A detailed project report on the

"Design of a Dual-Band Microstrip Patch Antenna for 5G and Wideband Communication"

Submitted for the partial fulfilments for the requirement of paper in B.Tech. 5th Semester

"BEC 508: Design Project Phase – I"

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Declaration

This is to certify that the project work entitled " **Design of a Dual-Band Microstrip Patch Antenna for 5G and Wideband Communication** " is a bonafide work carried out by us bearing University Enrolment Number " **U1951019" &** "**U1951026"** as a student of B.Tech(ECE), 5th Semester in the Department of Electronics and Communication, University of Allahabad, Prayagraj (INDIA), under the esteemed supervision of ***" Prof. J. A. Ansari "*** &***"Prof R.S. Yadav".***

I declare that the work presented here is carried out by us and has not been submitted anywhere else for the award of any degree/certificates.

Signature

(''Prem Narayan & Sachi Dwivedi")

Work presented in this report has been done under my supervision.

Signature

("Prof. J.A. Ansari" & "Prof. R.S. Yadav")

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Acknowledgement

It is our privilege to express our sincerest regards to our project supervisor, prof. "**J.A. Ansari**", "**Prof. R.S. Yadav**", & " **Mr. S.K. Jha**" for their valuable inputs, able guidance, encouragement, wholehearted cooperation and constructive criticism throughout our project. We deeply express our sincere thanks to our head of department Prof. "R.S Yadav" for encouraging and allowing us to present the project of the topic "**Design of a Dual-Band Microstrip Patch Antenna for 5G and Wideband Communication**"

I also acknowledge with a deep sense of reverence, my gratitude towards my parents, who has always supported me morally as well as economically. Last but not least gratitude goes to "**Mr Shekhar Yadav**" & "Ms **Iqra Masroor**" who helped me a lot in this project without them this project would not have been completed.

ABSTRACT

A very compact, high efficiency and simple microstrip patch antenna for wideband applications is presented in this communication. The design employs a slotted rectangular patch fed by a 5**0*Ω*** micro strip line. The bandwidth is increased by cutting some rectangular slots on the patch. The antenna is designed on a small size ground plane (20 mm x 20 mm) and is simulated by "**ANSSY HFSS**" version- 15.0.0, The impedance bandwidth at -10 dB return loss for the proposed antenna is about (19.4 to 20.4 GHz) & (22.5 to 22.9) with centre frequency at 19.9 and 22.7 GHz.

CHAPTER 1

Introduction

1.1 Introduction

The recent trends show that wireless communication has evolved at a fast rate. 5G wireless standard has evolved to be the most recent technology nowadays. With the stupendous increase in mobile data, technologies are approaching from 4G i.e., the fourth generation to 5G, fifth-generation various fields has already adopted the 5G technology such as Internet of Things (IoT), advanced MIMO structure, advanced small cell technology etc. Some of the future systems that will become a reality due to 5G are Smart grids, Smart Cities, Smart transportation, Telemedicine, Machine to machine communication etc. Microstrip Patch Antenna and Printed Inverted F Antenna are the emerging candidates in fields of 5G wireless communication And other field microstrip antenna are used in a broadband range of applications from radar, telemetry Navigation, bio-Medical, mobile, Satelite and GPS.UWB (Ultra Wideband) technology enables fast and reliable transmission of data and consumes very low power
Microstrip antennas became very popular in the 1970s primarily for spaceborne applications. Today they are used for government and commercial applications. These antennas consist of a metallic patch on a grounded substrate. The metallic patch can take many different configurations. However, the rectangular and circular patches, are the most popular because of ease of analysis and fabrication, and their attractive radiation characteristics, especially low cross-polarization radiation. The microstrip antennas are low profile, comfortable to planar and nonplanar surfaces, simple and inexpensive to fabricate using modern printed-circuit technology, mechanically robust when mounted on rigid surfaces, compatible with MMIC (Monolithic microwave integrated circuit) designs, and very versatile in terms of resonant frequency, polarization, pattern, and impedance. These antennas can be mounted on the surface of high-performance aircraft, spacecraft, satellites, missiles, cars, and even mobile devices

1.2 Objective

The main objective of this project is design Design of a Dual-Band Microstrip Patch Antenna for 5G and Wideband Communication. This project aims to introduce the general techniques produced to improve the bandwidth, return loss and gain.

