Logo Textile Antenna for WiFi and Bluetooth Applications

A Seminar Report

Submitted to the APJ Abdul Kalam Technological University

in partial fulfillment of requirements for the award of degree

Bachelor of Technology

in

Electronics and Communication Engineering

by

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KOTHAMANGALAM 2022 - 23

CERTIFICATE

This is to certify that the report entitled **Logo Textile Antenna for WiFi and Bluetooth Applications** submitted by **Febin Sebastian (MAC19EC048), Fuhad Sanin (MAC19EC050), Sahal Sameer (MAC19EC094), Sheba Sajeev TM (MAC19EC104)** , to the APJ Abdul Kalam Technological University in partial fulfillment of the B.Tech. degree in Electronics and Communication Engineering is a bonafide record of the project work carried out by him under our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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DECLARATION

We Febin Sebastian (MAC19EC048), Fuhad Sanin (MAC19EC050), Sahal Sameer (MAC19EC094), Sheba Sajeev TM (MAC19EC104) hereby declare that the project report **Logo Textile Antenna for WiFi and Bluetooth Applications**, submitted for partial fulfillment of the requirements for the award of degree of Master of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by us under supervision of Prof. Sanjana Peter .

This submission represents my ideas in our own words and where ideas or words of others have been included,We have adequately and accurately cited and referenced the original sources.

We also declare that We have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. We understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

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Abstract

The demand for wearable electronics have gained much attention recent years due to their attractive features and possibilities in enabling lightweight, flexible, low cost, and portable wireless communication and sensing.Such antennas need to be conformal when used on different parts of the human body, thus need to be implemented using flexible materials and designed in a low profile structure.In this project we design a logo textile antenna for the material with substrate permittivity = 3. Here we use Dacron fabric textile material as Antenna substrate.This Logo-Type antenna represents name of our college. It is used for body centric communication.This report aims to present different challenges and issues in designing wearable antennas, their material selection, and fabrication techniques.

Acknowledgement

We take this opportunity to express our deepest sense of gratitude and sincere thanks to everyone who helped us to complete this work successfully. We express our sincere thanks to **Dr.Thomas George**, Head of Department, Electronics and Communication Engineering, Mar Athanasius College of Engineering Kothamangalam for providing us with all the necessary facilities and support.

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Finally We thank my family, and friends who contributed to the successful work.

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Chapter 1

Introduction

Wearable technology is kind of electronic device to be worn on users body. Logo type textile antenna is one of the most fascinating and cutting edge research area of modern era.Smart e-textiles are a promising platform for body area wireless sensor networks. Antenna design on textiles has been an increasingly popular research area with fully-textile, hybrid and fully grid antennas designed for integration in garments. Antennas in one of the most significant components in wearable devices as they contribute to the overall efficiency of a wearable wireless link.

The meaning of "wearable antenna" is the flexible and efficient system connected with the human body for wireless communication. In addition to safety, health and living standards, the design and creation of these systems is of utmost importance . People are now much more interested in antenna used for body-centric communication since they see it as an increasingly popular kind of communication which used in body part-based physically implemented elements for capture and data communication. In wearable technology the most dominating research issue is textiles or fabric-based antennas. Since clothing is an everyday The associate editor coordinating the review of this manuscript and approving it for publication was Debabrata Karmokar . necessity for most people it makes sense to incorporate electrical devices in their clothes and turn them into smart clothing. With the wearable antenna people can live their lives more comfortably and without difficulty.

A smart textile has applications in a number of diverse disciplines including the sports, fashion, military, medical and healthcare sectors. The criteria of most applications are light weight, low cost, nearly maintenance free and easy to install, which is why the wearable antenna fulfils these needs. It is essential to have an antenna that is smaller in size and more durable to achieve the aforementioned requirements.The antenna described here are appropriate for everyone from the elderly to athletes and they are used to monitor various activities. Textile-based antennas are especially reliant on fabric while in development. To produce a high-performance antenna system the fabric must be lightweight and pourable.

Wearables have diverse applications in our daily life. They are not limited to wristwatches, fitness bands, augmented reality glasses, but also encompasses many medical applications. In the field of healthcare, wearable devices are used to monitor critical health conditions of the patients several aspects need to be considered when designing wearable antennas for use as a part of wearers outfit. They need to be unobtrusive, flexible and operate with minimum degradation in proximity to the human body. Wearable antennas are also challenging in terms of fabrication - the availability of space on specific body locations, the effects of the host body, and performance degradation due to structural deformation are issues that need to be considered in the design process.

1.1 Motivation

An antenna is an essential device for the development of wireless electronic textiles. It allows communication between sensors in the garment with external devices. Wearable antennas have to be flexible, lightweight, washable, and robust. Textile antennas are a special class of antennas that are partially or entirely made out of textile materials, in contrast to conventional antennas, which consist of rigid materials.

As can be intuitively understood, the reason behind the use of textile materials in antennas lies in the application for which they are intended, being smart textile systems and body-centric communication.An antenna is an essential device for the development of wireless electronic textiles. It allows communication between sensors in the garment with external devices. Wearable antennas have to be flexible, lightweight, washable, and robust. Wearing may affect the properties of the antenna, as well as the permittivity and thickness of the substrate.

1.2 Objective

Textile antennas have a variety of applications, including health monitoring, skin cancer detection, various sports activities, heart rate monitoring, temperature monitoring, and so on.It allows communication between antennas.The practical use of textile antennas is most convenient when they are integrated into clothing. Due to the latest development of antennas and wireless communication in recent years,there is widespread usage of wireless electronic devices that are becoming smaller and smaller every day.The main objective of a wearable antenna is to provide a wireless communication or sensing capability to a portable device, such as a wearable device.

Chapter 2

Literature Review

The evolution of antenna technology for man-machine interface has taken quantum leaps in utilizing textile materials as antenna substrates. In that sense, textile materials form interesting substrates hence fabric antennas can be easily integrated into clothes. Textile materials generally have a very low dielectric constant, which reduces the surface wave losses and improves the impedance bandwidth of the antenna. In comparison with high dielectric substrates, textile antennas are physically larger. Textile material is generally classified into two categories: Man Made fibers and Natural fibers. Synthetic fiber is subcategory of manmade fibers[2].

Utilization of wearable textile materials for the development of microstrip antenna segment has been rapid due to the recent miniaturization of wireless devices. The use of wearable textile antennas is increasing rapidly in wireless applications. A wearable antenna is meant to be a part of the clothing used for communication purposes, which includes tracking and navigation, mobile computing and public safety. Specific requirements for wearable antennas are a planar structure and flexible construction materials. Several properties of the materials influence the characteristics of the antenna. For instance, the bandwidth and the efficiency of a planar microstrip antenna are mainly determined by the permittivity and the thickness of the substrate. The use of textiles in wearable antennas requires the characterization of their properties. This paper reviews a variety of wearable textile antennas in order to provide background information and application ideas for designing such antennas. The various materials used in the construction of wearable textile antennas, their fabrication methods, as well as the antenna types and their application fields are summarized[1].

In communicating with external networks, antenna can be fabricated as implantable device and also be placed as wearable device for continuous monitoring. The communication can also be established in two ways such as link can be established either wireless for body-mounted devices and radio link can be established between body worn devices and base units. This can also be connected by establishing networks like Personal Area Networks (PAN) and Body Area Networks (BAN). The most important need of wearable antenna is that it should be in light weight, low maintenance cost, easy installation etc. The resident of body wearable antenna should be hidden and inconspicuous[4].

In the broad context of Wireless Body Sensor Networks for healthcare and pervasive applications, the design of wearable antennas offers the possibility of ubiquitous monitoring, communication and energy harvesting and storage. Specific requirements for wearable antennas are a planar structure and flexible construction materials. Several properties of the materials influence the behaviour of the antenna. For instance, the bandwidth and the efficiency of a planar microstrip antenna are mainly determined by the permittivity and the thickness of the substrate. The use of textiles in wearable antennas requires the characterization of their properties. Specific electrical conductive textiles are available on the market and have been successfully used. Ordinary textile fabrics have been used as substrates. However, little information can be found on the electromagnetic properties of regular textiles. Therefore this paper is mainly focused on the analysis of the dielectric properties of normal fabrics. In general, textiles present a very low dielectric constant that reduces the surface wave losses and increases the impedance bandwidth of the antenna. However, textile materials are constantly exchanging water molecules with the surroundings, which affects their electromagnetic properties. In addition, textile fabrics are porous, anisotropic and compressible materials whose thickness and density might change with low pressures. Therefore it is important to know how these characteristics influence the behaviour of the antenna in order to minimize unwanted effects. This paper presents a survey of the key points for the design and development of textile antennas[5].

Chapter 3

Methodology

3.1 Block Diagram

Wearable antennas are built using different kind of conductive and dielectric materials. These materials are carefully chosen to provide a reasonable amount of mechanical deformations (bending, twisting, and, wrapping) with minimal influence based on different weather conditions (rain, snow, ice, etc.) and proper EM radiation protection. Recently, other types of fabric/nonfabric materials have been used for wearable antennas.

Apparel with textiles are notable for employing antennas with which wireless properties can be discovered, identified, analyzed, controlled, etc. without causing the user discomfort. Smart wearable antennas are gaining in popularity because of the recent developments in fashion technology. As a result of their vast range of potential applications which include health control, sports, navigation and military, wireless systems have received more attention in recent years.

A textile antenna is a type of antenna that is integrated into or made using textile materials. It is designed to be flexible, lightweight, and wearable, making it suitable for applications in smart textiles, wearable electronics, and other emerging technologies. Here is a block diagram description of a typical textile antenna:
There are several steps involved in the design and development of wearable antennas. The first step in designing a wearable antenna is to determine the frequency range

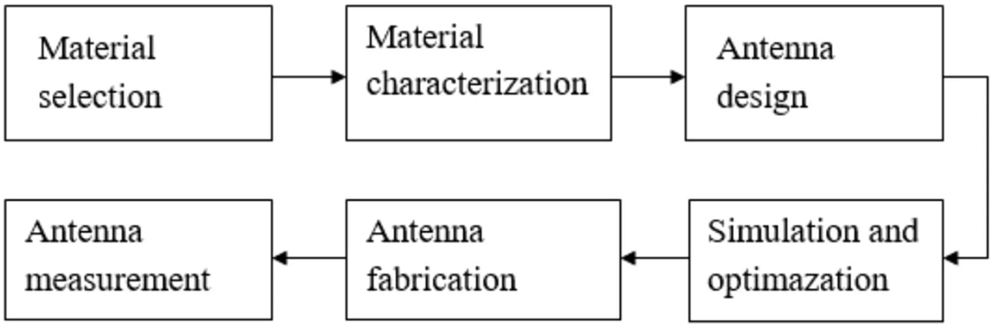

Figure 3.1: Block Diagram

and performance characteristics that are required for the specific application.Choose a suitable antenna design.The materials used for the antenna and its supporting structure will affect the performance and durability of the antenna. Factors such as electrical conductivity, strength, and weight will need to be considered when selecting materials. Once the antenna design and materials have been selected, the antenna can be fabricated using appropriate manufacturing techniques. The antenna can then be tested to ensure that it meets the desired performance specifications.The final step in the development process is to integrate the antenna into the wearable device, ensuring that it is properly positioned and supported to provide optimal performance.
Overall, the block diagram of a textile antenna illustrates the integration of the antenna components into a flexible textile substrate, enabling wireless communication or sensing in wearable applications.

