.

- Zhoyun Chen, Xiwang Dai, Guoqing Luo, 2019 In this paper the H-Shaped coupling slots feed to radiating patches, which can realize the radiation function of antenna.This antenna has bandwidth of 0.78GHz.

- Parthrajsi K Jhala et al Int. Journal of Engineering Reasearch and Application,2015 , In this paper many types of portable electronics devices namely cellular phones, GPS receivers, Parthrajsinh K Jhala et al Int. Journal of Engineering Research and Application ISSN : 2248-9622, Vol. 5, January 2015.

- Prakash Bhartia , j. Bahl , P.Bhartiya, 2018 [18] In this paper describes the design of a multilayer , dua linearly polarized microstrip patch array antenna with resonant frequencies at 28.9 and 29.4 GHz respectively.

- Pramod Dhande ,2017, [19] In this paper performance characteristic, testing application of antennas in modern Wireless communication system. Measurement techniques. Antennas and its Applications", DRDO Science Spectrum, March 2009, pp 66-78.

- Achmad Munir†, BungaDwiWulandari, WisnuAditomo, Yogi Prasetio, 2017 In this paper the development of DGS-based UWB micro strip band pass filter and its analysis through equivalent circuit have been demonstrated.[20].

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- L. Zhu, H. Bu and K. Wu,2002,In this paper, a micro strip stub-loaded dual-mode resonator is used which exhibit very wideband but slow attenuations in the stop band.[21]

- WenjieFeng, WenquanChe and Quen Xue,2010,In this paper, a stepped Impedance resonator and a T-shaped line resonator are used which can created a bandwidth of 108% and three transmission zeros but bad rejection levels in the lower stop bands.[22]

- Tan Lin, Jin Long, Yang Guo-qing, 2011, In this paper, a broadband micro strip band pass filter with triple-mode resonators is investigated. The resonator consists of half-wave line and a T-shaped stub.

- Zhewang Ma, Wenqing He, Chun-Ping Chen, Yoshio Kobayashi,and Tetsuo Anada, 2008,A novel compact UWB band pass filter studied in this paper, developed by using micro strip stub-loaded dual-mode resonator doublets.[23

CHAPTER-3

FUNDAMENTALS OF ANTENNA

3.1 Basics of Antenna

In order to make a circular polarized patch antenna various reference papers were studied by different researchers and the base paper, which is “ C band has frequency range from 6 to 8 GHz that is used for satellite communication ,Radar and wireless computer networks. For circular polarization, the axial ratio (AR) less than 3 dB can be produced by cutting slots and fractal technique.For antenna $S_{11} < -10$ dB, VSWR <2 and contain maximum gain.

3.1.1 Axial Ratio

Axial ratio, for any structure or shape with two or more axes, is the ratio of the length (or magnitude) of those axes to each other - the longer axis divided by the shorter. In chemistry or materials science, the axial ratio is used to describe rigid rod-like molecules. It is defined as the length of the rod divided by the rod diameter.In physics, the axial ratio describes electromagnetic radiation with elliptical, or circular, polarization The axial ratio is the ratio of the magnitudes of the major and minor axis defined by the electric field vector[14].

3.1.2 VSWR

In radio engineering and telecommunications, **standing wave ratio** (**SWR**) is a measure of impedance matching of loads to the characteristic impedance of a transmission line or waveguide. Impedance mismatches result in standing waves along the transmission line, and SWR is defined as the ratio of the partial standing wave's amplitude at an antinode (maximum) to the amplitude at a node (minimum) along the line.

The SWR is usually thought of in terms of the maximum and minimum AC voltages along the transmission line, thus called the **voltage standing wave ratio** or **VSWR** (sometimes pronounced "vizwar"). For example, the VSWR value 1.2:1 denotes an AC voltage due to standing waves along the transmission line reaching a peak value 1.2 times that of the- minimum AC voltage along that line. The SWR can as well be defined as the ratio of the maximum amplitude to minimum amplitude of the transmission line's currents, electric field strength, or the magnetic field strength[15-16]. Neglecting transmission line loss, these ratios are identical

3.1.3 Return Loss (S_{11})

In telecommunications, return loss is the loss of power in the signal returned/reflected by a discontinuity in a transmission line or optical fiber. This discontinuity can be a mismatch with the terminating load or with a device inserted in the line. It is usually expressed as a ratio in decibels (dB).

3.1.4 Gain

In electromagnetics, an antenna's **power gain** or simply **gain** is a key performance number which combines the antenna's directivity and electrical efficiency. In a transmitting antenna, the gain describes how well the antenna converts input power into radio waves headed in a specified direction. In a receiving antenna, the gain describes how well the antenna converts radio waves arriving from a specified direction into electrical power. When no direction is specified, "gain" is understood to refer to the peak value of the gain, the gain in the direction of the antenna's main lobe. A plot of the gain as a function of direction is called the gain pattern or radiation pattern[17].

Antenna gain is usually defined as the ratio of the power produced by the antenna from a far-field source on the antenna's beam axis to the power produced by a hypothetical lossless isotropic antenna which is equally sensitive to signals from all directions. Usually this ratio is expressed in decibels, and these units are referred to as "decibels-isotropic" (dBi). An alternative definition compares the received power to the power received by a lossless half-wave dipole antenna, in which case the units are written as *dBd*. Since a lossless dipole antenna has a gain of 2.15 dBi, the relation between the su nits is For a given frequency, the antenna's effective area is proportional to the power gain. An antenna's effective length is proportional to the square root of the antenna's gain for a particular frequency and radiation resistance[18]. Due to reciprocity, the gain of any reciprocal antenna when receiving is equal to its gain when transmitting.

Directive gain or directivity is a different measure which does not take an antenna's electrical efficiency into account. This term is sometimes more relevant in the case of a receiving antenna where one is concerned mainly with the ability of an antenna to receive signals from one direction while rejecting interfering signals coming from a different direction.

3.2 Microwave Region

Microwav spectral region is a form of electromagnetic radiation with wavelength ranging from as long as one meter to as short as one millimeter, or 0.3 GHz and 300 GHz frequencies. This definition includes both UHF and EHF bands.

Table 2: Various bands of microwave region

Sr. No	Name of band in microwave	Frequency Range	Application
1	High Frequency(HF)	3 - 30 MHz	Shortwave broadcast, RFID, Marine & mobile Communications
2	Very High Frequency (VHF)	30 - 300 MHz	FM, Television broadcasts and Line of sight communications, Mobile communications

3	Ultra High Frequency (UHF)	300 -3000 MHz	Television broadcasts, Microwave oven, Microwave-Device, Wireless LAN, Bluetooth, GPS
4	Long wave (L)	1 – 2 GHz	Military telemetry, GPS, Mobile phone (GSM)
5	Short wave(S)	2 – 4 GHz	Weather radar, Surface ship radar, Some satellite communication, WLAN
6	C-Band	4 – 8 GHz	Long distance communication
7	X -Band	8 – 12 GHz	Satellite communication, Terrestrial broadcast radar, Space communication, Amateur radio
8	Ku-Band	12 – 18 GHz	Satellite communication
9	K-Band	18 - 27 GHz	Astronomical observation, Automotive radar, Satellite communication, Radar
10	Ka-Band	27 – 40 GHz	Satellite communication

11	V-Band	40 – 75 GHz	Millimeter wave radar research and other kinds of Scientific research
12	W-Band	75-110 GHz	Millimeter wave radar research, Military radar targeting and tracking applications, Satellite
13	Millimeter-Band	110 -300 GHz	Millimeter scanner, DBS, Direct-energy weapon, Satellite television broadcasting, Amateur radio

3.3 Directivity

In electromagnetics, **directivity** is a parameter of an antenna or optical system which measures the degree to which the radiation emitted is concentrated in a single direction. It measures the power density the antenna radiates in the direction of its strongest emission, versus the power density radiated by an ideal isotropic radiator(which emits uniformly in all directions) radiating the same total power[19-20].

An antenna's directivity is a component of its gain the other component is its (electrical) efficiency. Directivity is an important measure because many antennas and optical systems are designed to radiate electromagnetic waves in a single direction or over a narrow angle. Directivity is also defined for an antenna receiving electromagnetic waves, and its directivity when receiving is equal to its directivity whentransmitting.

The directivity of an actual antenna can vary from 1.76 dB for a short dipole, to as much as 50 dB for a large dish antenna[20-21].

3.4 Radiation Resistance

Radiation resistance is that part of an antenna's feedpoint resistance that is caused by the radiation of electromagnetic waves from the antenna, as opposed to *loss resistance* (also called *Ohmic resistance*) which generally causes the antenna and its surroundings to heat up.

The energy depleted by loss resistance is converted to heat radiation; the energy lost by radiation resistance is converted to radio waves. When the feed point is at a voltage minimum, the total of radiation resistance and loss resistance is the electrical resistance of the antenna[22]. The ratio of the radiation resistance to the total resistance is the antenna efficiency.

The radiation resistance is determined by the geometry of the antenna, whereas the loss resistance is primarily determined by the materials of which it is made and its distance from and alignment with other conductors nearby, and what they are made of Both radiation and loss resistance depend on the distribution of current in the antenna. .

3.5 Antenna Temperature

Antenna Temperature (T_A) is a parameter that describes how much noise an antenna produces in a given environment. This temperature is not the physical temperature of the antenna. Moreover, an antenna does not have an intrinsic "antenna temperature" associated with it; rather the temperature depends on its gain pattern and the thermal environment that it is placed in. Antenna temperature is also sometimes referred to as **Antenna Noise Temperature**.

To define the environment (and hence give the full definition of antenna temperature), we will introduce a temperature distribution - this is the temperature in every direction away from the antenna in spherical coordinates[23-24]. For instance, the night sky is roughly 4 Kelvin; the value of the temperature pattern in the direction of the Earth's ground is the physical temperature of the Earth's ground. This temperature distribution will be written as T. Hence, an antenna's temperature will vary depending on whether it is directional and pointed into space or staring into the sun.

For an antenna with a radiation pattern given by R,the noise temperature is mathematically defined as:

$$T_A = \frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi} R(\theta,\phi)T(\theta,\phi)\sin\theta d\theta d\phi$$

This states that the temperature surrounding the antenna is integrated over the entire sphere, and weighted by the antenna's radiation pattern.[25-26] The noise power received from an

$$P_{TA} = KT_A B$$

antenna at temperature T_A can be expressed in terms of the bandwidth (*B*) the antenna (and its receiver) are operating over: In the above, *K* is Boltzmann's constant (1.38 * 10^-23 [Joules/Kelvin = J/K]).

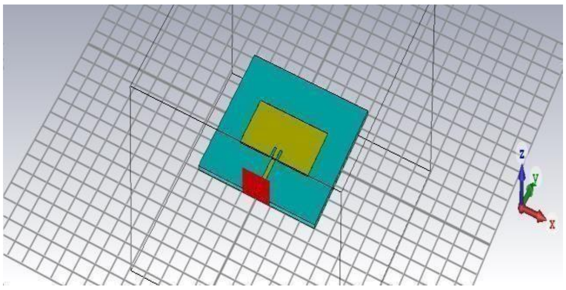
These concepts begin to illustrate how antenna engineers must understand receivers and the associated electronics, because the resulting systems very much depend on each other. A parameter often encountered in specification sheets for antennas that operate in certain environments is the ratio of gain of the antenna divided by the antenna temperature (or system temperature if a receiver is specified). This parameter is written as G/T, and has units of dB/Kelvin [dB/K].[28-29]

Finally, note that many RF engineers like to use the term Noise Figure (or Noise Factor, NF) to describe systems. This is the ratio of the input SNR (signal to noise ratio) to the output SNR. Basically, all RF devices (like mixers and amplifiers) add some noise. Antenna temperature doesn't really relate to a Noise Figure, as the signal level power input varies greatly with the desired signal's direction of arrival, while the noise added is a constant.