1.3 Literature Survey

The invention of Microstrip patch antennas has been attributed to several authors, but it was certainly dated to the **1960s** with the first works published **by ''Deschamps"**. Greig and Engle man and Lewin, among others. After the 1970s research publications started to flow with the appearance of the first design equations. Since then different authors started investigations on Microstrip patch antennas like James Hall and David M. Pozar and some contributed a lot. Throughout the years, authors have dedicated their investigations to create new designs or variations to the original antenna that, to some extent, produce either wider bandwidths or multiple-frequency operation in a single element. However, most of these innovations bear disadvantages related to the size, height or overall volume of the single element and the improvement in bandwidth suffers usually from the degradation of the other characteristics.

This project aims to introduce the general techniques produced to improve the bandwidth, return loss and gain.

CHAPTER 2

Design of microstrip patch antenna

2.1 Design structure

There are three main specifications of the microstrip patch antennas, which depends upon the whole system. The other parameters are the resonant frequency, the substrate's stature, the substrate's stature, and the dielectric steady. This project shows the three parameters in which the resonant frequency is taken on be 19.9 GHz and 22.7 GHz. A dielectric constant **FR-4 Epoxy(4.4)** has been used. The height of the substrate is taken to be 1.6mm. Microstrip patch antenna contains three **layers namely the patch, substrate and the earth level surface**. The design is shown in fig.1

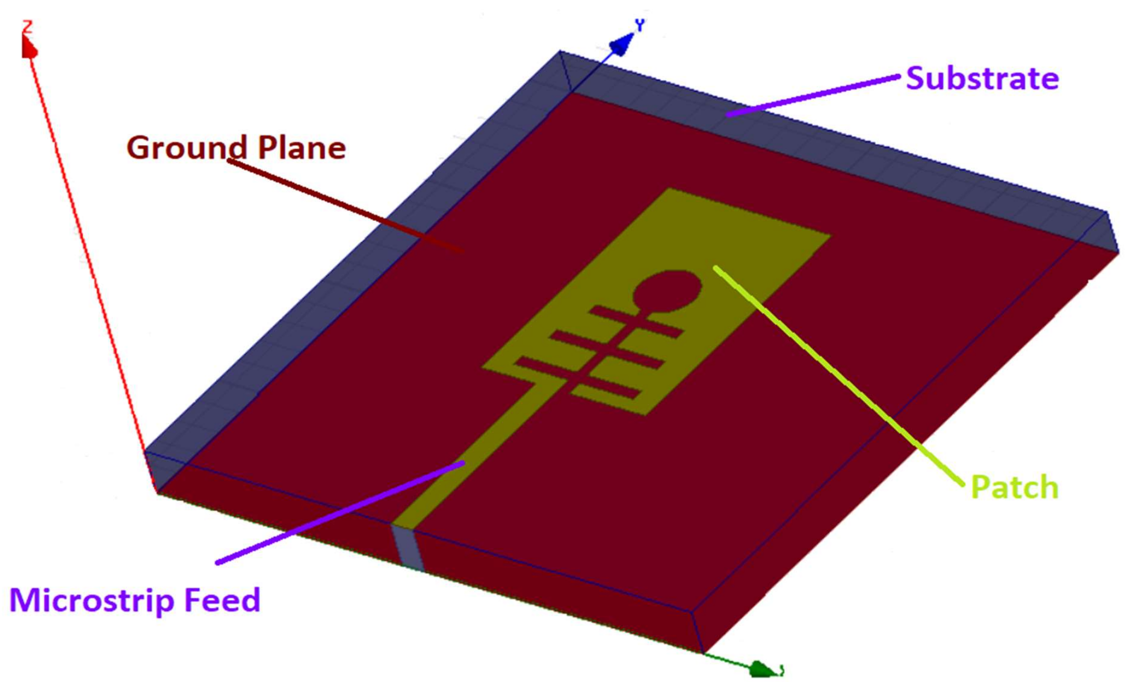

Fig.1. Design of microstrip Patch antenna

A. Patch

It is the top mainly layer of the microstrip patch antenna. It is usually made up of Copper or Gold. Electromagnetic radiations emit from here. To determine the operating frequency. we use the length and the width of the antenna. The magnitude of the antenna decreases with the increase in frequency. Similarly, the decrease in the frequency increases the size of the antenna.