3.2 Hardware Components

3.2.1 FR4 Epoxy substrate

FR-4 is a glass-reinforced epoxy laminate material. FR-4 is a composite material composed of woven fiberglass cloth with an epoxy resin binder that is flame resistant (self-extinguishing). ”FR” stands for ”flame retardant”, and does not denote that the material complies with the standard UL94V-0 unless testing is performed to UL 94, Vertical Flame testing in Section 8 at a compliant lab. The designation FR-4 was created by NEMA in 1968 FR-4 glass epoxy is a popular and versatile high-pressure thermoset plastic laminate grade with good strength to weight ratios. With near zero water absorption, FR-4 is most commonly used as an electrical insulator possessing considerable mechanical strength. Grade designations for glass epoxy laminates are: G-10, G-11, FR-4, FR-5 and FR-6. Of these, FR-4 is the grade most widely in use today. G-10, the predecessor to FR-4, lacks FR-4's self-extinguishing flammability characteristics. Hence, FR-4 has since replaced G-10 in most applications. .

3.2.2 ROGERS RO3006

Rogers RO3006 laminates are ceramic-filled PTFE composites designed to offer exceptional electrical and mechanical stability.RO3006 advanced circuit materials provide a stable dielectric constant (Dk) over a range of temperatures. This stability eliminates the step change in Dk that occurs for PTFE glass materials near room temperature.

Features

Dk of 6.15 +/- .15

Dissipation factor of .0020 at 10GHz

Low X, Y and Z axis CTE of 17, 17 and 24 ppm/°C, respectively.

3.2.3 SMA Connector

SMA (SubMiniature version A) connectors are semi-precision coaxial RF connectors developed in the 1960s as a minimal connector interface for coaxial cable with a screw-type coupling mechanism. The connector has a 50 impedance. SMA was originally designed for use from DC (0 Hz) to 12 GHz, however this has been extended over time and variants are available to 18 GHz and 26.5 GHz. There are also mechanically compatible connectors such as the K-connector which operate up to 40 GHz. The SMA connector is most commonly used in microwave systems, hand-held radio and mobile telephone antennas and, more recently, with WiFi antenna systems and USB software-defined radio dongles. It is also commonly used in radio astronomy, particularly at

Figure 3.2: SMA Connector

Figure 3.3: U.FL Connector

higher frequencies (5 GHz+).

3.2.4 U.FL Connector

U. FL Connectors are miniature surface-mount RF coaxial connectors developed by the Hirose Electric Group. These connectors offer high-frequency performance from DC to 6 GHz and are ideal for use in a wide range of miniature devices that require a compact connector solution.U.FL connectors are commonly used in applications where space is of critical concern, such as in smartphones and Laptop WiFi cards. U.FL connectors are commonly used inside laptops and embedded systems to connect the Wi-Fi antenna to a Mini PCI, Mini PCIe or M.2 WiFi card.

3.2.5 ESP 32

ESP32 can perform as a complete standalone system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor. ESP32 can interface with other systems to provide Wi-Fi and Bluetooth functionality through its SPI / SDIO or I2C / UART interfaces. ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth.

3.2.6 max30101

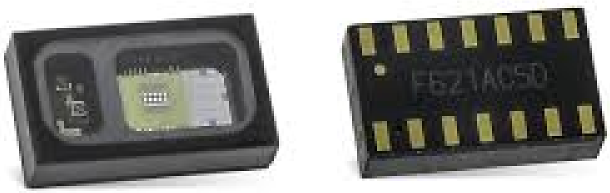

Figure 3.4: max30101

The MAX30100 is an integrated pulse oximetry and heartrate monitor sensor solution. It combines two LEDs, a photodetector, optimized optics, and low-noise analog signal processing to detect pulse oximetry and heart-rate signals. The MAX30100 operates from 1.8V and 3.3V power supplies and can be powered down through software with negligible standby current, permitting the power supply to remain connected at all times.

3.2.7 CH340G

Figure 3.5: CH340G

CH340 is a series of USB bus adapters, that provides serial, parallel or IrDA interfaces over the USB bus.Its functions include USB to serial port and USB to IrDA infrared or USB to printer port. In the serial port mode, CH340 provides commonly used MODEM contact signals, which are used to expand asynchronous serial ports for computers, or to directly upgrade common serial devices to USB bus.

3.2.8 AMS1117

The AMS1117 is a popular SMD package 3-pin voltage regulator that is available in many models for fixed and adjustable voltage requirements. The IC can deliver a maximum current of 1A and the output voltage can vary from 1.5V to 5V. It also has a low drop out voltage of 1.3V when operating at maximum current.