3.6 Methodology

We're using a software named CST (circuit simulation technology). CST is a 3D electromagnetic (EM) simulation software for designing and simulating high-frequency electronic products such as antennas, antenna arrays, RF or microwave components, high-speed interconnects, filters, connectors, IC packages and printed circuit boards.

By the use of CST, we're going to design and analysis of Micro-strip Patch Antenna and will study the various parameters of antenna like Gain, VSWR ,axial ratio return loss, etc.



3.7 Design Procedure

The essential design flow in this study is given in flow chart

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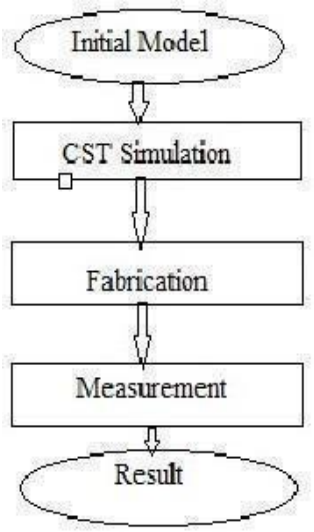


A Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane another side.

Substrate is the dielectric layer between the patch and the ground, generally preferred FR4 having height 1.6 and loss tangent 0.006.

Patch and ground is made up of copper materials. In our design we consider circular patch.

The most four popular feeding techniques for microstrip patch antenna are:

(coaxial feeding, microstrip feeding, proximity feeding and aperture feeding).[30]

For achieve circular polarization and to reduce the size, cutting slots and fractal techniques is preferred.

The software used for this design is CST (Computer Simulation Technology). It works on the principle of FDTD technique(Finite Difference Time Domain).

3.8 Technical Description (Block Diagram Explanation)

Ground: It is the metallic part found on the other side of the substrate. There are some perturbations that can be done to the ground to enhance the antenna performance towards certain specifications, like inserting shapes or slots in the ground plane.

Substrate: It is the dielectric layer between the patch and the ground. There are a lot of substrate material and specifications to choose from according to the antenna requirement. The most two factors specifying dielectric substrate is substrate height ($0.003\ \lambda \leq h >= 0.05\ \lambda$) and dielectric constant ($2.2 \leq \mathcal{E} r \leq 12$) As $\mathcal{E}$ r gets higher value.

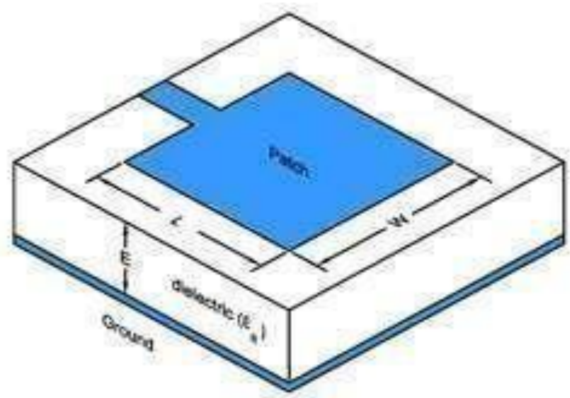


Fig 3.1: Rectangular patch antenna

Patch: It consists of a very thin metallic sheet mounted on dielectric substrate. The antenna patch shape as shown in Figure can be square, rectangular, strip, circular, triangular, elliptical, or any combination of these shapes.The square, rectangular, and circular are the most popular shapes because they are the easiest in analysis and fabrication**.**

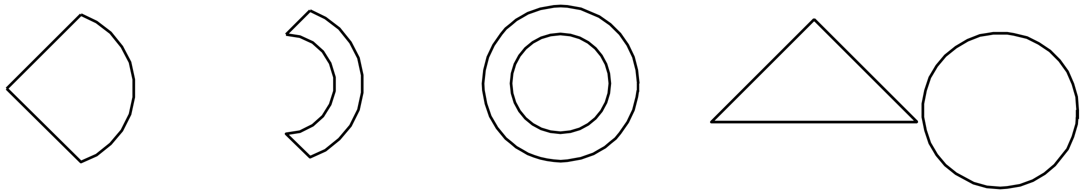


Fig3.2: Different shapes of patch

3.9 Feeding:

The most four popular feeding techniques for microstrip patch antenna are: (coaxial feeding, microstrip feeding, proximity feeding and aperture feeding

3.9.1 Coaxial Feed

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As seen from Figure 2.4, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch

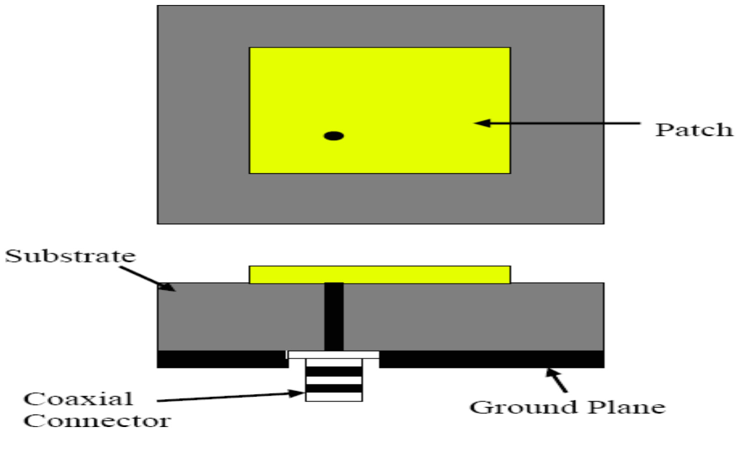


Figure 3.3:Probe feed Rectangular Microstrip Patch Antenna

The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems. It is seen above that for a thick dielectric substrate, which provides broad bandwidth, the microstrip line feed and the coaxial feed suffer from numerous disadvantages. The non-contacting feed techniques which have been discussed below, solve these issues.

3.9.2 Aperture Coupled Feed

In this type of feed technique, the radiating patch and the microstrip feed line are separated by the ground plane as shown in Figure 2.5. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane.

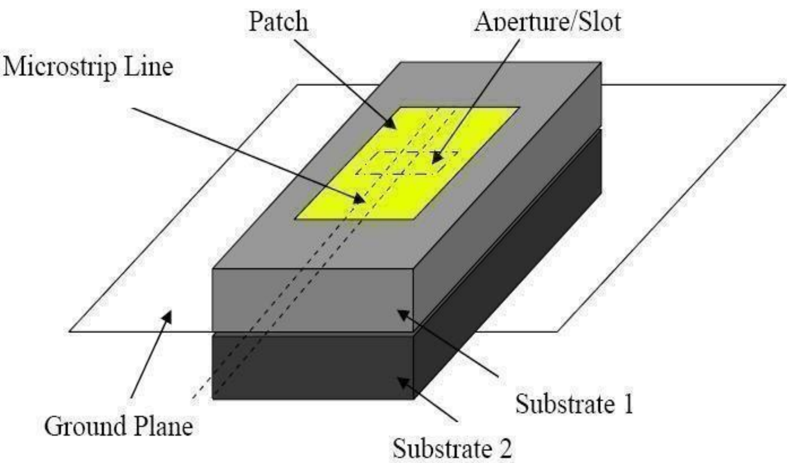


Figure 3.4:Aperture-coupled feed

polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture. Since the ground plane separates the patch and the feed line, spurious radiation is minimized. Generally, a high dielectric material is used for bottom substrate and a thick, low dielectric major disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which also increases the antenna thickness. This feeding scheme also provides narrow bandwidth.The coupling aperture is usually centered under the patch, leading to lower cross

3.9.3 Proximity Coupled Feed

This type of feed technique is also called as the electromagnetic coupling scheme. As shown in Figure 2.6, two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth (as high as 13%), due to overall increase in the thickness of the microstrip patch antenna. This scheme also provides choices between two different dielectric media, one for the patch and one for the feed line to optimize the individual performances.

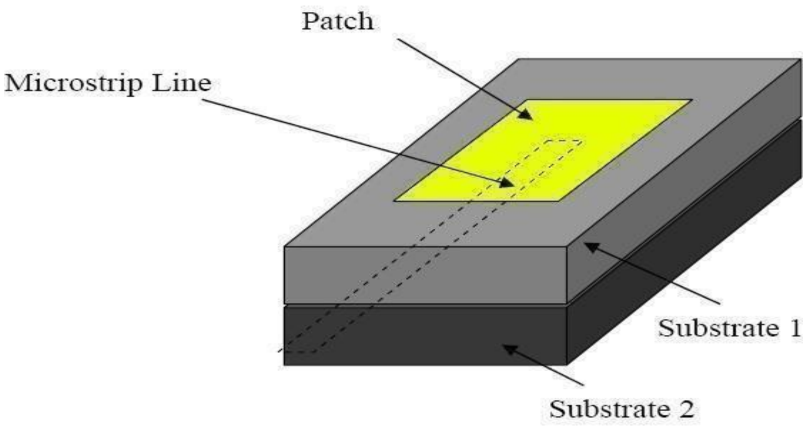


Figure3.5:Proximity-coupled Feed

Matching can be achieved by controlling the length of the feed line and the width-to-line ratio of the patch. The major disadvantage of this feed scheme is that it is difficult to fabricate because ofthe two dielectric layers which need proper alignment. Also, there is an increase in the overall thickness of the antenna.

3.9.4 Microstrip Line Feed

In this type of feed technique, a conducting strip is connected directly to the edge of the Microstrip patch as shown in Figure 3.3. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure.

The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. However as the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth of the antenna. The feed radiation also leads to undesired cross polarized radiation.

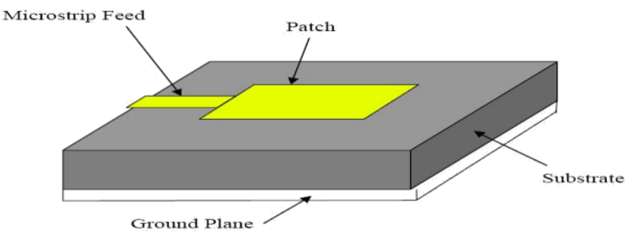


Fig 3.6: Micro strip line

3.10 Materials & Software

- **Required:** Ground: Metal
- (Copper) Substrate: Dielectric

   (FR4)
- ➢ (εr = 4.4, thickness h =
- 1.6mm) Patch: Metal

   (Copper)

3.10.1 Software Required:

- CST (Computer Simulation Technology

3.11 Transmission Line Model

3.11.1 Introduction:

In an electronic system, the delivery of power requires the connection of two wires between the source and the load. At low frequencies, power is considered to be delivered to the load through the wire. In the microwave frequency region, power is considered to be in electric and magnetic fields that are guided from place to place by some physical structure. Any physical structure that will guide an electromagnetic wave place is called a Transmission Line.