B. Substrate

The selection of a suitable substrate for a microstrip patch antenna is critical. The substrate depends on the thickness and appropriate loss tangent. For a thicker substrate, the radiation increases decreased conductor loss and enhanced impedance bandwidth. This thicker substrate must be mechanically strong. Some things needed to be noted down during these characteristics. They are di-electric loss, surface wave loss, weight and unrelated radiation emission. When the substrate gets thicker from 0.1120, the rectangular patch antenna stops resonating. The primary reason for this is the inductive reactance of the feed.

C. Dielectric Constant

Dielectric constant plays an important role in the fringing field. Its role is somehow similar to that of the width in the substrate A substrate with low di-electric steady results in the increased fringing fields. Anis increases power radiation.

Before starting the project design, We should know about its basic parameters

There are three basic parameters of the patch antenna in operating frequency, dielectric constant used and Height of substrate.

1. Operating Frequency

The frequency range by the IS ranges from 2400 to 2483MHz. This range of frequency is used normally for wireless networks, Bluetooth applications. The resonant frequency selected in the project is to be 19.6 GHz and 22.7GHz.

2. Di-electric Constant

Di-electric constants are usually in the range of $2.2 \leq \varepsilon r \leq 12$. The ones that are most desirable for good antenna performance are thick substrates whose dielectric constant is in the lower end of the range because they provide better efficiency, larger bandwidth, loosely bound fields for radiation into space, but at the expense of larger element size. In my project dielectric constant is Fr-4 Epoxy (4.5).

3. Height of Substrate

In my project, the height of the substrate is 1.6mm.

2.2 Design Project

Based on the simplified formulation that has been described, a design procedure is outlined which leads to practical designs of rectangular microstrip antennas. The procedure assumes that the specified information includes the dielectric constant of the substrate (εr), the resonant frequency (fr), and the height of the substrate h. The procedure is as follows. Before designing a microstrip patch antenna, choose the specific dielectric constant and the h substrate. The parameters depend upon the frequency. The current design chosen here has 19.6 GHz. And 22.7GHz. FR4 Epoxy is the dielectric material select purpose. The dielectric constant has a value of the current design. The height of the substrate is chosen mm. To reduce the dimension of the antenna, choose a substrate with a high dielectric constant.

The important parameters for the design are below

- **fr = 19.6 GHz and 22.7GHz**
- **Ɛr = 4.5**
- **h = 1.6mm**

the parameter to be calculated are as given below

Step1: Calculation of the width(W):

The width of the patch can be calculated by the equation

$$W = \frac{c_0}{2f_r}\sqrt{\frac{2}{\varepsilon r+1}} \text{ -- (1)}$$

Where

W it is the width of the patch

c_0 it is the Speed of light

εr it is the value of the dielectric substrate

Step2: Calculation of effective dielectric constant (Effective refractive index:

The successful refractive recons estimation of a fix is an essential parameter in the structuring methodology of a microstrip fix receiving the wire. The radiations going from the fix towards the ground go through the air and some through the substrate (called bordering). Both the air and the substrates have diverse dielectric esteems, along these lines to account for this, we discover the estimation o successful dielectric steady. The estimation of the viable dielectric (reff) steady is determined to utilize the accompanying condition.

$$\varepsilon reff = \frac{(\varepsilon r+1)}{2} + \frac{(\varepsilon r-1)}{2}\left[1+12\left(\frac{n}{w}\right)\right]^{\frac{-1}{2}} \text{ -----------------(2)}$$

Step3: Calculation of the resonant length of the patch

The actual length of the patch can now be determined by solving (4) for L,

$$\Delta L = (\varepsilon r + 0.3)\left(\frac{W}{h} + 0.264\right) \text{----------------------------(3)}$$

$$L = \frac{1}{2fr\sqrt{\varepsilon eff}\sqrt{\mu_0\varepsilon_0}} - 2\Delta L \text{ ----------------------------(4)}$$

Leff = L + 2 ΔL --(5)

2.2 User interface design

In this project rectangular Microstrip Patch antenna design at 19.9 GHz and 22.7 GHz frequency has been modelled and simulated. The patch is the dominant figure of a microstrip antenna. The other components are the substrate and ground, which are the two sides of the patch. In this project, some slots in the patch according to return loss and gain.