Chapter 4

Schematics and PCB Design

4.1 Schematic

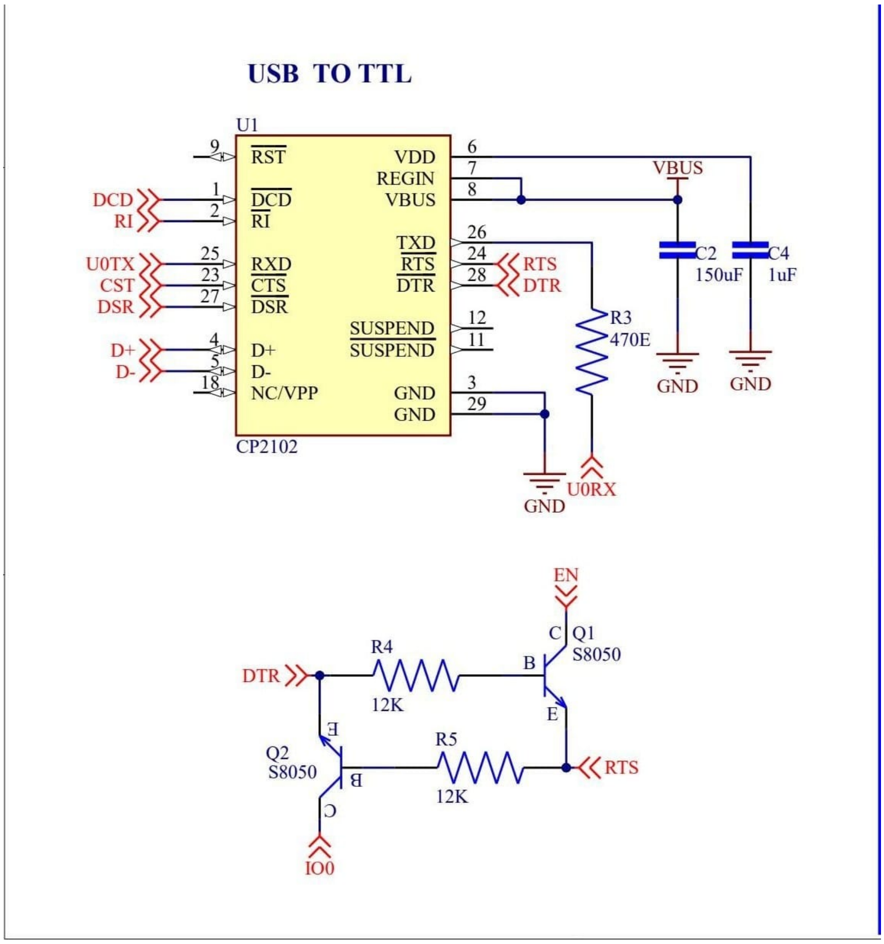

Figure 4.1: Schematic Diagram

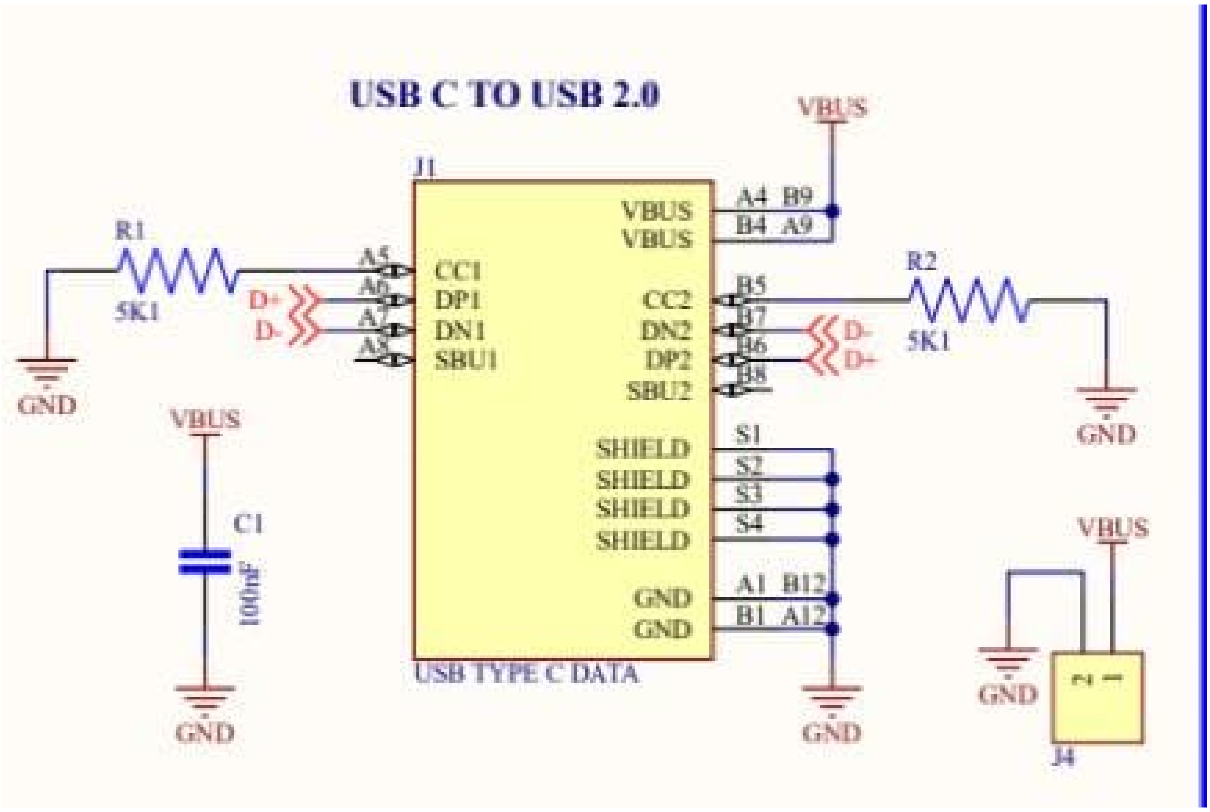

Figure 4.2: Schematic Diagram

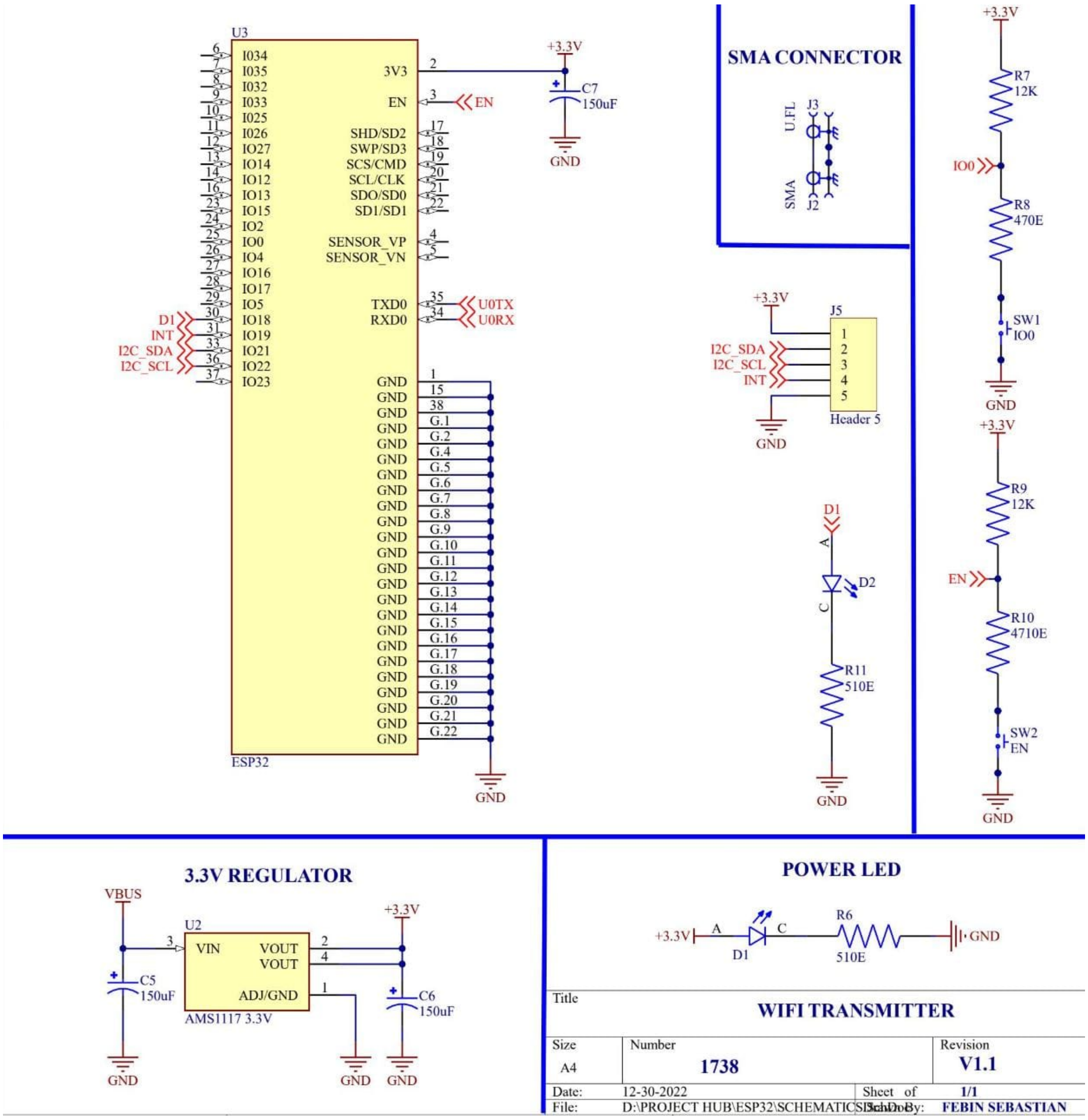

Figure 4.3: Schematic Diagram

This is a transmitter circuit. It collects data from the heart rate sensor and the oxymeter sensor and updates to the cloud based server.