- Transmission lines are used in power distribution (at low frequencies), and in communications (at high frequencies).

- A transmission line consists of two or more parallel conductors used to connect a source to a load., the source may be a generator, a transmitter, or an oscillator and the load may be a factory, an antenna, or an oscilloscope, respectively.

- Transmission lines include coaxial cable, a two wire line, a parallel plate or planar line, a wire above the conducting plane, and a micro-strip line

- Cross sectional views of these lines consists of two conductors in figure ,each of these lines consists of two conductors in parallel

- Coaxial cables are used in electrical laboratories and in connecting T.V sets to T.V antennas

- Micro-strip lines are important in integrated circuits where metallic strips connecting electronic elements are deposited on dielectric substrates. There are different types of modes propagate between the two conductorsof transmission line as: - TE, transverse electric, i.e. EZ □ 0,HZ □ 0 - TM, transverse magnetic, i.e. HZ □ 0,EZ □ 0 - TEM, transverse electro-magnetic i.e. HZ □ EZ □ 0 - Propagate in Z- direction, HZ EZ [31].

Our analysis of transmission lines will include the derivation of transmission line equations and characteristic quantities, the use of Smith chart , various practical applications of transmission lines, and transients on transmission lines.

Transmission Lines Parameters: We must describe a transmission line in terms of its line

parameters. R[Ω/m] ….conductivity of conductor

L[H/m]….self inductance of wire

G[Ω-1 /m]….dielectric between two conductors

C[F/m]….proximity between

We have : LC =με , Gε=σC,

3.11.2 Distributed element model of a Transmission Line

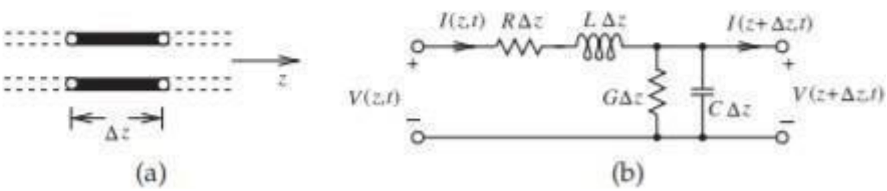


Fig 3.7: Transmision line

1-The line parameters R,L,G, and C are not discrete or lumped but distributed as shown .by this we mean that the parameters are uniformly distributed along the entire length.

2- For each line, the conductors are characterized by C , C , 0 C , and the homogeneous dielectric separating the conductors is characterized by , ,

3- R G 1 ; R is the ac resistance per unit length of the conductors comprising the line and G is the conductance per length due to the dielectric medium separating the conductors.

4- The external inductance per unit length; that is, L □Lext . The effects of internal inductance L (Rl□) in □ are negligible at high frequencies at which most communication systems operate.

5- For each line, LC □□□ and □□□ C G Transmission Line Equations: As mentioned above , two conductor transmission line supports TEM wave; the electric and magnetic fields on the line are transverse to the direction of wave propagation . an important property of TEM waves is that the fields E and H are uniquely related to voltage V and current I respectively:

$$\int V = -E.dl , \int I = H.dl$$

In view of this , we will use circuit equations V and I in solving the transmission line problems instead of solving field quantities E and H (i.e solving Maxwell's equations and B.C.), the circuit model is simpler and more convenient.

Let us examine an incremental portion of length Δz of a two conductor transmission line . we intend to find an equivalent circuit for this line and drive the line equations. From the figure of distributed element model of transmission line, we assume that the wave propagates along +z direction , from the generator to the load.

By applying Kirchoff's voltage law to the outer loop in the model of distributed element model , we obtain:

KVL: $\sum V = 0$, we get equations;

V (z) = Vx+ e^ −γz + Vy − e^γz

I(z) = V/ Zo e ^−γz– V/ Zo e γz .

where the propagation constant is γ = α + jβ = sq.root{ (R + jωL)(G + jωC)}

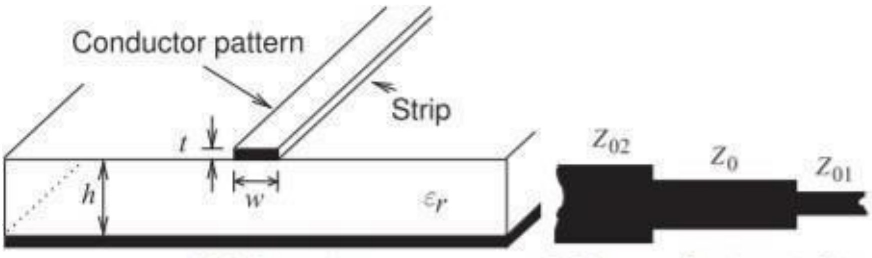
and the characteristic impedance is

Zo=sq.root{(R + jωL)/(G +jωC)}

3.12 Microstrip Line

A microstrip line is shown in Figure 3.8.1(a). This is a commonly used transmission line, as it can be cheaply fabricated using printed circuit board techniques. This line consists of a metal-backed substrate of relative permittivity εr on top of which is a metal strip. Above that is air. The width of the strip determines the characteristic impedance of the line. The characteristic impedance of microstrip lines having various strip widths is shown in Figure 3.8.2 for several substrate permittivities. So the wider the strip and the higher the substrate permittivity, the lower the characteristic impedance of the line.

The EM fields are partly in air and partly in the dielectric and an effective permittivity must be used when calculating the electrical length of the line. The results of field simulations of the effective permittivity of lines of various widths and with various substrate permittivity's are shown in Figure 3.8.3, where it can be seen that the effective relative permittivity, εe, increases for wide strips. This is because more of the EM field is in the substrate. Microstrip transmission line structures are often drawn showing just the layout of the strip, as shown in Figure 3.8.4(b), where



(a) Microstrip (b) Layout of microstrip lines

Figure 3.8.1: Microstrip transmission line. The layout (or top) view is commonly used with circuit n designs using microstrip. This is the pattern of the strip where (b) shows three lines of different width.

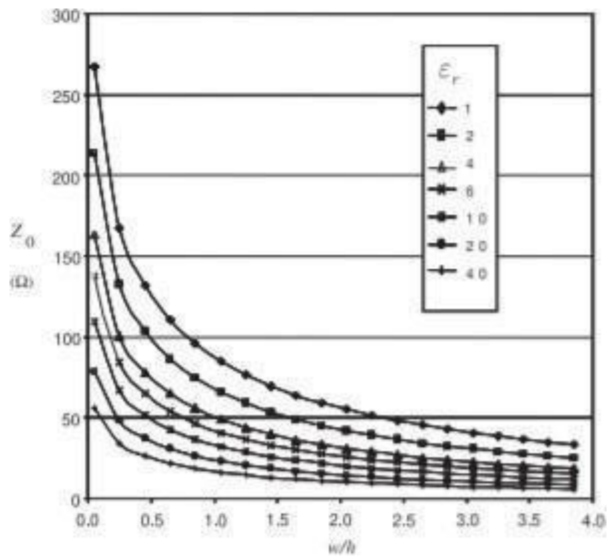


Figure 3.8.2: Dependence of Z0 of a microstrip line at 1 GHz for various $\varepsilon_r\varepsilon_r$ and aspect (w/h) ratios. Calculated using EM simulation.

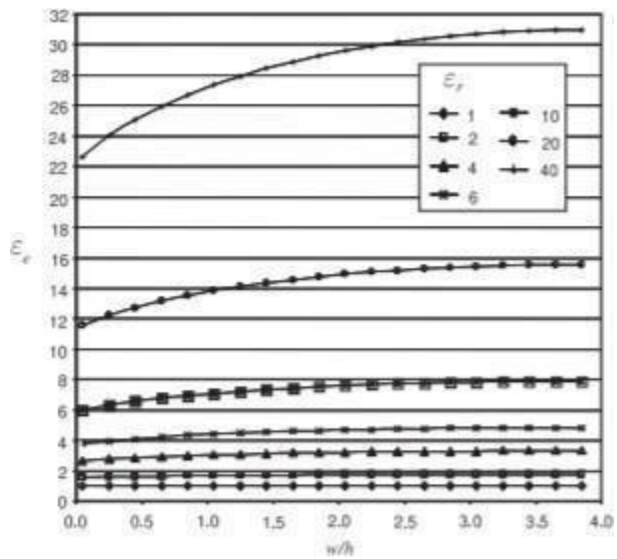


Figure 3.8.3: Dependence of effective relative permittivity ε_e of a microstrip line at 1 GHz

CHAPTER – 4

Antenna for Biotelemetry Devices

4.1 Introduction

Nowdays, with the development of the healthcare life, more and more importance have been attached to the study of medical implantable devices. Painless, real-time, high efficiency has become basic performance of those devices that researchers pursue. Implantable medical devices can transmit in- body physical information to outer receivers wirelessly, and they have been employed in several biomedical telemetries, such as glucose monitoring, neural recording, and RFID-inspired brain caring. For implants, numerous characteristics such as impedance bandwidth, miniaturization, polarization matching, radiated safety and radiation efficiency are worthy of noting[32].

In recent days, Implantable medical devices have gained more attention in the field of medical diagnosis and treatment. The transmitter specification is an essential design aspect of Implantable medical devices and it should be able to function in the ISM band of range between 2400 MHz and 2480 MHz. The size of the implantable antenna is much small and it is alike with conventional antennas which are employed for general wireless applications such as mobile phones. These implant antennas will be placed inside a complex lossy environment which is another complication. There are several researchers have been focused on implantable antennas for the purpose of medical applications such as balloon angioplasty or hyperthermia and some sensing applications. At both cases, the operation of antennas lies around its close field and it can cover a particular distance over propagation.

4.2 Antenna Design

The proposed system is designed with CPW feed, so it responses to the high frequency range and to reduce the back radiation of an antenna. The total volume of an antenna is very small. Then the antenna is designed and analyzed with human phantom model such as skin, fat and muscle with their relative dielectric permittivity, electrical conductivity and mass density. The method of feeding is coplanar waveguide, in this case CPW (Coplanar waveguide) feed is proposed for high frequency response , so the accuracy of the proposed system is increased and reduces the back radiation of the antenna and the proposed system is analyzed with human tissues such as muscle with their relative dielectric constant.

4.3 Advantages

- Glucose monitoring: We present a sensing system operating at millimetre (mm) waves in transmission mode that can measure glucose level changes based on the complex permittivity changes across the signal path. The permittivity of a sample can change significantly as the concentration of one of its substances varies: for example, blood permittivity depends on the blood glucose levels.

- Neural recording: Neural activity monitoring in the brain requires high data rate (800 kb/s per neural sensor), and we target a system supporting a large number of sensors, in particular, aggregate transmission above 430 Mb/s (~512 sensors). Ultra wide band (UWB) short-range communication systems have proved to be valuable in medical technology, particularly for implanted devices, due to their low-power consumption, low cost, small size, and high data rates.