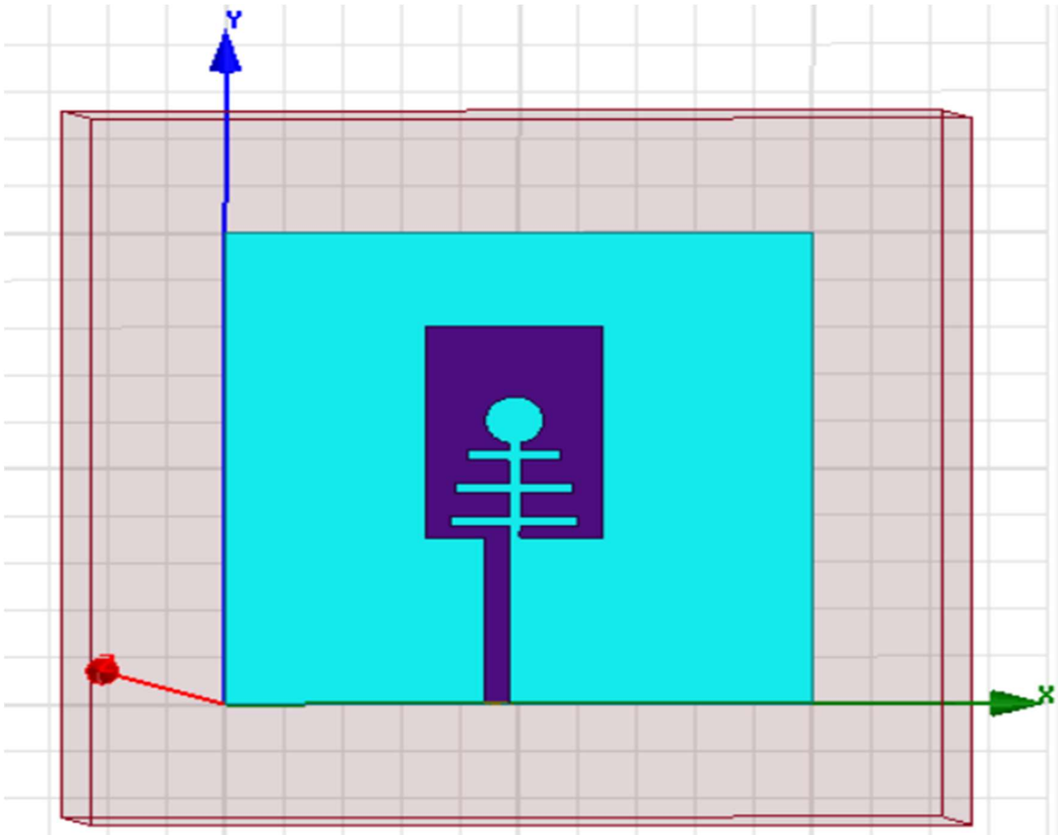

Fig.1 Rectangular Microstrip Patch Antenna

the above figure can represent the rectangular Microstrip patch antenna. Fig.1 can explain about single element patch antenna design.

2.3 Result

The microstrip rectangular patch antennas simulation is performed by ANSSY HFSS software. The parameters evaluated were VSWR, Radiation pattern, return loss, gain, 3d Polar plot.