4.2 PCB design

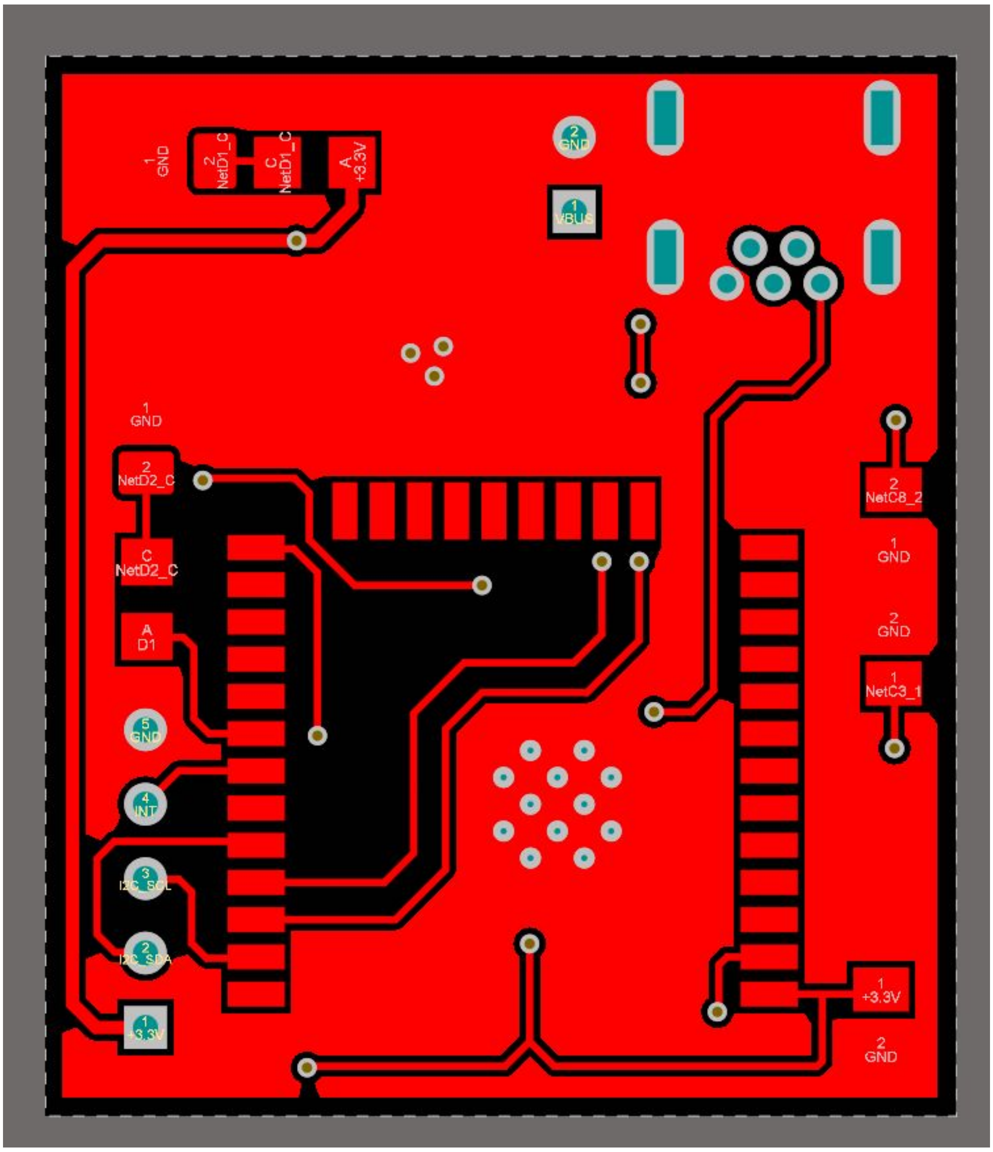

Figure 4.4: Transmitter

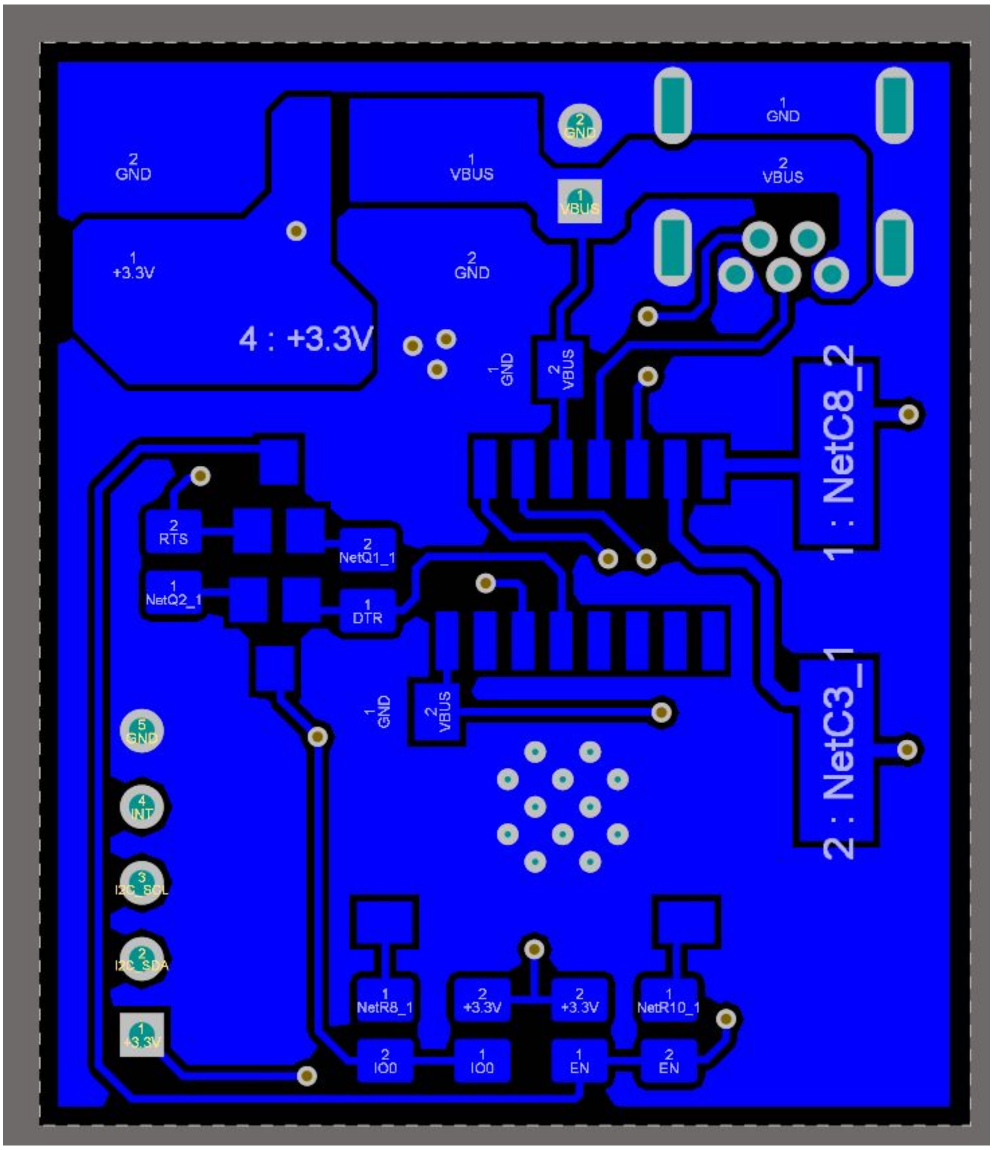

Figure 4.5: Receiver

4.3 3D View of PCB

The figure 4.6 and figure 4.7 shows the three dimensional view of pcb design.

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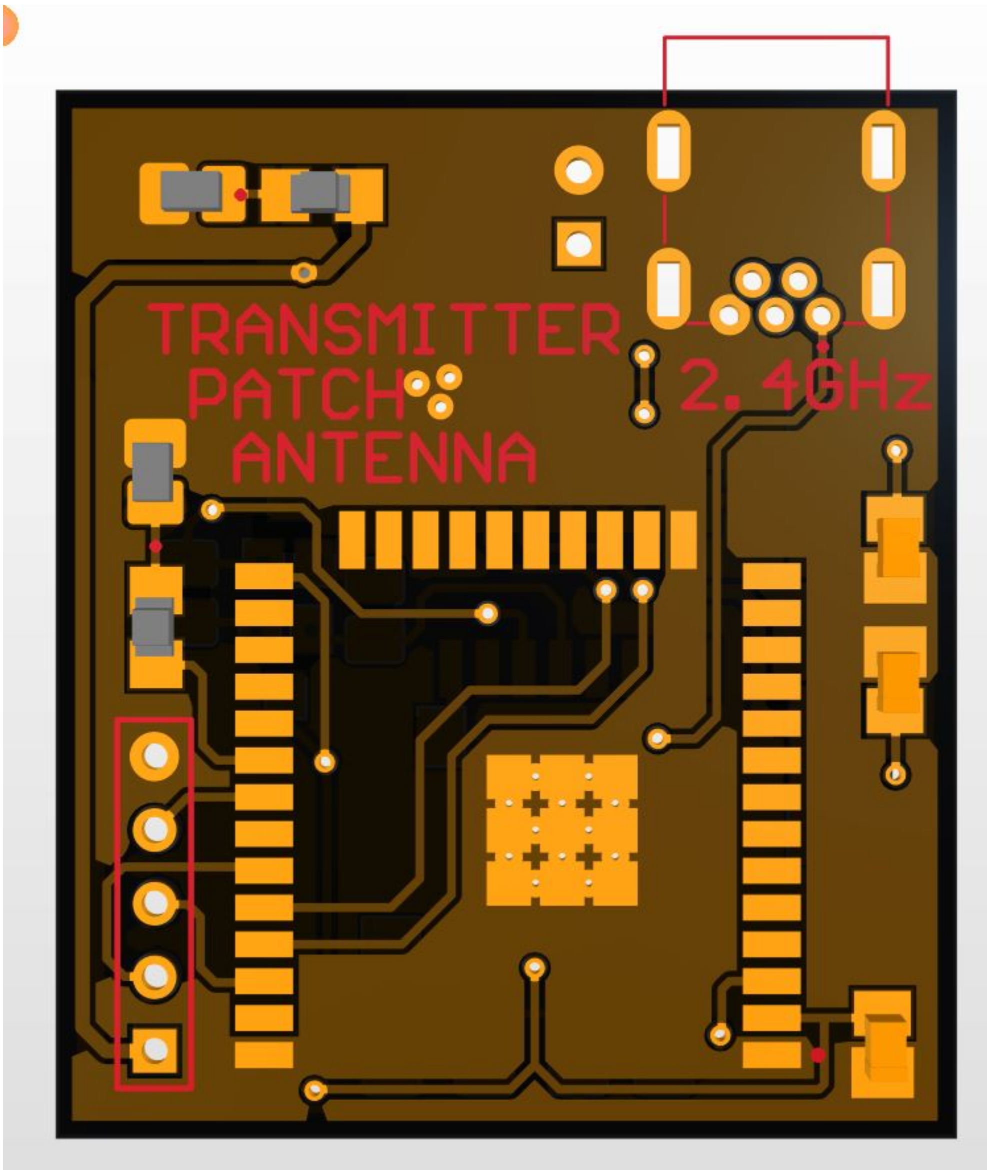