- RFID-inspired brain caring : With more than 86 billion neurons and other supportive glial cells constituting the cerebrum, the brainstem and the cerebellum, the human brain forms the central nervous system that regulates all our daily physiological activities. Thus, any injury to the brain usually leads to serious deterioration of physical and mental capacity. In the pursue toward better life quality for those suffering from debilitating neurological conditions, researchers have recently found wireless care based on implantable sensors and stimulators a compelling approach to achieve a long term intracranial physiological monitoring, wireless implantable sensors brings the promising prospects for the treatment of intracranial diseases. To achieve the transcranial wireless links for data transmission between the implanted sensor and the off-body receiver

4.4 Telemedicine

Health care, as we know, is primarily about people-to-people interactions. It is about understanding, diagnosis, physical contact, communication and ultimately, providing care. All of this is facilitated by the technical processes of imaging, pathological testing, information gathering, research and so forth. The task for every health care system is how to maximize the personal contact at the same time as maximizing the technical input, while all the time operating within a sustainable financial framework.

People working in developing countries have had to think about this task with even more urgency than those working in richer countries. They have had to think about how to obtain an expert opinion in remote places, how to support local clinicians who may not have all the skills they need, how to make sure technical information is interpreted wisely in very difficult circumstances and how best to use very scarce resources. Telemedicine offers help in meeting these conflicting needs by improving access to data and to individuals, while driving down the costs of doing so (Richard Wootton et al) [33].

Telemedicine tool enables the communication and sharing of medical information in electronic form and thus facilitates access to remote expertise and knowledge. A physician located far from a reference centre can consult his colleagues remotely in order to solve a difficult case, follow a continuing education course over the internet to improve his knowledge, or access medical information from digital libraries.

Telemedicine is defined as the use of information technologies to exchange health information and provide health care services across geographical, time, social, and cultural barriers (Reid, 1996). In general; telemedicine technology includes both store-and-forwards (asynchronous) as well as live videoconferences (synchronous) transmissions via satellite networks. In the last decade, pilot studies in SSA countries have shown the potential benefits of telemedicine for patients and healthcare providers (Kifle et al., 2006). The results demonstrated the socio-economic impacts of telemedicine, and its potential in the area of improving accessibility, containing costs, and providing quality care.

Statement of Research Problem

In most developing countries, many villages still lack basic ICT infrastructure, such as telephone lines and power supplies that influence telemedicine technology transfer. That is why the transfer of information systems in developing countries is usually described as a problem.

Specifically, when it comes to the health sector, the digital divides between developed and developing countries are wider than the gap observed in other productive and social sectors Furthermore, productive sectors such as banking have accepted ICT faster, and allocate 5-10 percent budget for IT, while the healthcare sector is 10-15 years behind the productive sector, with only 2-3 percent of its budget allocated to IT.

Previous Information and Communication Technology Transfer (ICTT) attempts from partners in developed countries to developing countries have failed because of neglecting infrastructural, socioeconomic and cultural factors that impact such transfers. Accordingly, understanding barriers due to infrastructural and cultural factors for telemedicine transfers motivates this work.

The following rationale underscores the research significance:

- Recent ICTs (and telemedicine) developments in Africa and Ghana as such are encouraging, including wireless ICT diffusion, Internet use, electronic information exchanges, and remote consultations.
- Healthcare is essential for Ghanaians with multiple medical problems. Many have reported growing medical problems in Sub-Saharan Africa (SSA). These problems stimulated new approaches like telemedicine for better access and reduced costs as iterated by Dr. Osei Darkwa, President Ghana Telecom University College on Monday May 7, 2007.
- There is dire shortage of medical personnel and facilities in SSA including Ghana.
- The "brain drain" phenomenon is apparent throughout SSA. WHO (2006) statistics revealed that SSA-trained physicians currently practicing in OECD countries represent 23% of existing doctor workforce in countries of origin.

- Healthcare providers in developing countries and international organizations are promoting telemedicine transfer. Additionally, influence of ICTs due to governmental policies, economic, sociopolitical, cultural and infrastructure factors have attracted international collaborations (Avgerou, 1998).

4.4.1 Justification

The following rational underscores the research significance**;**

- There are disparities in the provision of health care within developing countries, where the health facilities in the urban areas are relatively well off in terms of manpower. Other medical facilities and resource as compared to those in rural areas. Such disparities mean that rural areas are often at a disadvantage with health workers facing daunting challenges.

- In order to provide basic health care for all population, health workers need communication facilities to obtain advice and information from more affluent urban health centres, as well as to transmit pertinent data such as epidemiological information hence, the need for extensive research into telemedicine[34].

- Health care providers in developing countries and international organization are promoting telemedicine transfer. (Avgerou,1998)

4.4.2 Significance of the Study

- Telemedicine is significant particularly, in countries where specialists are few and where distance and the quality of the infrastructure hinders the movement of physicians or patients from rural to the urban centres.

- Ghanaians have experienced many inequalities and these have extended to the health care setting. One of the major challenges that needs to be addressed is the accessibility and availability of health care and specialized medical services in rural areas in Ghana hence the need for an extensive research into telemedicine as a tool in arresting the problem.

- The study document could serve as a secondary source data for further study of economic importance in future

4.4.3 Anticipated Problems

- Financial constraint or cost involved in conducting research over a wide area or scope
- Limited time of conduct and present the project
- Scarcity of data on telemedicine as it is a developing application of clinical medicine

4.5 Types of Telemedicine –

Basically telemedicine is divided into three main types namely:

- Store-and-forward
- Interactive services
- Remote monitoring

4.5.1 Store and forward

With the help of store and forward Telemedicine type all details related to medical data, images, video, audios reports and everything is collected and transmitted to the medical expert, doctor, for diagnosis or assessment offline. It requires the clinician to rely on a history report and audio information in place of physical examination.

4.5.2 Interactive Service

This is a real time communication in between patient and doctor. This includes telephonic conversation, home visit as well as online interactions. Lots of activities like review of history, physical examination, assessment and check-ups are carried out in such type of telemedicine. This clinician interaction telemedicine procedure is affordable.

4.5.3 Remote monitoring

Also known as self-monitoring or testing enables medical professionals to monitor a patient remotely using various technological devices. Lots of chronic disease, specific conditions like heart disease, asthma, or even diabetes can be managed and monitored by this means. These are definitely comparable and cost effective as compared to those traditional; face to face interactions between the doctor and patient.

Growing Demand for Telemedicine -

Telemedicine can be depended on in times of emergency when there is no medical doctor. Learning and using telemedicine techniques during emergency is simple today with the help of online source. Care at a distance, telemedicine is a handy tool for people trying to reach some medicines, treatment consultancy during illness.

Today telemedicine has developed rapidly as a means of receiving and interacting all about medical information, examination, and consultation.Surly telemedicine is fast, effective, simple, cost saving as well as the best way to receive some medical guidance when no doctor is around.

Due to the high demand of medical care needs especially for those who do not have access to medical centres and are most often concentrated within the rural areas. The aim is to find answers to the following;

- Will telemedicine improve the quality of health care?
- Will it improve the delivery of health care in remote areas?

4.6 Concept of Telemedicine

From the various definitions, a telemedicine system creates a 'visual' medical consultation where the local medical attendant becomes the eyes, ears and hands of the remote medical expert. He/she collects the necessary information for decision making and serves to implement the necessary actions and treatment.

Telemedicine provides tertiary healthcare to people at remote areas through a visual reduction in distance. Text, sound, pictures and videos are being merged and interconnected in completely new way for diagnoses and treatment thereafter.

Potentials of telemedicine –

- Building bridges between clinicians and patients to overcome the barriers of distance andtime.
- Developing visual communities that interacts and shares knowledge

- Enhancing continuity of care
- Improving access to healthcare in remote or isolated areas.

4.7 Generic application of Telemedicine –

- Clinical applications - include handling urgent consultations, scheduled consultations, remote visits of patients and the video reviews of certain studies done in advance.
- Administrative applications- covers telemedicine system for promoting and accelerating the replication, update and transfer of clinical information including medical records, examination data and financial information
- Educational application: this includes applications that facilitate the process of sharing the material available for teaching and examination purposes in the medical field.

4.8 Benefits of Telemedicine –

Telemedicine has a number of benefits namely:

- Reducing the cost of service delivery
- Easy and quick access to the specialist
- Cost effective post treatment consultation
- Travel time reduction
- Enhanced quality and efficiency of medical care

4.9 Technology

Telemedicine technology is based on a speciality centre and a consultation centre linked to each other. A speciality centre is a well-equipped room where a specialist can communicate with a patient in a remote area the equipment required are a high- resolution video camera (polycam) web camera, document camera, microscope, computer, microphone, speaker, telephone and a modem.

A consultation centre is a centre from whence the local Registered Medical Practitioner (RMP) or patient can consult the specialist in the speciality centre. The consultation centre and the speciality centre are linked to each other through on Integrated Services Digital Network (ISDN).

One of the essential devices used for consultation is a polycam. A polycam is a video conferencing tool accompanied by a voice transmission enabler.

From the consultation centre x-rays, CT-scan, colour Doppler, Ultrasound etc. are transferred over the ISDN line with the help of an interface. In the speciality centre the medical records are received on the system and can be alternatively viewed on the TV through the polycam using an interface. A web camera can be used in the absence of a polycam. A high resolution/luminosity subsystem is used for better transmission of x-rays and echocardiograms. High-end scanners are used in the speciality centre to capture negative and positive images. For the transfer of ECG, special trans-telephonic equipment is used which is connected to the ECG machine on one side be seen and heard on the system at the speciality centre.

An electronic or digital stethoscope can be used to hear the heartbeat. The equipment is placed on the patient and connected to the telephone line and the doctor at the speciality centre can hear the heart beat on the system or the telephone directly.

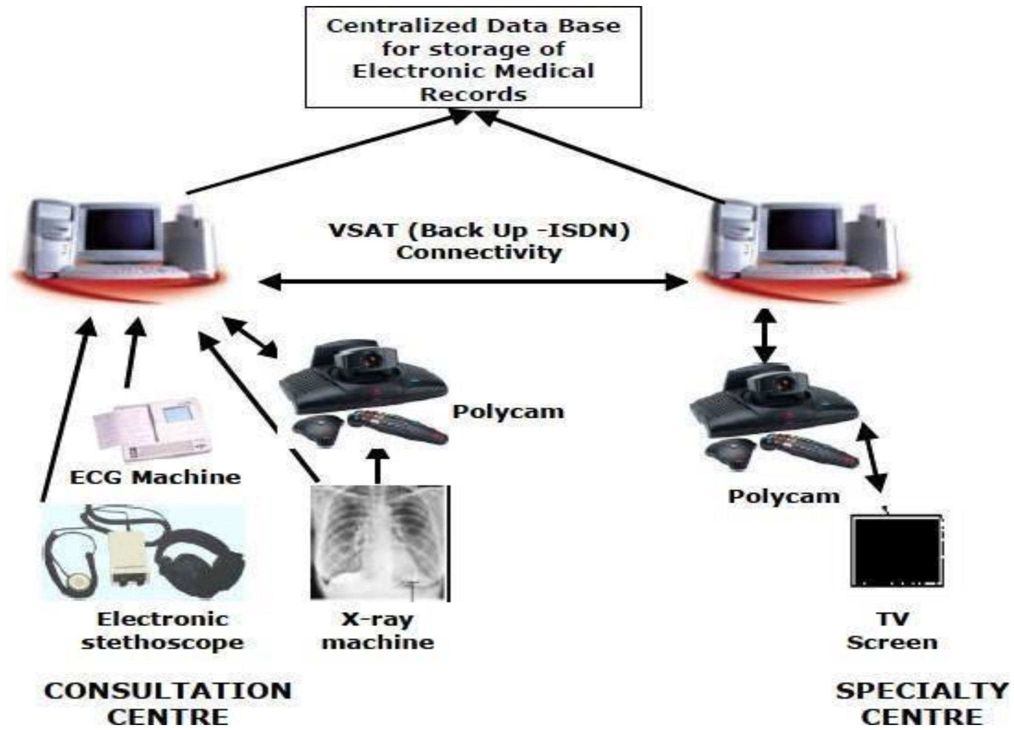


Figure 4.1: Telemedicine Network

CHAPTER – 5

Result and Discussion

5.1 Proposed Antenna Design

The performance of the proposed Antenna is studied using the CST simulation tool. It shows the analysis of S11 for GHz frequency and value of thickness h=1.6; εr=4.6. S11 gives the reflection coefficient at 2.4 Ghz is -18dB. It covers the C frequency band for military requirement for land, airborne and naval radars applications. The radiation power shows the maximum peak value at resonant frequency corresponding to the structure of substrate with thickness.