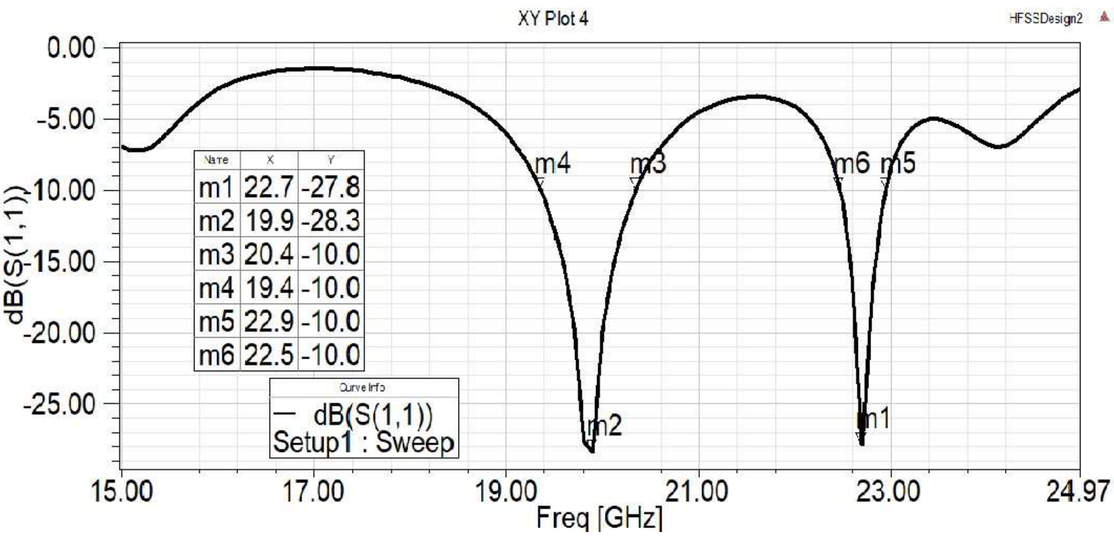

Fig-1. Return Loss v/s Frequency

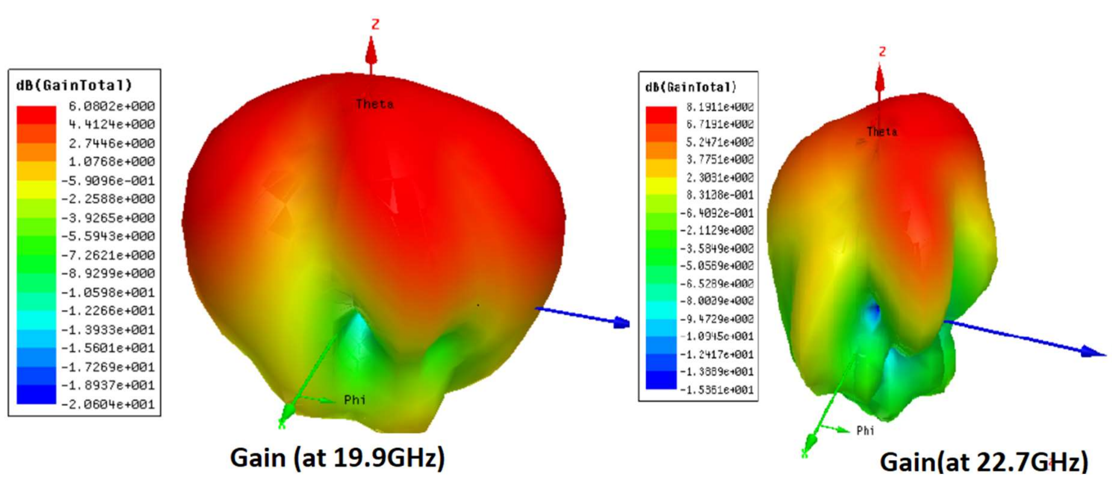

Fig2. 3D Gain at (19.9GHz and 22.7 GHz)