Figure 4.6: Transmitter

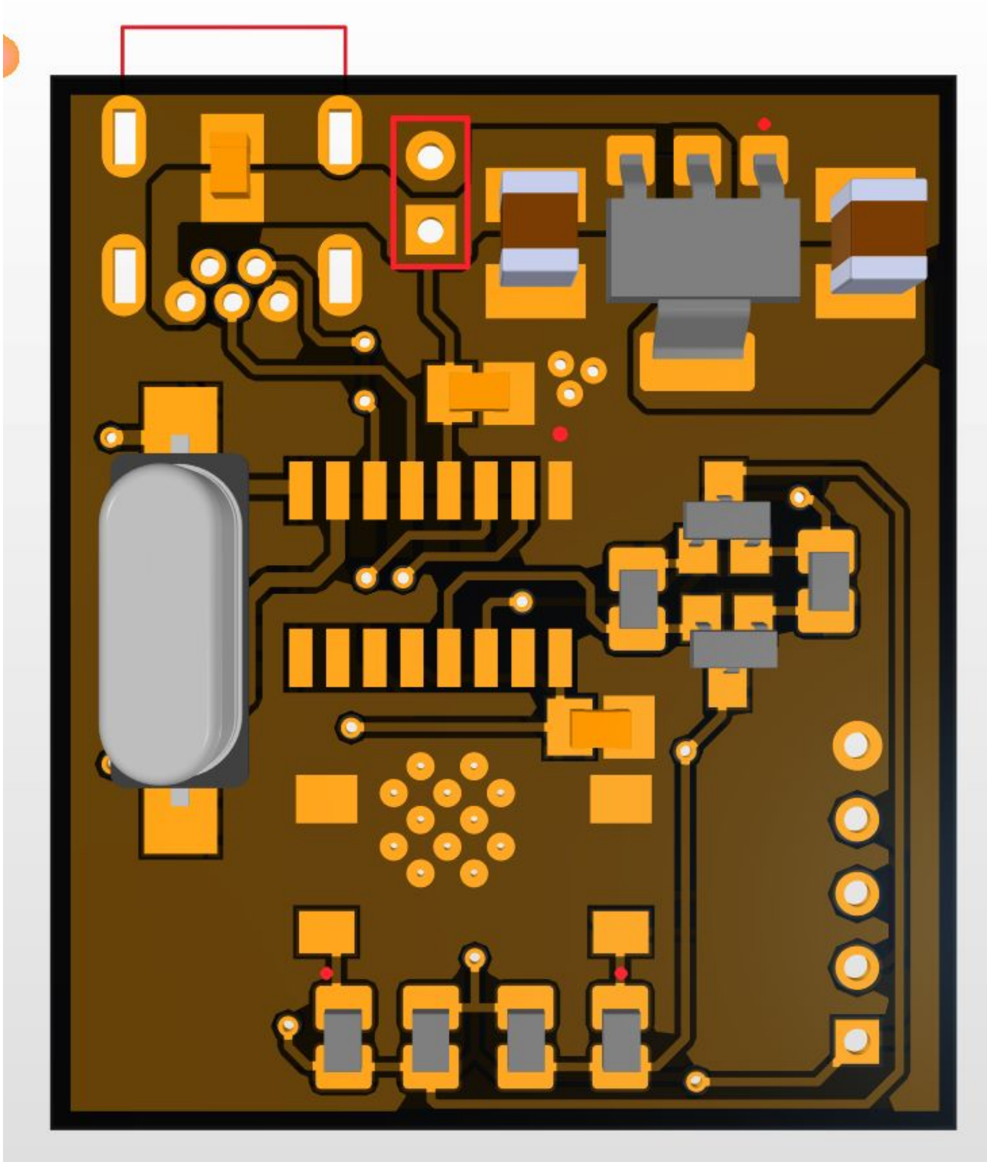

Figure 4.7: Receiver

4.4 Manufacturing and Assembly of PCB

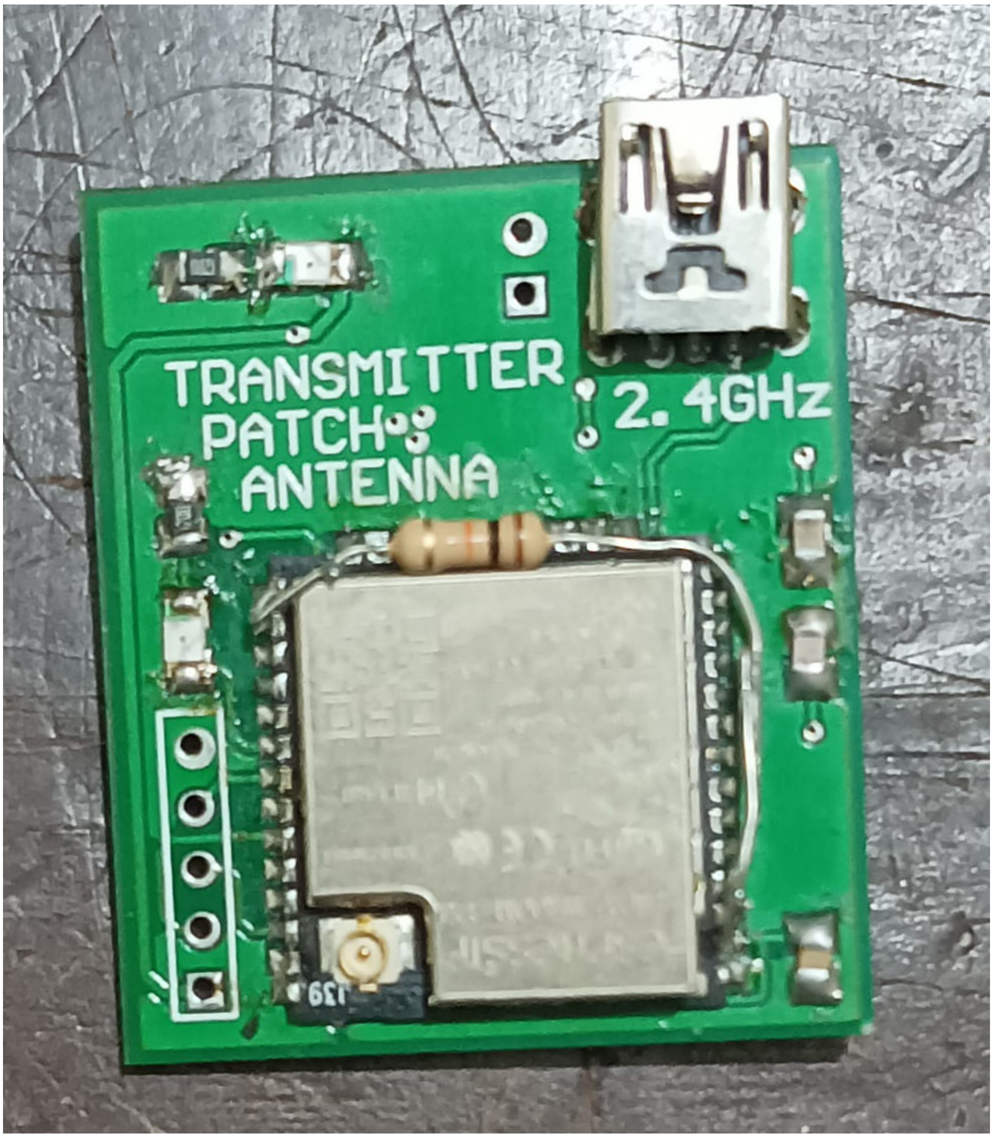

Figure 4.8: Tranmitter

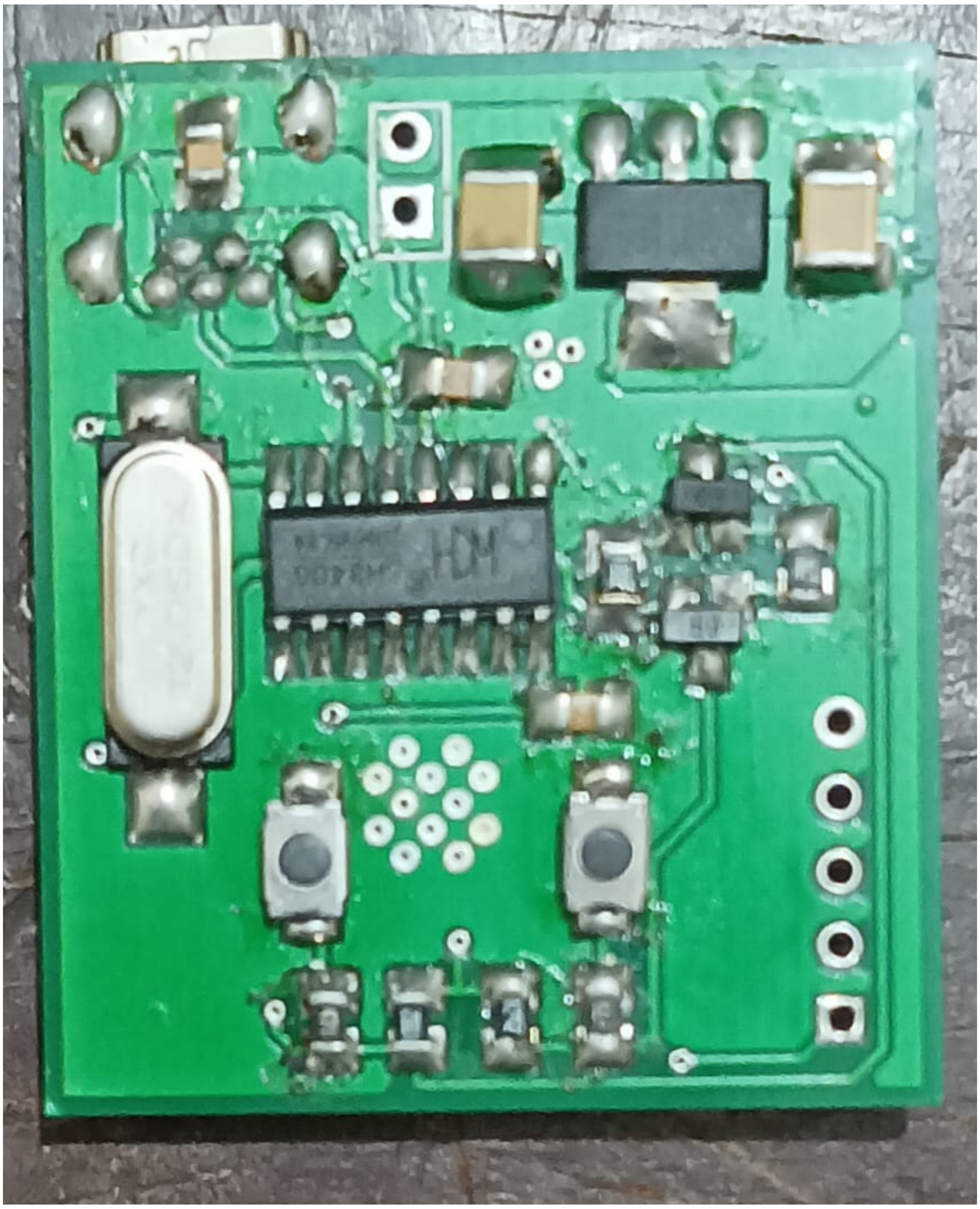

Figure 4.9: Receiver

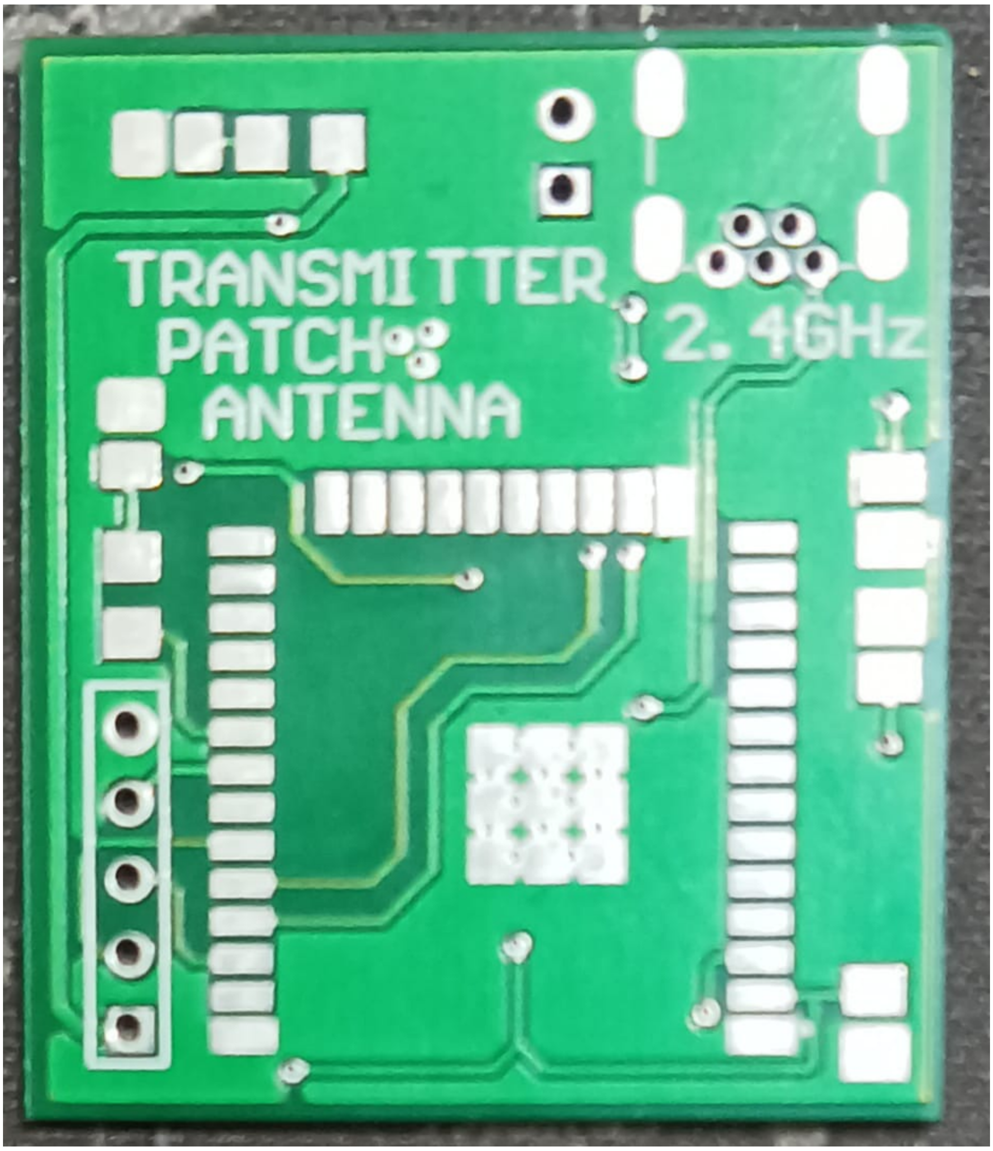

Figure 4.10: Tranmitter

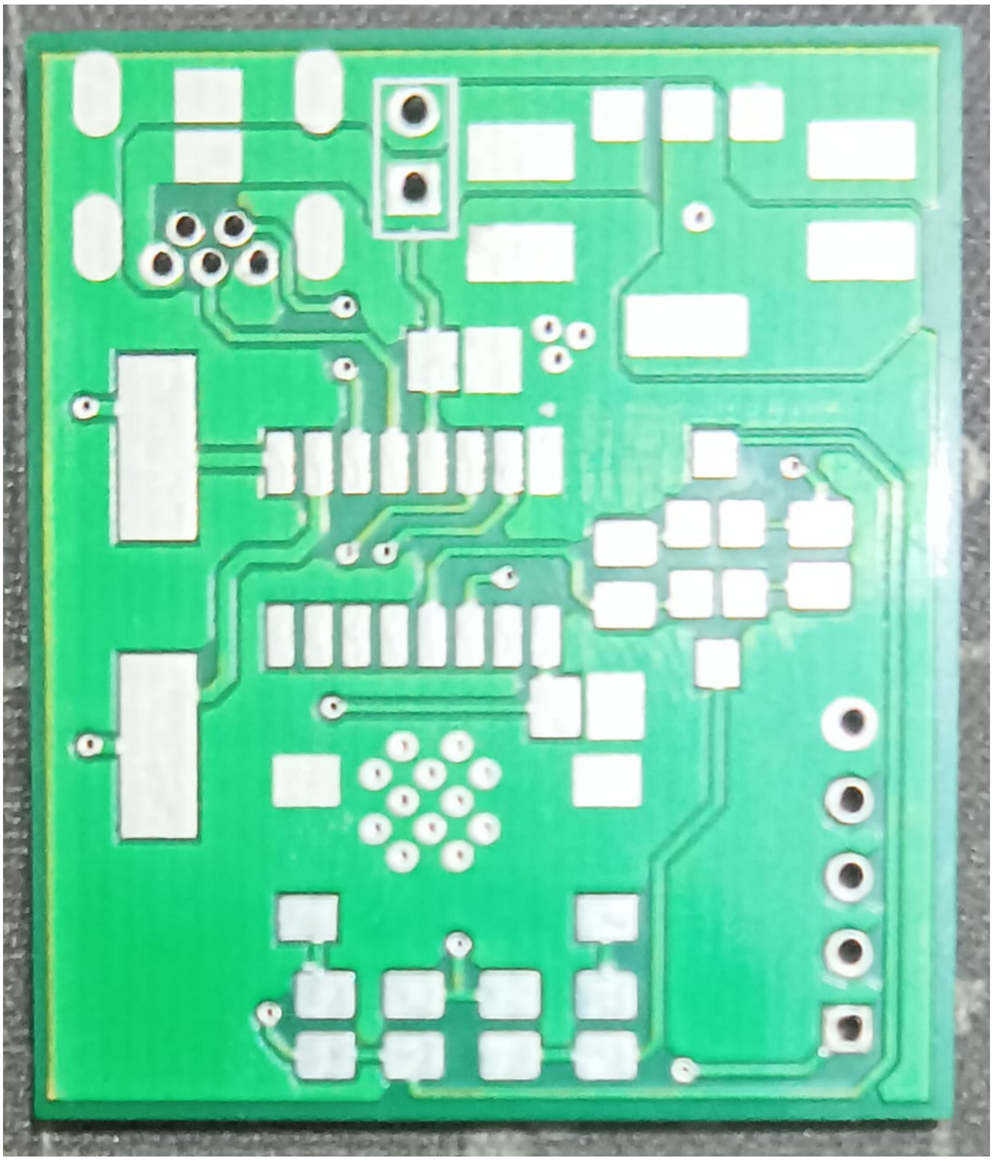

Figure 4.11: Receiver

Chapter 5

Software Description

5.1 Altium Designer 21.4.1

Altium Designer is a software package for PCB and electronic design automation tool for printed circuit boards. It is developed by Australian software company Altium Limited. Altium Designer's software encompasses four main functional areas: schematic capture, 3D PCB design, Field-programmable gate array (FPGA) development and release/data management. Altium Designer combines a myriad of features and functionality, including, Advanced routing technology Support for cutting-edge rigid-flex board design Powerful data management tools Powerful design reuse tools Real-time cost estimation and tracking Dynamic supply chain intelligence Native 3D visualizations and clearance checking flexible release management tools.

5.2 ANSYS HFSS

Ansys HFSS is a 3D electromagnetic simulation software solution for designing and simulating high-frequency electronic products such as antennas, RF and microwave components, high-speed interconnects, filters, connectors, IC components and packages and printed circuit boards.

5.3 CAD Feko

CAD Feko is used to create and mesh the geometry or model mesh, specify the solution settings and calculation requests in a graphical environment.It is the Feko component that allows you to create complex CAD geometry using primitive structures and to perform Boolean operations on the geometry. Complex geometry models and mesh models can be imported or exported in a wide range of industry standard formats. Reduce development time by using a component from the list of antennas and platforms in the component library.