Simulation is done by the CST software by following the procedures in that software. FR4 substrate is selected.

The Simulation Frequency range is set as 2.1 GHz – 2.7 GHz (adaptive sweep) and added a new Single Point of 2.46 GHz as below. Simulate option is selected and observed the simulation results in the data display.

Far field computation will be done and results will be displayed in the post processing windows. Window Tile is used and then Plot Properties are added from the bottom tabs and then selected the Far Field option and Antenna Parameters were selected to see all the required data.

TABLE 3. Characteristics and Values

Antenna characteristics	Measurement values
Directivity(dB)	7.072
Gain(dB)	5.87
Power radiated(W)	0.0091
BW(MHz) (2.38-2.58GHz)	200

TABLE 4. Results of the Designed Patch Antenna

Parameters	**Simulation**
S11(dB)	-18
VSWR	1.28
Impedance	1.0-j0.001

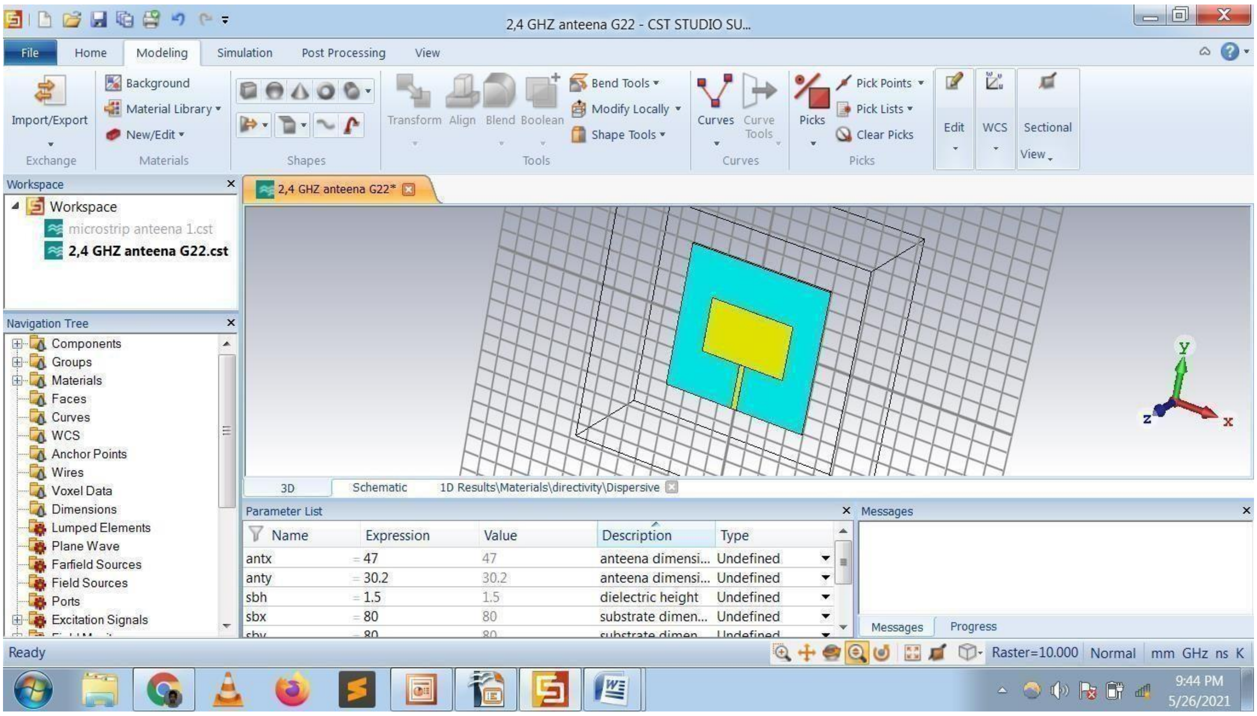


Fig 5.1 Simulation of Antenna using CST

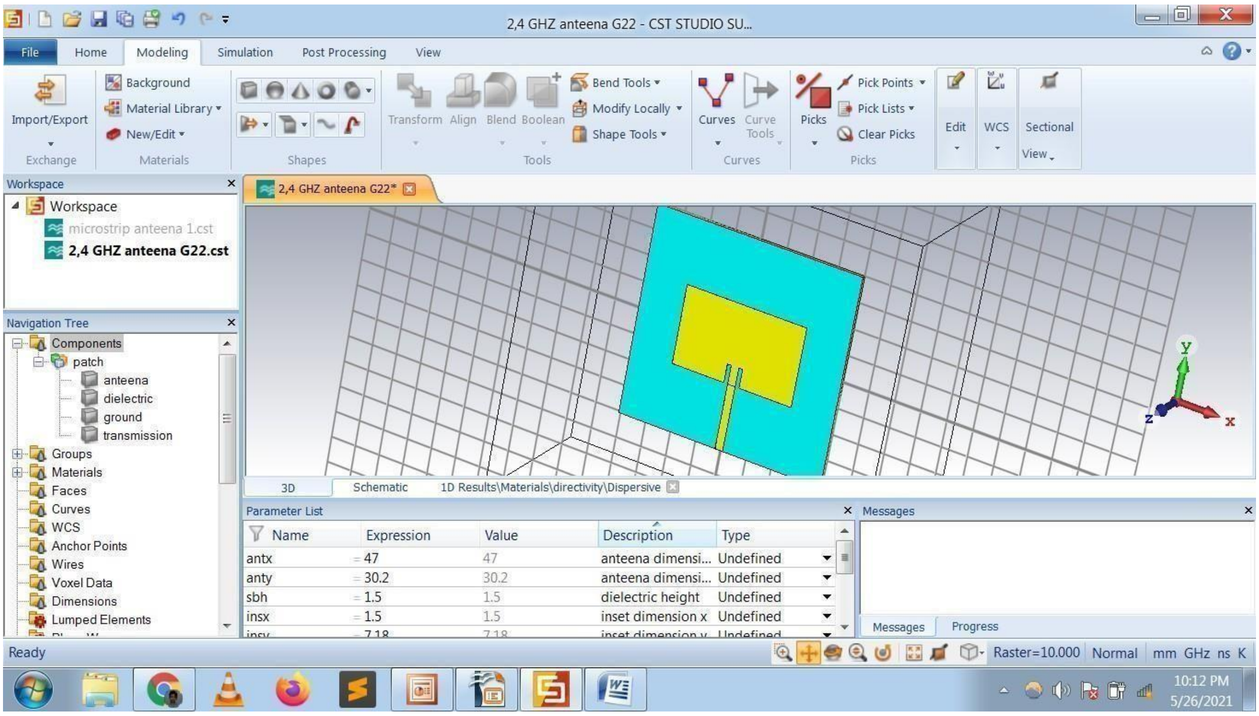


Fig 5.2 Simulation of Antenna using CST

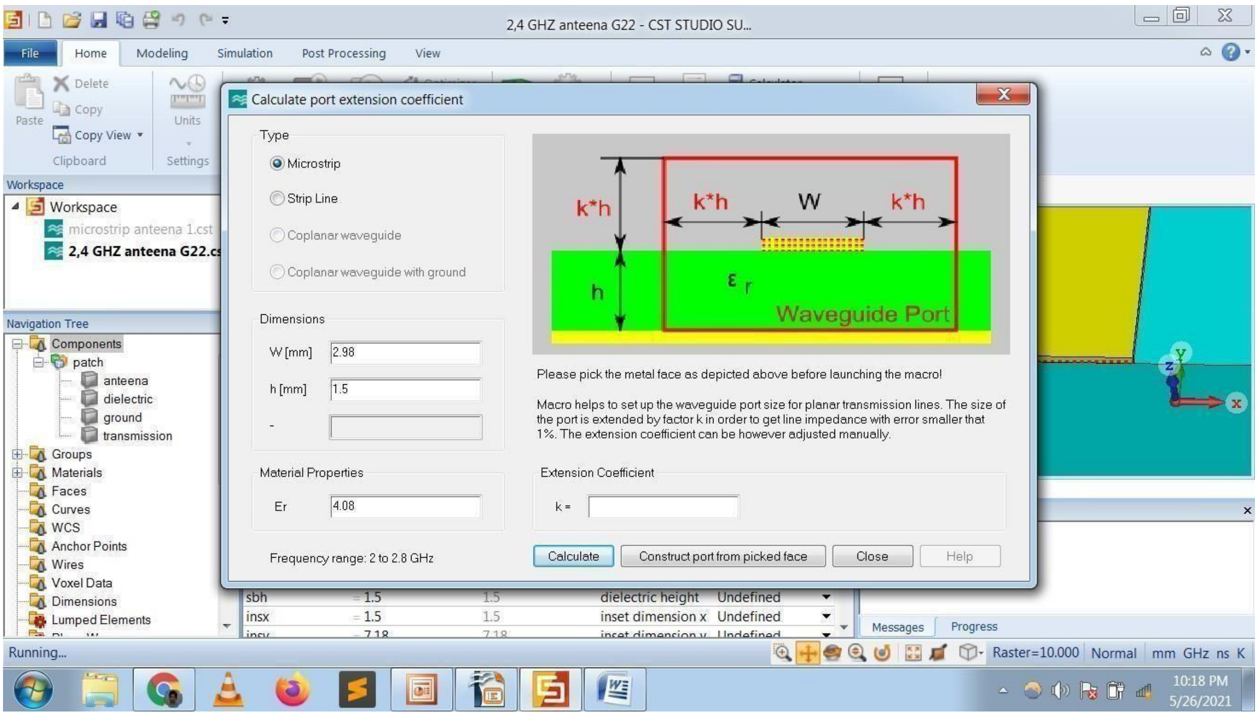


Fig 5.3 Simulation of Antenna using CST

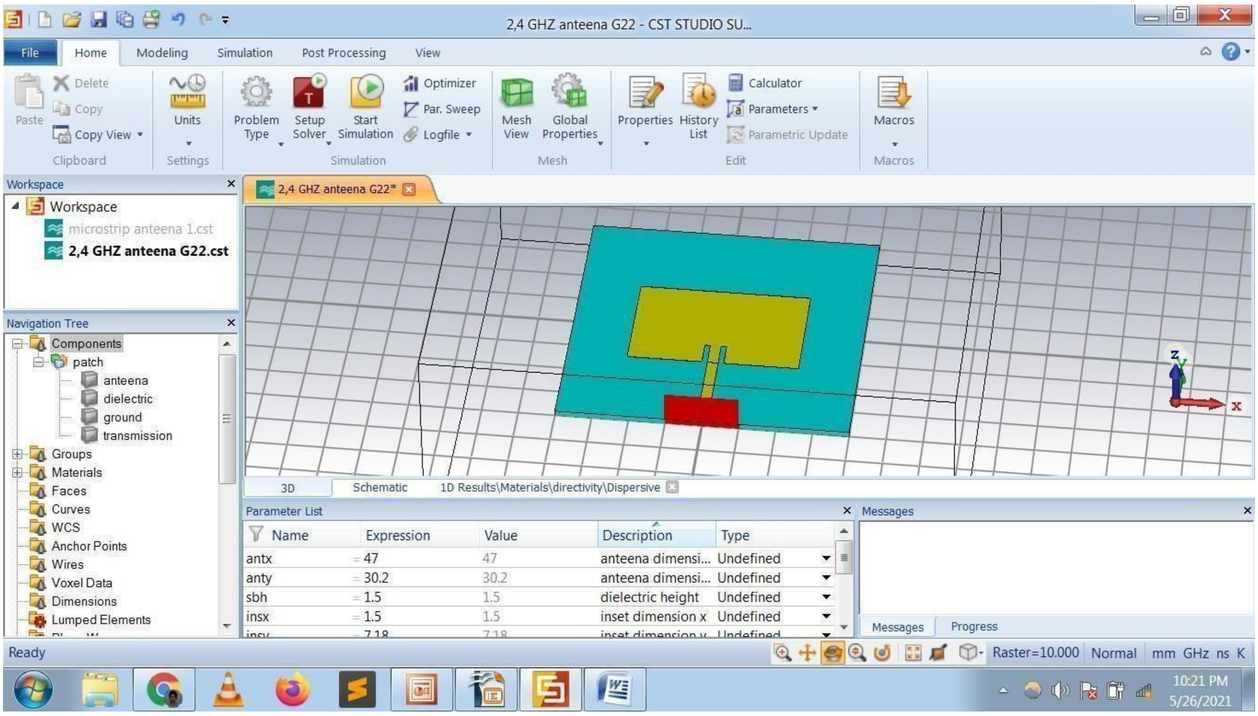


Fig 5.4 Simulation of Antenna using CST

5.2 Result-

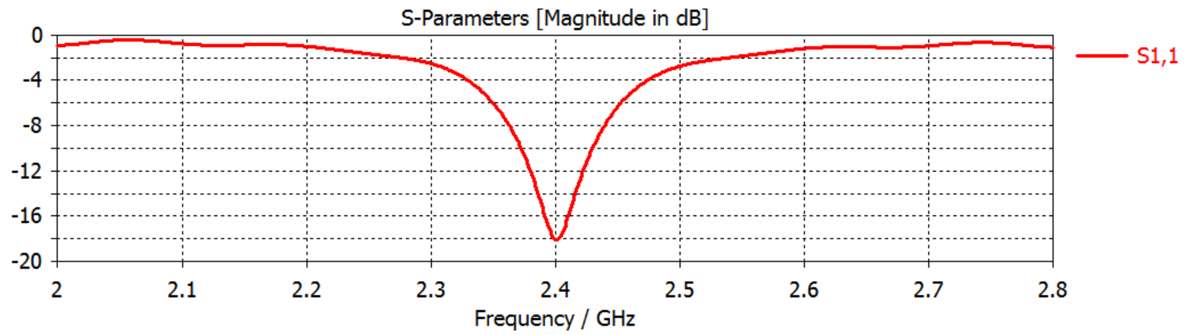


Fig 5.5: Simulated S- Parameter

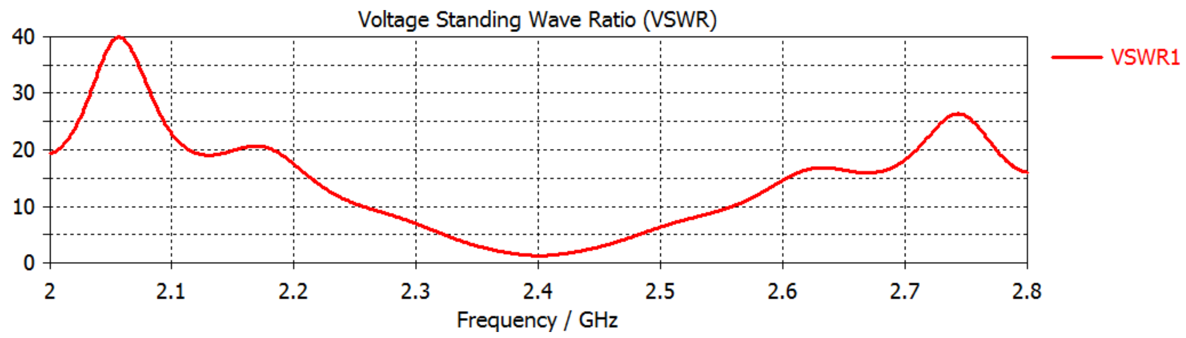


Fig 5.6: Simulated VSWR

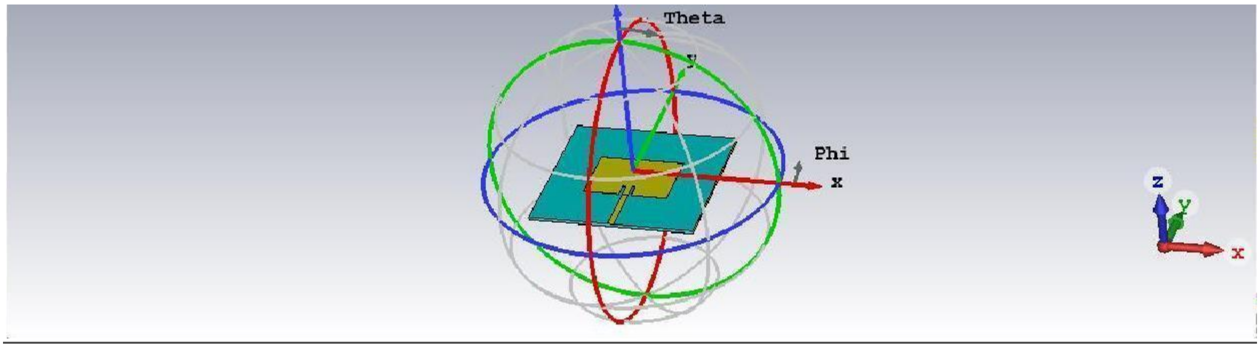


Fig 5.7: Simulated Farfield

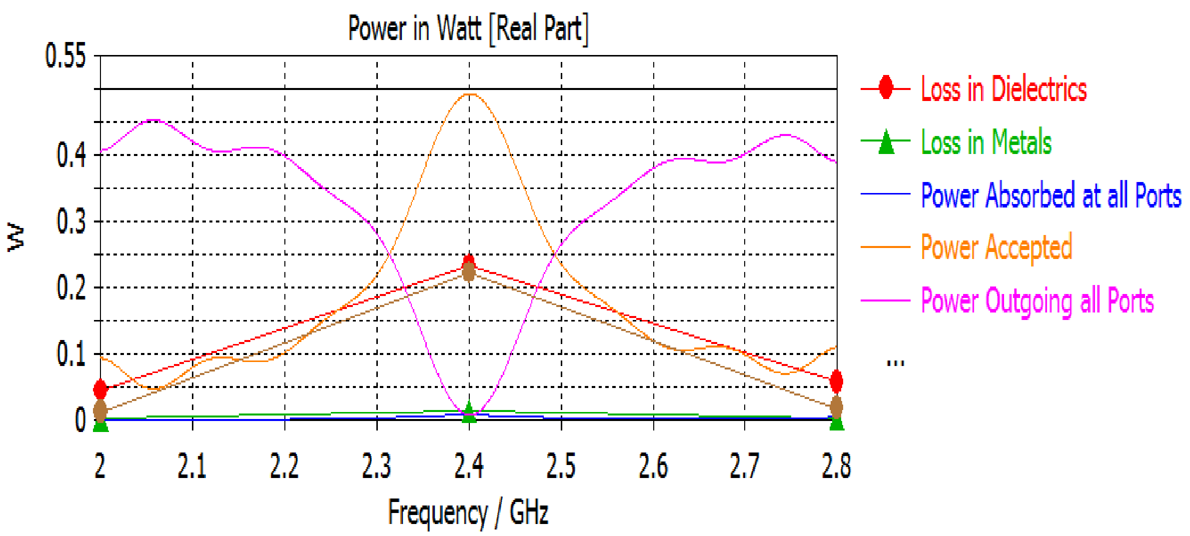


Fig 5.8 Simulated Power of Antenna

5.3 Applications

The Microstrip patch antennas are well known for their performance and their robust design, fabrication and their extent usage. The advantages of this Microstrip patch antenna are to overcome their de-merits such as easy to design, light weight etc. Microstrip patch antenna has several applications. Some of these applications are discussed as below:

Mobile and satellite communication application: Mobile communication requires small, low-cost, low profile antennas. Microstrip patch antenna meets all requirements and various types of microstrip antennas have been designed for use in mobile communication systems. In case of satellite communication circularly polarized radiation patterns are required and can be realized using either square or circular patch with one or two feed points.