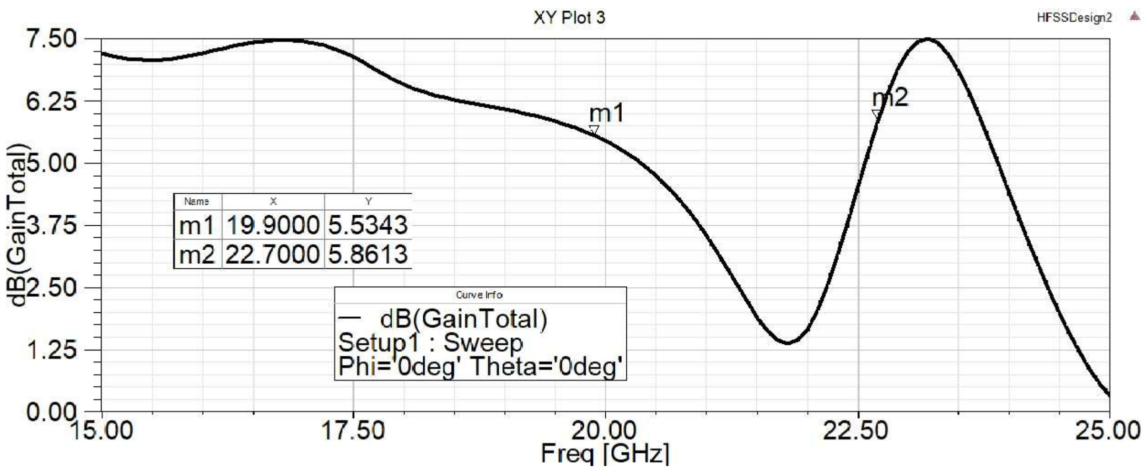

Fig.3 Gain v/s Frequency at (19.9 GHz and 22.7 GHz)

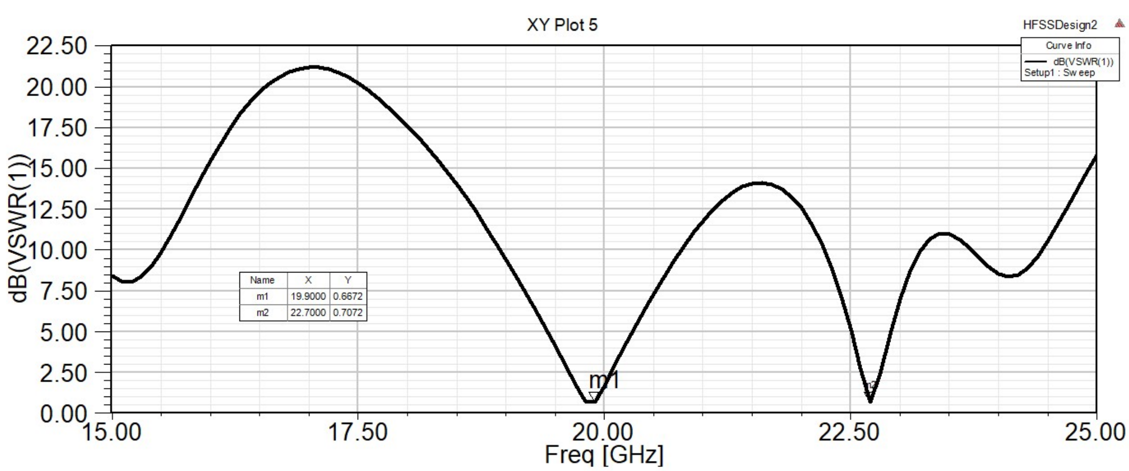

Fig.4 VSWR v/s Frequency (at 19.9 and 22.7)

CHAPTER 3

Analysis

3.1. Existing System

5G, like 4G LTE, is based on OFDM (Orthogonal frequency division multiplexing) and will follow the same mobile networking concepts as 4G LTE. The new 5G NR (New Radio) air interface, on the other hand, will improve OFDM much further, giving it far more flexibility and scalability.

In comparison to 4G LTE, 5G will not only provide faster and better mobile broadband services, but it will also expand into new service sectors such as mission-critical communications and linking the huge Internet of Things. Many new 5G NR air interface design strategies, such as a new self-contained TDD subframe design, make this possible.

3.2 Drawback of the Existing system

3.2.1 Connectivity Can be Affected by Obstructions

Because frequency waves can only travel a short distance, the 5G connection has a limited range. The fact that 5G frequency is disrupted by physical impediments such as trees, towers, walls, and buildings add to this disadvantage. The high-frequency transmissions will be blocked, disrupted, or absorbed by the obtrusions. To compensate for this setback, the telecommunications sector is expanding existing cell towers to enhance the broadcast range.

3.2.2 The Initial Costs of Rollout are Extremely High

Developing 5G infrastructure or making adjustments to present cellular equipment will cost a lot of money. Customers are likely to bear the brunt of these exorbitant fees, which will be worsened by ongoing maintenance expenditures necessary to maintain high-speed internet. Companies that provide cellular services are looking for methods to save money by utilizing alternative options such as network sharing.

3.2.3 Rule Access Limitations

While 5G may deliver true connectivity to most metropolitan regions, people living in rural areas may not necessarily benefit from the link. Many distant places around the country now lack access to any type of cellular service. The 5G carriers intend to focus on large cities with enormous populations, ultimately expanding to the outskirts, although this is unlikely to happen anytime soon. As a result, 5G communication will only benefit a small portion of the population.