Chapter 6

Design,Simulation and Results

6.1 Simulation of the antenna

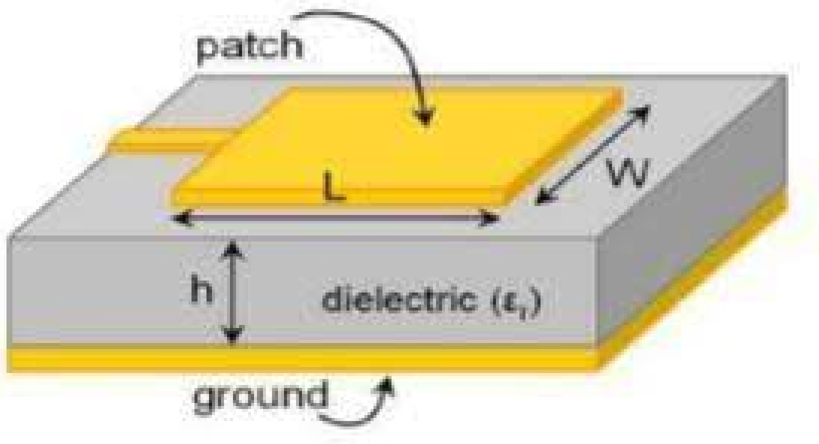

Figure 6.1: Microstrip Patch

In this Project we have designed two types of antennas:

i) Rectangular Shaped Patch Antenna

ii) Rectangular with MACE logo Patched Antenna

We have used FR4 as the substrate for designing the antenna. FR4 having good mechanical strength and good insulating capacity gives suitable applications. FR4 has a relative permittivity of 4.4 and loss tangent of 0.02 at 1GHZ. The antenna gain and stability depends upon the height of the substrate we use in antenna. We can calculate the size of the patch using the di-electric value and height of the antenna.

We have also designed our MACE logo using random dimensions for the appropriate results. And also provided a 3mm feed line for the simulation having a 50ohm resistance with a radiated port.

The width of patch antenna can be calculated by:

$$Width = \frac{C}{2f_0\sqrt{\frac{\epsilon_R+1}{2}}} \tag{6.1}$$

The length of patch antenna can be calculated by:

$$Length = \frac{c}{2f_0\sqrt{\epsilon_e ff}} - 0.824h(\frac{(\epsilon_e ff + 0.3)(\frac{W}{h} + 0.264)}{(\epsilon_e ff - 0.258)(\frac{W}{h} + 0.8)}) \tag{6.2}$$

Effective permittivity can be calculated by:

$$\epsilon_e ff = \frac{\epsilon_R + 1}{2} + \frac{\epsilon_R - 1}{2}[\frac{1}{\sqrt{1 + 12(\frac{h}{W})}}] \tag{6.3}$$

6.2 Design

Table 6.1: Measurements

SL.NO	DESCRIPTION	DIMENSION
1	Substrate Thickness	1.6mm
2	Feedline Width	3mm
3	Patch Width	31.6mm
4	Patch Length	42mm
5	Substrate Dimension	49 x 50mm