Radar Application: Radar can be used for detecting moving targets such as people and vehicles. It demands a low profile, light weight antenna subsystem, the microstrip antennas are an ideal choice. Recently, there have also been radar systems developed that operate in the ISM bands, specifically the 2.4 GHz ISM band, due to the readily available and inexpensive wireless ICs available for these frequencies.

C-band radar frequency sub-bands are used in civil, military and government institutions for weather monitoring, air traffic control, maritime vessel traffic control, defense tracking and vehicle speed detection for law enforcement.

Biomedical Application: For medical purposes, such as diathermy, hyperthermia therapy, and RF/microwave ablation the purpose of medical applications such as balloon angioplasty
or hyperthermia and some sensing applications. At both cases, the operation of antennas lies around its close field and it can cover a particular distance over propagation.

Commercial Application: The most common everyday uses of the ISM bands are for low-power and short range telecommunications, such as WiFi, Bluetooth, Zigbee, wireless telephones, RFID, and NFC. Many in the US are familiar with the 2.4 GHz ISM band, as most WiFi and Bluetooth communications operate in these bands.

CHAPTER -6

Conclusions and Further Work

6.1 Conclusions

An optimal microstrip-fed antenna with T-shaped slot radiators is sussecfully proposed, simulated and fabricated for WLAN/Wi Max operation experiment are carried out to validate design concept and method showing good agreement between simulation and measurements. The proposed antenna features compact size, good triband operating bandwidth,stable radiation patterns indicating that it can be good candidate for WLAN and WiMax applications. The antenna is compacat ,cheap, planer,with adequate gain,co and cross polarization levels. The suggested antenna had a very giood radiating efficiency. This Antenna can be further extended for any array.application.with circular polarization and can be realized easily using photolithography technique.