3.2.4 Device Battery Drain

When it comes to 5G-enabled cellular devices, it appears that the batteries are not capable of lasting a long time. To enable this enhanced connectivity, battery technology must develop to the point where a single charge can run a cellphone for an entire day. Users are saying that, in addition to exhausted batteries, 5G-enabled devices are becoming extremely heated.

3.2.5 Drain the Device’s Battery

It appears that the battery in 5G-enabled cellular devices is not capable of lasting a lengthy time. Battery technology must advance to the point where a single charge can power a cellphone for an entire day to provide this expanded connection. Users report that 5G-enabled smartphones are growing excessively hot, in addition to having depleted batteries.

3.2.6 Diminishing the Aesthetics

Most towns reject the construction of new cellphone towers or the extension of existing cellphone towers because they are seen to detract from an area's general appearance and feel. Increased infrastructure development will be required for 5G, which may not necessarily be perceived as a good thing by local communities.

CHAPTER 4

Feasibility study of the project

4.1 Feasibility study

Wireless communication is dominated by digital transmission, not only for human contact but also for huge data transfer. 5G wireless mobile communications, as defined by IMT-2020 and ITU-R M.208, hold great potential. High-speed data transfer ranging from 1 Gbps to 20 Gbps. These data speeds are feasible employing a variety of methods, such as modulation or large bandwidth to accomplish broad bandwidth, carrier aggregation on modulation or the use of a higher frequency is a possible solution. A higher frequency band for 5G wireless mobile Communication was detailed in ITU-R M.2376-0. The 5G application was proposed to be deployed in a frequency range above 6 GHz, including 10 GHz or 20 GHz. An antenna system is one of the most critical components of a wireless mobile communication system. Antenna systems serve as transducers. Its role is to convert electrical energy is converted into electromagnetic wave energy. As a result, the antenna system requires should be given with the best-designed, lightweight, and compact antenna to construct the greatest wireless mobile communication performance. one of the smallest and lights microstrip antennae would be used.

This project proposes a lightweight and small microstrip antenna that uses proximity coupling to increase bandwidth. The proposed antenna operates at 19.9 and 22.7 GHz. The situation arises because the feasibility and efficiency of mm-wave communications proposed for 5G cellular communication have been demonstrated to be 20 times greater than that of 4G (LTE) cellular communication. The demand for 5G technology leads to the conclusion because an antenna with wide bandwidth and high gain is required.

CHAPTER 5

Conclusion and Future Scope for further development

5.1 Conclusion

Two aspects of Microstrip antennas have been studied in this project. The first aspect is the design of a typical rectangular Microstrip antenna and the second is the design of a dual-band Microstrip antenna. A simple and efficient technique of the inset method has been introduced for an impedance matching improvement of the antennas. The main concern of the project is to study a Dual-band patch antenna using different techniques and frequency ratios of the Microstrip antenna. The dual-band Microstrip antenna is a more conventional approach for the implementation of a broadband antenna and for satellite communication where the low-frequency ratio is used. Initially, a single element rectangular Microstrip antenna is designed to operate at frequency GHz and then, the dual-band Microstrip antenna is designed to resonate at frequency range 19.9 GHz to 22.7 GHz. The dual-band antenna shows that with the correct selection of slot dimensions and positions, the dual-frequency response can be achieved, while still allowing the use of a planar feed.

5.2 Future Scope for Further Development

Based on gathered observations while completing this project, topics were identified which would benefit from further investigation.

- ❖ At present facility for fabrication of the patch, Antenna is available in our institute, the same work will be performed later. The simulated optimized and experimental results will be compared.

- ❖ Using the dial frequency Microstrip antenna as a basis, the circular dual-frequency Microstrip antenna can be developed for using the same INSET feeding technique, in terms of wavelength, between the corresponding slots on the dusting edge, the spokes of the antenna are arranged around the circumference.

- ❖ Using the shorting post and changing the sot position in this patch to develop the WLAN concept (24 GHz & 52 GHz frequency) and also this patch can be used in satellite communication where the low-frequency ratio patch is issued.

- ❖ This microstrip patch antenna resonant at near to 5g band.

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