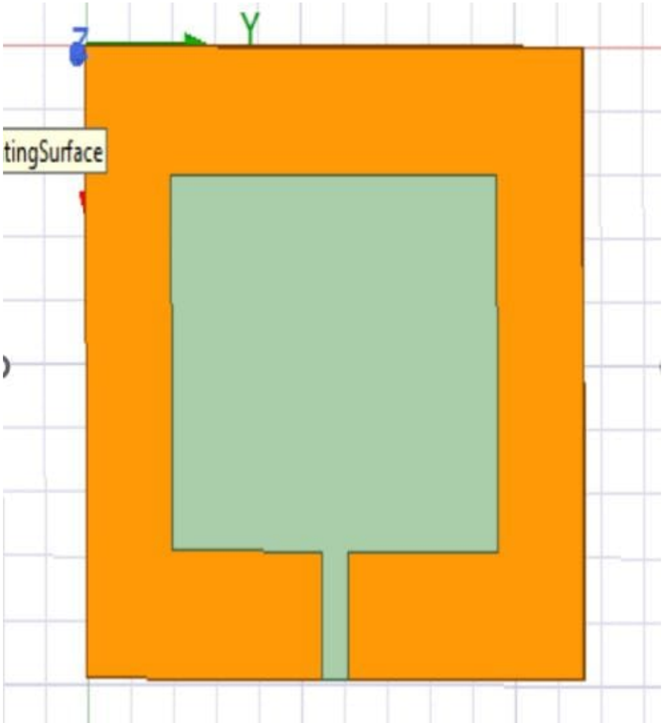

Figure 6.2: Rectangular Patch

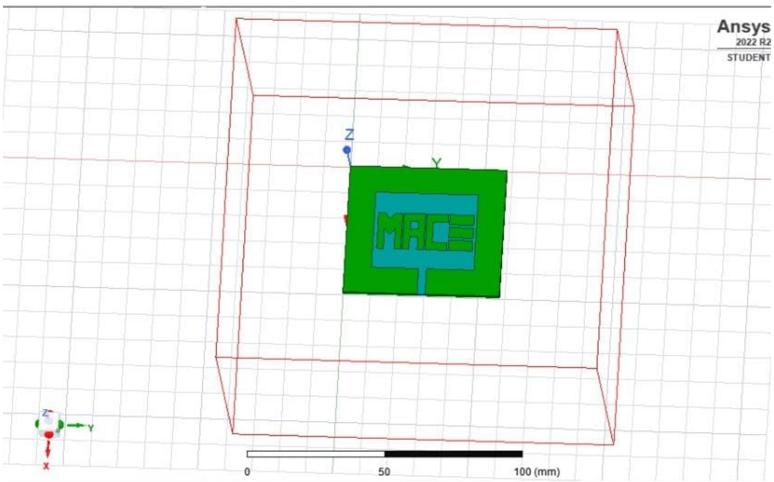

Figure 6.3: Rectangular Patch with MACE

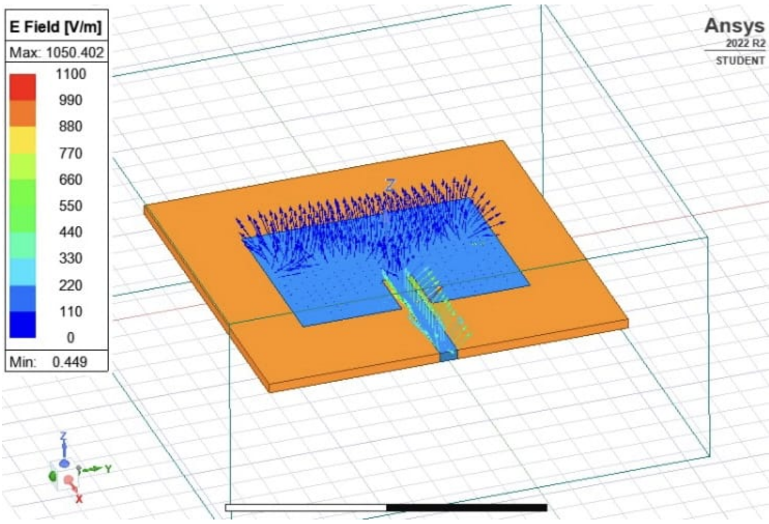

Figure 6.4: Rectangular Patch with direction of electric field

6.2.1 Polyster Patch with MACE logo

A polyester patch antenna is a type of antenna that is constructed using a patch made of polyester material. It is a variation of the microstrip patch antenna, which is a popular and widely used type of antenna in wireless communication systems.

The polyester patch antenna is designed by etching a metallic patch on a polyester substrate, typically using techniques such as photolithography or screen printing. The metallic patch acts as a radiating element and is usually made of materials like copper or gold.

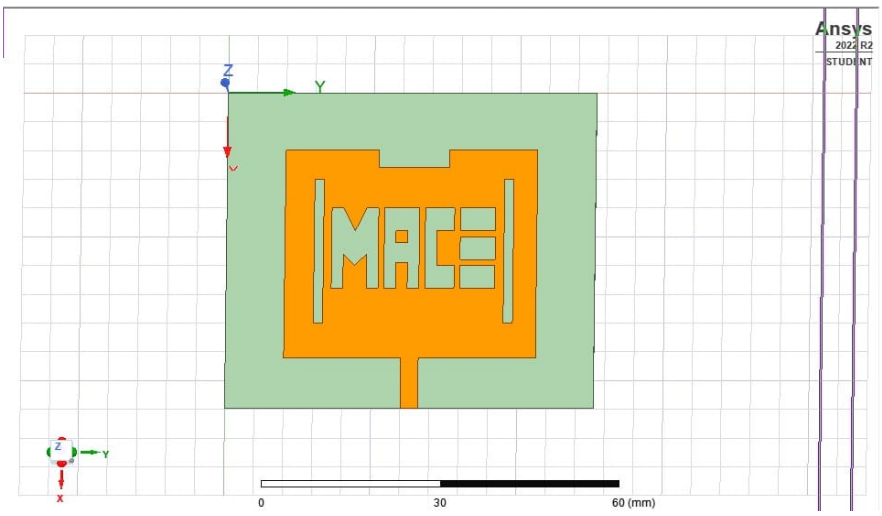

Figure 6.5: Polyster Rectangular Patch with MACE 1

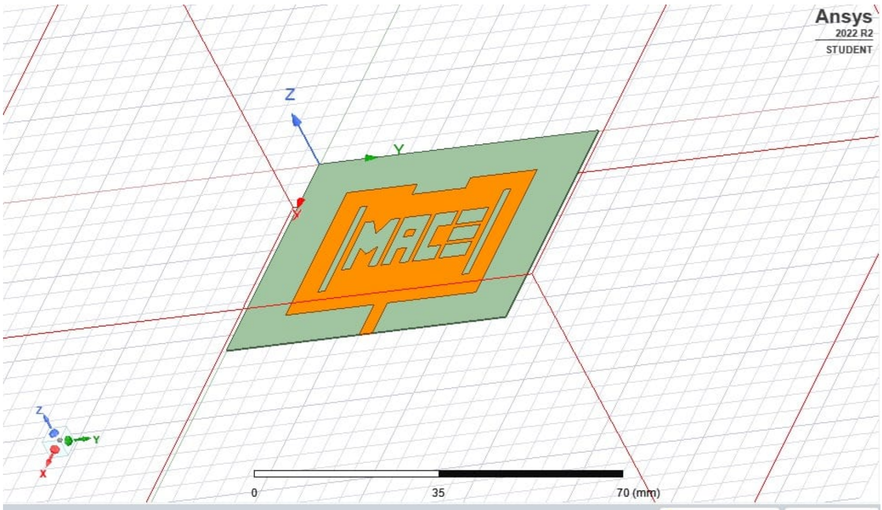

Figure 6.6: Polyster Rectangular Patch with MACE 2

6.2.2 Nylon Patch with MACE logo

A nylon patch antenna is a type of antenna that uses a patch made of nylon material as its substrate. Similar to the polyester patch antenna, it is a variant of the microstrip patch antenna and is designed for wireless communication applications.

Nylon is a lightweight and durable material with good mechanical properties, making it suitable for various antenna designs. It offers advantages such as flexibility, low cost, and ease of manufacturing. Nylon patch antennas are typically constructed by etching or printing a metallic patch on a nylon substrate, similar to the process used for other microstrip patch antennas.

One of the key benefits of using a nylon substrate is its low dielectric loss, which can contribute to improved antenna efficiency and broader bandwidth compared to some other materials.Nylon patch antennas are commonly utilized in applications such as wireless communication systems, RFID tags, Wi-Fi devices, and other wireless networking devices. They can be optimized for specific frequency bands, gain requirements, radiation patterns, and impedance matching, based on the intended application. Overall, nylon patch antennas provide a lightweight, cost-effective, and flexible antenna solution for various wireless communication applications, where performance trade-offs and specific requirements should be carefully evaluated during the design process.