6.2 Further work

For higher gain we increase the number of elements in the array. The planner array can also be developed.

APPENDIX

Substrate Selection

The substrate selection is a primary and a crucial process to design a high frequency antenna or waveguide. Since, micro strip antennas are low profile structures so they require a strong mechanical strength. To meet this requirement, the dielectric properties of a substrate should have low electrical losses, low power dissipation, low moisture absorption and efficiency. Hence, a substrate is considered suitable when both electrical and mechanical requirements are fulfilled, which is quite desirable.

Criteria for Substrate Selection

Some parameters are considered while selecting a material based on its dielectric properties in the design of antennas.

(a) Surface wave excitation.

(b) Dispersion of the dielectric constant and loss tangent of thesubstrate.

(c)Copper loss.

(d) Substrate anisotropy.

(e) Effects of humidity, temperature and aging on the substrate material.

(f) Mechanical strength such as machinability, conformability, solderability, weight and etc.

(g) Cost.

Surface waves can be excited at the dielectric-to-air interface. Surface waves also causes unwanted coupling between the elements which is an undesirable feature. The dielectric constant $\varepsilon_r$and height h of the substrate influences the phase velocity of the surface waves. While designing an antenna the substrate is put over the metal ground plane which also excites some portion of the surface waves along with the transmitted wave. 43

FR-4 or (**FR4**) is a grade designation assigned to glass-reinforced epoxy laminate sheets, tubes , rods and printed circuit boards(PCB). FR-4 is a composite material composed of woven fiberglass cloth with an epoxy resin binder that is flame resistant (self-extinguishing).

FR-4 glass epoxy is a popular and versatile high pressure thermo set plastic laminate grade with good strength to weight ratios. With near zero water absorption, **FR-4** is most commonly used as an electric insulator possessing considerable mechanical strength.

Software Introduction

This research work has been carried out through CST for antenna designing through the dissertation. CST is a 3D EM Simulator based on the Finite Integration Technique (FIT). CST can be use for passive and Active circuit simulation. CST is a better approach for time domain.

CST MICROWAVE STUDIO® (CST MWS) is a specialist tool for the 3D EM simulation of high frequency components. The unparalleled performance from CST MWS makes it the first choice in leading R&D departments.

CST MWS enables the fast and accurate analysis of high frequency (HF) devices such as antennas, filters, couplers, planar and multi-layer structures and SI and EMC effects. Exceptionally user friendly, CST MWS quickly gives you an insight into the EM behavior of your high frequency designs.

Itpromote Complete Technology for 3D EM. Users of our software are given great flexibility in tackling a wide application range through the variety of available solver technologies. Besides the flagship module, the broadly applicable Time Domain solver and the Frequency Domain solver, CST MWS offers further solver modules for specific applications. Filters for the import of specific CAD files and the extraction of SPICE parameters enhance design possibilities and save time. In addition, CST MWS can be embedded in various industry standard workflows through the CST STUDIO SUITE® user interface.

CST MICROWAVE STUDIO is seen by an increasing number of engineers as an industry standard development tool.

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LIST OF PUBLICATION

1. Author: Ananya Shreesh, Kishore jha, Shivam Dubey, Shivam Kumar. **Design and analysis of microstrip patch antenna at ISM band.** Design and Analysis 2021, 1-53.

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Seventh International e-Conference on

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6th June,2021

This is to certify that Prof./Dr./Mr./Ms Ananya Shreesh of Noida Institute of Engineering and Technology has Participated/presented a paper titled Design and analysis of Microstrip patch antenna using ISM band in 7th International e-Conference on Green Technologies for Power generation, Communication and Health Care on 6th June,2021 organized by Department of ECE , EEE & BME at SPIHER, Chennai, India.

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Design and Analysis of Microstrip Patch Antenna at ISM Band

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Abstract- The research work of design, simulation, development, and measurement done on the rectangular microstrip patch antenna for the ISM band of frequencies is presented in this paper. This rectangular patch antenna is fed by a microstrip line feed. Its resonance frequency performance is studied between 2.4-2.5 GHz. This band of frequencies is ISM band of wireless applications. The design and simulation are done in Computer Simulation Technology (CST) software with FR4 substrate. According to its real application, the material, shape, and the type, the microstrip antenna is designed. The size of the antenna is calculated by the length, width expressions. Then the antenna is simulated for the radiation parameters obtained through optimizing and matching to meet the requirements. The parameters of antenna such as Reflection coefficient, Gain, VSWR and Band width are measured.

Keywords- Rectangular patch; lossy substrate; microstrip antenna; simulation; fabrication

Design and Analysis of Microstrip Patch Antenna at ISM Band

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***Abstract*—** The research work of design, simulation, development, and measurement done on the rectangular microstrip patch antenna for the ISM band of frequencies is presented in this paper. This rectangular patch antenna is fed by a microstrip line feed. Its resonance frequency performance is studied between 2.4-2.5 GHz. This band of frequencies is ISM band of wireless applications. The design and simulation are done in Computer Simulation Technology (CST) software with FR4 substrate. According to its real application, the material, shape, and the type, the microstrip antenna is designed. The size of the antenna is calculated by the length, width expressions. Then the antenna is simulated for the radiation parameters obtained through optimizing and matching to meet the requirements. The parameters of antenna such as Reflection coefficient, Gain, VSWR and Band width are measured.

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I. INTRODUCTION

- An antenna is a device used to transform an RF signal, traveling on a conductor, into an electromagnetic guided wave in free space (i.e., in either transmitting or receiving mode of operation).
- Printed circuit techniques can be utilized to design the antennas on low frequency substrates to produce low cost and reconfigurable antennas in a low profile.
- The antennas are generally used in wireless application due to their higher performance, less cost, small weight, reduced size, appropriate shape, and easy to construct.
- A microstrip antenna consists of a sandwich of two parallel conducting layers separated by a single dielectric substrate. The lower conductor is called ground plane and upper conductor is known as patch.
- Antennas are frequency dependent devices. Each antenna is designed for a certain frequency band, and it rejects signals beyond the operating band.
- The Industrial, Scientific, and Medical (ISM) frequency bands are designated radio frequency bands as defined by the ITU (International Telecommunication Union).
- In a typical wireless communication system increasing the gain of antennas used for transmission increases the wireless coverage range, decreases errors, increases achievable bit rates and decreases the battery consumption of wireless communication devices.
- Microstrip patch antenna used to send onboard parameters of article to the ground while under operating conditions.

II. LITERATURE SURVEY

By surveying it is planned to design and implement Rectangular microstrip Patch Antenna resonating at ISM Band of 2.46 GHz frequency. Microstrip patch implementation is well given by Salai Thillai Thilagam [salai thillai, 2018]. Design features were taken from Prakash Bhartia [Prakash Bhartia, 2018]. S Sreenath Kashyap contribution on ISM band are noted [7] Based on the above inputs the proposed antenna is designed using CST software and tested its antenna parameters using network analyzer [6]. Microstrip patches are popular by their less weight, small space, and work with components with minimum cost. These antennas can be interconnected by networks and active devices with printed microstrip line fed. A patch antenna comprises of a radiation part as colored on dielectrics substrate top side and bottom side as ground shown in Figure 1. Both sides are made by copper material. The radiating patch and the microstrip feed lines are designed on the dielectric substrates. The radiating patch structure is usually square, rectangular, circular, triangular, elliptical and/or some common design. A rectangular geometry is plannedhere.

III. DESIGN AND ANALYSIS

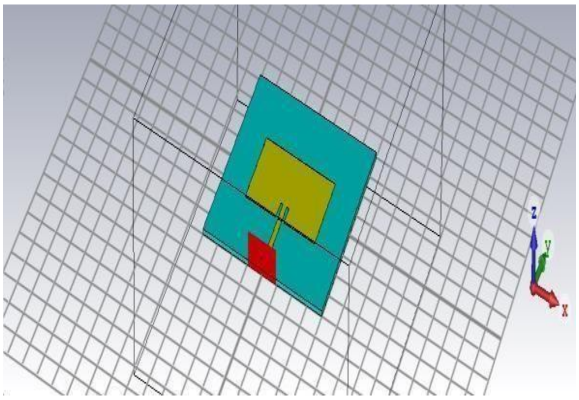
Microstrip patch antennas can be powered by a variety of techniques by two main types of contacting type and non-contacting type. The RF current is given to the radiating patch by connecting a microstrip line and probe in contacting type. Coupling of electromagnetic fields is done by the non- contacting type. The common feeding techniques utilized are the coaxial probe, microstrip line, through aperture coupling and by proximity coupling.

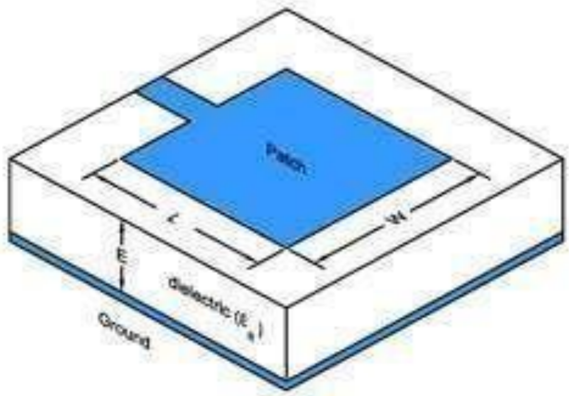
Microstrip Line Feeding: In this technique, a conducting microstrip line is attached directly to the center edge of the microstrip patch as shown in Figure 1. The feeding strip thickness is less than width dimension. This feeding gives a planar structure.

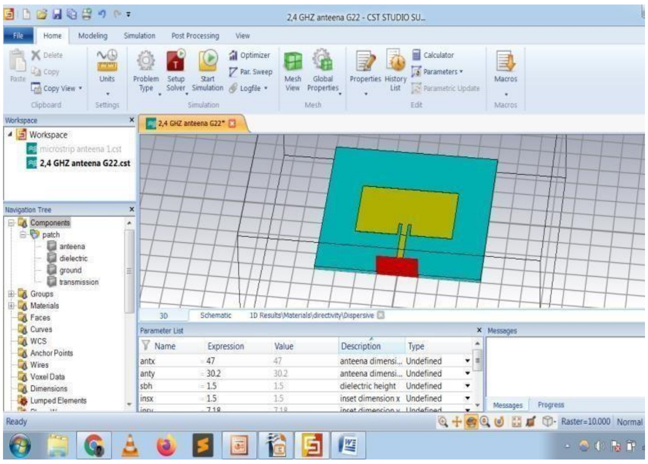
Aperture Coupled Feeding: In this type of non-contact, the feed is given as microstrip line to patch through aperture made centered on ground plane. Coupling is done on waves. The coupling amount depends on the shape, size and location of the aperture. This method increases the antenna thickness and also provides shortbandwidth.

Coaxial Feed: The microstrip antennas are energized by Coaxial probe feed technique normally. In this, the inner conductor of the coaxial probe is connected to the radiating patch, while the outer conductor is soldered to the ground plane. The advantage of this feeding is to feed at any location in the patch by matching with its input impedance.

Figure 1. Structure of a Microstrip Patch Antenna with microstrip line.







This includes design, simulation, fabrication and measurement. The design of a rectangular microstrip patch antenna has the following parameters:

(i) Operating Frequency (fo): The antennas operating frequency is taken considerably. The Mobile Communication Systems uses the frequency range from 1800-5600 MHz. Hence these antennas resonant frequency is selected as 2.4 GHz for thisdesign.

(ii) Substrate Dielectric constant (εr): The dielectric material selected for this design is FR4 of dielectric constant of 4.6. This one is easily available low-cost lossy substrate.

(iii) Dielectric substrate thickness or height (h): For the microstrip patch antenna to be used in cellular phones, it should not be bulky. Hence, the dielectric substrate height is considered as 1.6 mm [1]. Hence, the essential parameters are taken for the design: fo= 2.4 GHz, εr = 4.6, h = 1.6 mm

Step 1: Patch width Calculation (W): It is expressed by the equation (1) as:

$$W = \frac{c}{2f_0\sqrt{\frac{(\varepsilon r+1)}{2}}} \qquad (1)$$

By Substituting c = 3x10^8 m/s, εr = 4.6 and fo = 2.46 GHz, width is got as W = 36.5 mm

Step 2: Effective dielectric constant Calculation (εreff): It gives the value as:

$$\varepsilon_r = \frac{\varepsilon_{r+1}}{2} + \frac{\varepsilon_{r-1}}{2} + [1 + 12\frac{h}{W}]^{\frac{1}{2}}(2)$$

By Substituting εr = 4.6, width as 36.5 mm and thickness as 1.6 mm it is got as εreff=6.12

Step 3: Calculation of the Effective length (Leff): Equation (3) gives the effective length as:

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \qquad (3)$$

By Substituting εreff = 6.12, c = 3x10^8 m/s and fo = 2.46 GHz it is got as Leff = 24.64 mm

Step 4: Length extension Calculation (ΔL): Equation (4) gives the length extension as:

$$\Delta L = 0.412h\,\frac{(\varepsilon_{reff+0.3})\frac{W}{H}+0.264}{(\varepsilon_{reff-0.258})\frac{W}{H}+0.8}(4)$$

By Substituting εreff = 6.12, W = 36.5 mm and H = 1.6 mm it is got as ΔL=1.09mm

Step 5: Actual length of patch Calculation (L): The length is obtained by re-writing equation (5) by Substituting Leff = 24.64 mm and ΔL =1.09 mm it is calculated as

L =23.55 mm (5)

Step 6: The ground plane dimensions Calculation (Lg and Wg): Infinite ground is assumed in the method of transmission line model. However, for practical purpose, it is essential to have a finite ground plane. It has been obtained by approximately six times the substrate thickness in addition to length [2]. It is shown below in the followingexpression.

Lg=L+6*h =23.55+6*1.6=33.15mm (6)

Wg=W+6*h =36.5+6*1.6=46.1mm (7)

Step 7: Determination of feed points: A coaxial probe is used to connect in this design. The feed point location is denoted as (Xf ,Yf). That must be located on the patch, where the 50 ohms input impedance is achieved. For different locations of the feed point, the return loss is compared and that feed point is selected where the R.L is most negative. According to the existing point along the length of the patch where the return loss is minimum. Hence in this design, Yf will be zero and only Xf will be varied to locate the optimum feed point[1].

Step 8: Microstrip line calculation

$$Zo = \frac{87.0}{\sqrt{\varepsilon_r + 1.41}} \times \ln\left(\frac{5.98h}{0.8W + t}\right) \quad (8)$$

It is calculated that W=2.95 mm and L 5.22 mm for Z0=50 ohm, Electrical length =28.1mm

Dimensions for designed Antenna is calculated and Patch antenna dimensions are presented after the calculations in tabular form.

The layout overview of patch antenna is following below. Designing the antenna with appropriate dimensions, Simulate the antenna, Analyse the design in layout view, Evaluate the performance measure of frequency, return loss, power, gain, Fabrication, Measuring. In order to have the desired resonance at more than one frequency generally we can go for multi band [8]techniques.

TABLEI. DIMENSIONS OFANTENNA

Plane	Dimension	Measurement values(mm)
Radiating patch	W	36.50
Length	L	23.55
Ground plane	Wg	46.10
Length	Lg	33.15

TABLEII. CHARACTERISTICS ANDVALUES

Antenna characteristics	Measurement values
Directivity(dB)	5.64
Gain(dB)	5.87
Power radiated(W)	0.0091
BW(MHz) (2.38-2.58GHz)	200

IV. RESULT ANDDISCUSSIONS

Simulation is done by the CST software by following the procedures in that software. FR4 substrate is selected.

The Simulation Frequency range is set as 2.1 GHz – 2.7 GHz (adaptive sweep) and added a new Single Point of 2.46 GHz as below. Simulate option is selected and observed the simulation results in the data display. Simulated results are shown in figure 2.

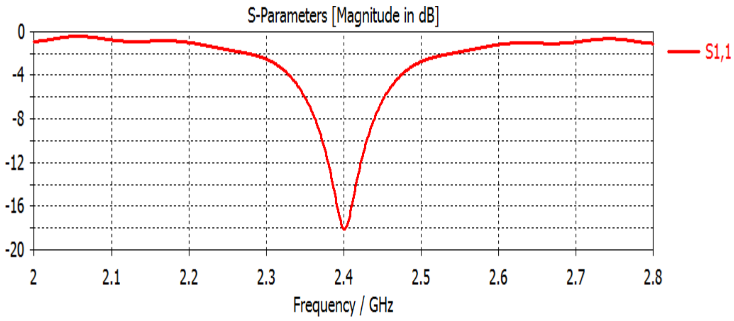


Figure 2. Simulation results Frequency Vs Magnitude

Far field computation will be done and results will be displayed in the post processing windows. Window Tile is used and then Plot Properties are added from the bottom tabs and then selected the Far Field option and Antenna Parameters were selected to see all the required data.

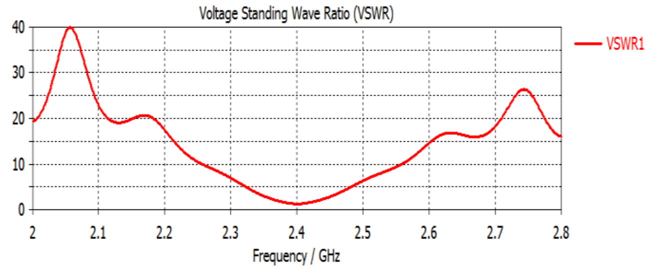


Figure 3. Measured VSWR for designed antenna

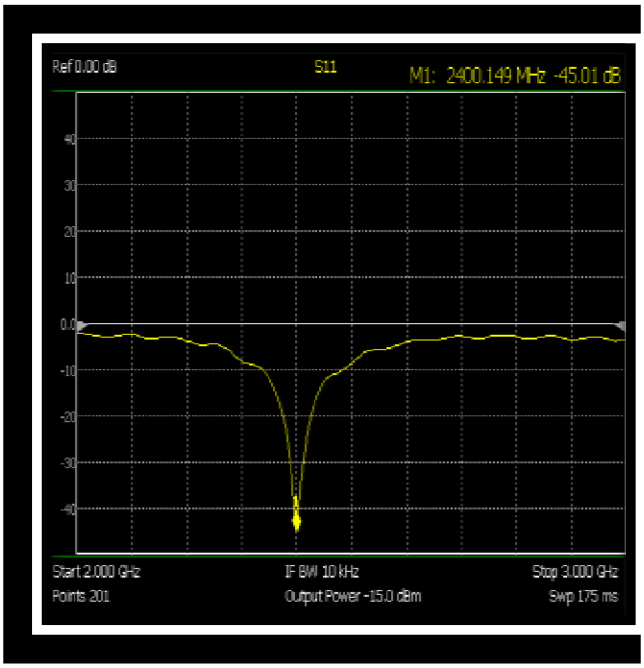


Figure 3. Measured Reflection Co-efficient of designed Antenna

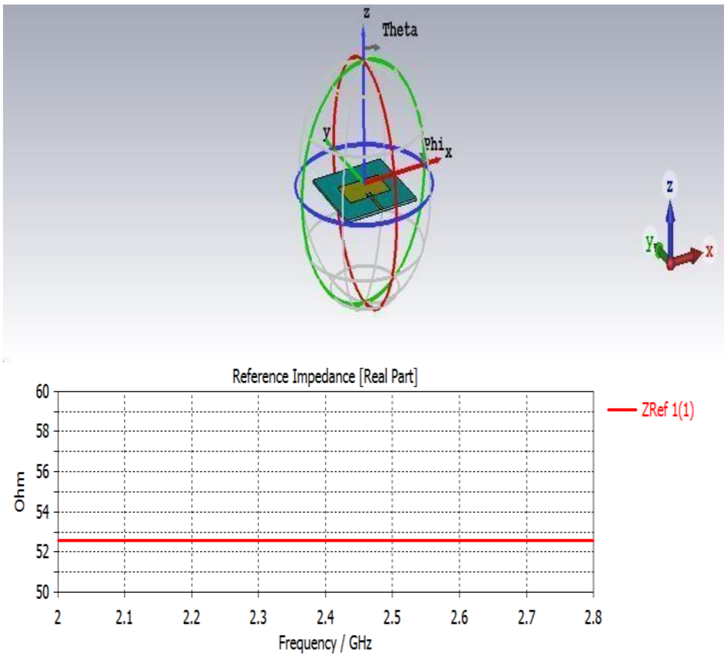


Figure 4. Impedance Measurement for designed antenna

Figure 3 shows measurement of reflection coefficient of rectangular microstrip patch antenna using network analyzer.

The corresponding value of VSWR is 1.45 shown in figure 2. The value of impedance is 49.8 Ω at frequency 2.46 GHz are shown in Figure.4

Because of more microstrip line thickness, the antenna radiates for high gain value. The Results of the developed antenna is tested and results are presented. and Discussed in Table 3 and 4. It shows the comparison of simulation with measured results and with other research design for the designed rectangular microstrip patch antenna.

TABLEIII. RESULTS OF THE DESIGNED PATCHANTENNA

Parameters	**Simulation**	
S11(dB)	-18	
VSWR	1.45	
Impedance	1.0-j0.001	
Gain	5.87	

V. CONCLUSION

Rectangular microstrip patch antennafed by microstrip line is expected and it is developed. The results are simulated using CST software and tested in the laboratory using Network analyzer. The designed microstrip rectangular patch antenna efficiently propagates at 2.46 GHz frequency and gives the return loss of -16 dB with an impedance matching at 50 GHz, feed point location is 45 ohms, directivity as 5.64 dB, VSWR is 1.45 and with a gain of 5.87 dB. Antenna Radiation Efficiency comes out to be 97.05% at 2.46 GHz. The measured and simulation results are found to be satisfactory and antenna may be suitable at ISM frequency band applications like Bluetooth, WLAN etc. This research can be further developed on high frequency substrates to increase the gain value.

Acknowledgment

The authors are thankful to the research center, ECE Department, Noida institute of engineering and technology College, Greater Noida.

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