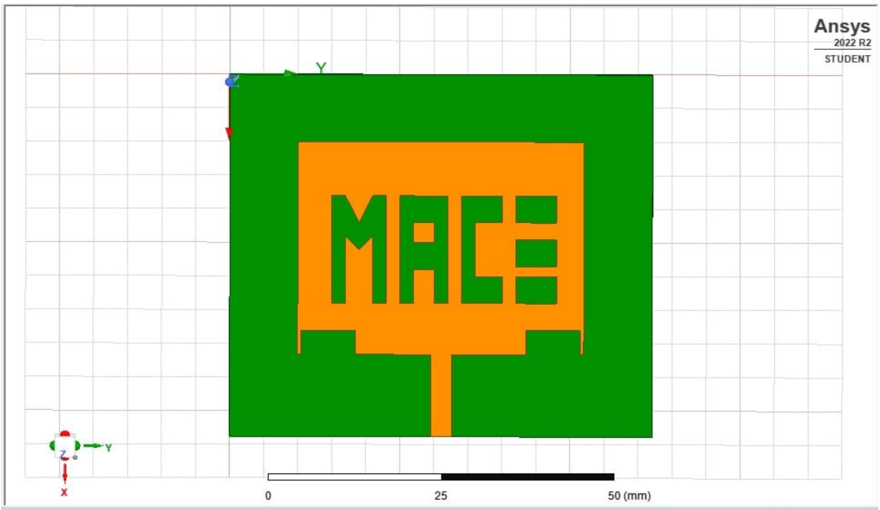

Figure 6.7: Nylon Rectangular Patch with MACE 2

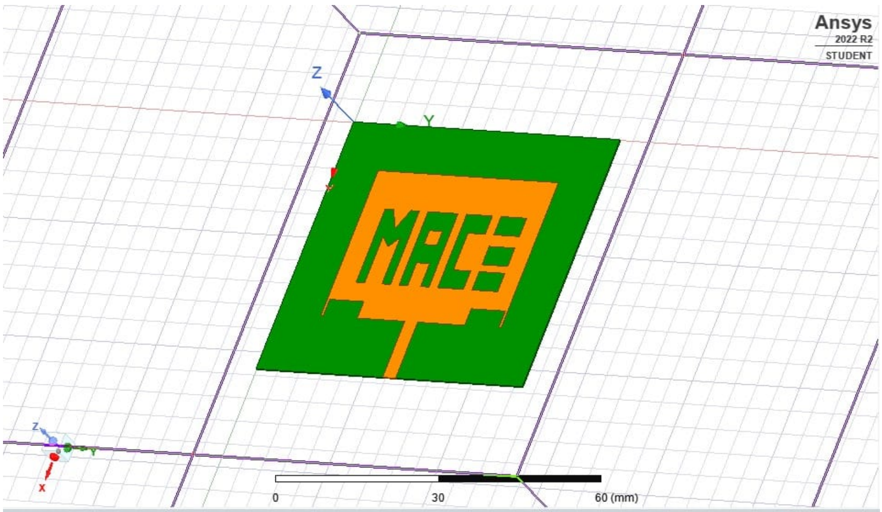

Figure 6.8: Nylon Rectangular Patch with MACE 2

6.3 Simulation

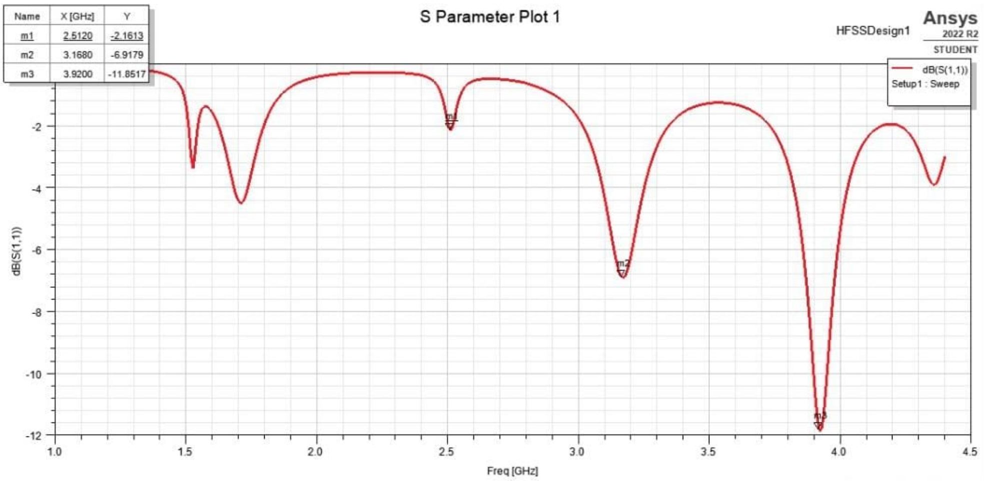

Figure 6.9: S parameter plot 1

We have designed and simulated the designed in ANSYS HFSS , which is a 3D-Electromagnetic simulation software for designing the simulating high-frequency electronic products. We have designed both antennas to resonate at 2.4GHz and we have got the resonating frequency as 2.2GHz and 2.6Hz for both antennas respectively with a return loss of -26.75 and -2.6 respectively as shown in the figure.We have also obtained the radiation plot graph.

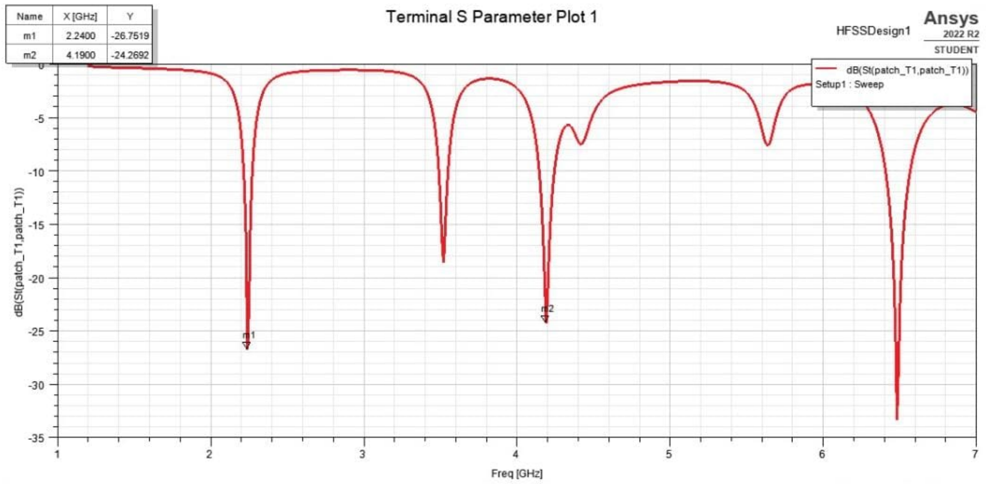

Figure 6.10: terminal s parameter

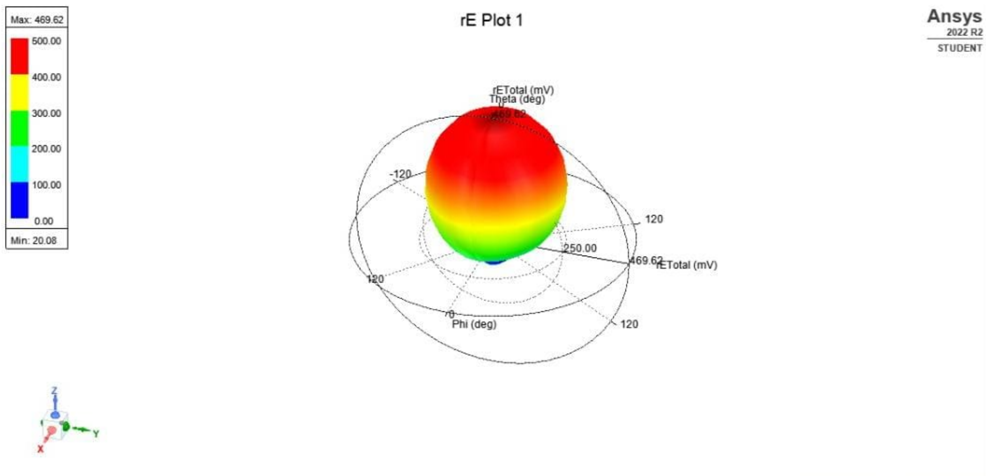

Figure 6.11: rE plot1

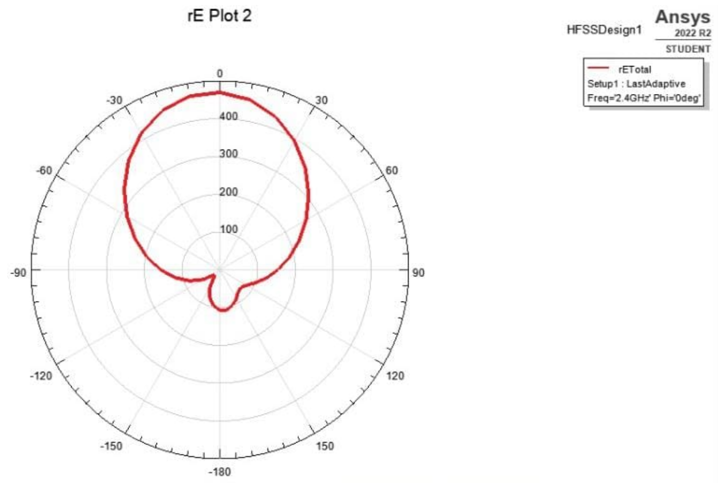

Figure 6.12: rE plot 2

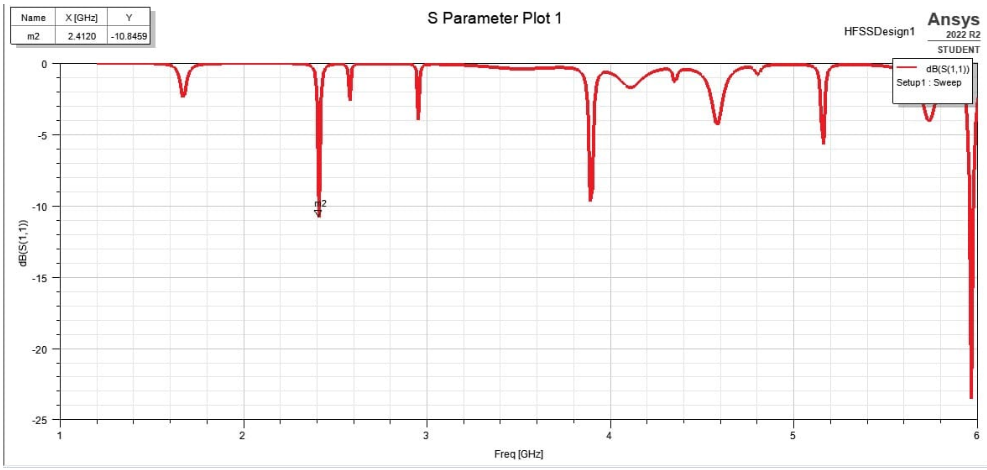

Figure 6.13: S parameter plot for polyster patch

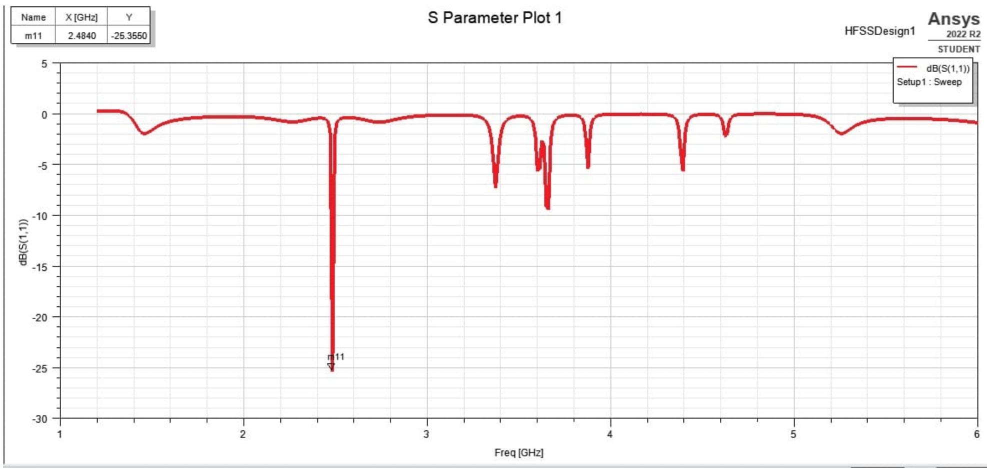

Figure 6.14: S parameter plot for nylon patch

Chapter 7

Conclusion and Future Work

The wearable technology is making new revolution in today's world. Wearable antennas are one of the critical components in the realization of wearable and portable devices. Due to their lightweight, flexibility, low cost and conformal characteristics, they are ideal for wireless communication and sensing applications in a worn form. Besides that, this will also enable the antenna to be operating in its highest possible efficiency, depending on the type of antenna topology chosen.Wearable antennas play a pivotal role in wireless on body- centric communication. This project presents a textile antenna with WiFi applications.The fabrication techniques and materials used in designing textile antenna plays a significant role in defining and determining the ovaerall performance.

7.1 FUTURE WORK

The future work of the project carried out here will be to test the antenna with transmitters and receivers. Designing high-efficiency antennas on textiles is fundamental for the development of wirelessly-connected smart garments.The key challenges that are hindering the realisation of high efficiency antennas lie in the dielectric properties of fabrics, the conductivity of their traces, and their low textile thickness. Therefore, this logo antenna is a good candidate for wireless communication and anti-theft applications for fashionable wearable devices.

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