

DESIGNING A WEARABLE ANTENNA FOR TELEMEDICINE APPLICATIONS

A Project Report Phase – II

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Electronics and Communication Engineering

by

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**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS**

**SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited with Grade “A” by NAAC
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APRIL - 2023



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **MANASA G (39130275)** and **M ANUHYA (39130286)**, who carried out the project entitled **“DESIGNING A WEARABLE ANTENNA FOR TELEMEDICINE APPLICATIONS”** under our supervision from NOVEMBER 2022 to APRIL 2023.

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We, **MANASA G (39130275)** and **M ANUHYA (39130286)**, hereby declare that the Project Report entitled **DESIGNING A WEARABLE ANTENNA FOR TELEMEDICINE APPLICATIONS** is done by us under the guidance of **Ms. F.V.JAYASUDHA, M.E.(PhD), ASSISTANT PROFESSOR, ECE Dept, SIST**, is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

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We consider our self-most fortunate and immensely privileged to have worked under the guidance of **Ms. F.V. JAYASUDHA, M.E., (PhD), ASSISTANT PROFESSOR, ECE Dept, SIST**, Department of Electronics and Communication Engineering to complete this project successfully.

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ABSTRACT

In this project, a low-profile wearable antenna is designed for telemedicine applications. Telemedicine is the use of telecommunications technology as a medium to provide live, interactive audiovisual medical services for sites that are at a distance from the provider. Telemedicine and related healthcare technologies aim to provide efficient healthcare remotely. It has made elderly and sick people to live their life effortlessly. One such technology developed for this purpose is patient monitoring system. In these systems, wearable antenna plays a vital role. Today's technology has become diverse, and it has touched all walks of life. The objective of this paper is to provide a better solution for telemedicine application. Various wireless technologies are used, but wearable antenna is the best solution. In this paper wearable antenna is designed. The design consists of microstrip yagi patch antenna. This antenna is simulated on High frequency structure simulation (HFSS). This simulation gives improved return loss, low front to back ratio. The health parameters that may be transmitted wirelessly to remote stations (off body mode) in telemedicine systems. In addition to off body applications, on body mode is also necessary for communication between sensors devices located on or within the patient's body. Therefore, a reliable low-profile antenna is required for best performance.

The medical information is then sent through sensors to the receiver at low frequency. After the reception of medical information, all the data is collected from the sensors mounted on the human body and then sent to an external device. The doctor in the hospital or any remote location can look after the situation of the patient and suggest medicines immediately to improve the quality of healthcare. Many hospitals and nursing homes are deploying infrastructure- oriented wireless networks, such as wireless LANs, satellites, and cellular and GSM in telemedicine systems.

Keywords— Physiological Parameters, Wireless Sensor Network, Remote Monitoring Station, Wearable Monitor, Data Acquisition Hardware.

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LIST OF ABBREVIATIONS

S.NO	ABBREVIATION	FULL FORM
1	EEG	Electroencephalogram
2	ECG	Electrocardiogram
3	LAN	Local area Network
4	GSM	Global System for Mobile Communication
5	IMD	Indian meteorological department
6	GPRS	General packet radio services
7	WBAN	Wireless Body Area Network
8	EMG	Electromyography
9	GSR	Galvanic skin Response
10	SAR	Specific Absorption Rate
11	HFSS	High Frequency Structure Simulator
12	FCC	Federal Communication Commision
13	EBG	ElectroMagnetic Band Gap
14	HIS	High Impedance Surfaces
15	AMC	Artificial Magnetic Conductor
16	NFC	Near Full Communication
17	LoRA	Long Range
18	LTE	Long Term Evolution
19	ISDN	Integrated Service Digital Network

20	IJIRSET	International Journal of Innovative Research in Science Engineering Technology
21	FIT	Finite Integration Technique
22	VSWR	Voltage Standing Wave Ratio
23	CST	Computer Simulation Technology
24	ADAS	Advanced Driver Assistance System
25	ISM	International Safety Management

CHAPTER - 1

INTRODUCTION

In recent years, close collaboration has been forged between telecommunications and medicine. Designing a wearable antenna for telemedicine applications are being particularly used for various real-time health monitoring applications. wearable communication technologies can offer promising solutions in biomedical, consumer electronics, military, and smart home applications. These networks include the use of wearable antennas for transmitting and receiving of the data for healthcare related systems. In a military application, it is used to establish communication links between different soldiers including sending images and videos, location tracking and army protection. Furthermore, medical applications are used to check and monitor health parameters of a patient and can communicate with each other or with the outside world.

There are many challenges in wireless monitoring of patients, including the coverage, reliability and quality of monitoring. The work done in patient monitoring includes home monitoring wireless telemetry system for EEG epilepsy Bluetooth-based system for digitized ECGs a hospital-wide mobile monitoring system mobile telemedicine and, real-time home monitoring of patients. One of the most difficult challenges in patient monitoring using wireless networks, especially for emergency messages, is the reliability of message delivery. Many hospitals and nursing homes are deploying infrastructure-oriented wireless networks, such as wireless LANs, satellites, and cellular and GSM in telemedicine systems range from simple heart rate, blood pressure, body temperature to blood glucose levels and ECG wave forms. To overcome the coverage problems a reliable low profile antenna is required for best performance the structure of this paper is as follows.

Among the various branches in which telecommunications are concerned, we can cite antennas. These are essential to ensure an operation of emission or reception of electromagnetic waves in the Earth's atmosphere or in space. Printed antennas have known such a wide field of use that they are applied in medical field. Since their completion, research in this field has continued to evolve in order to exploit the many advantages of this type of antenna. Combining telecommunications with medicine has been very interesting and beneficial for patient and for the nursing staff.

This is how medical telemetry was born, which uses telecommunication transmission of medical information. Biomedical telemetry allows the measurement of physiological signals through either wired or wireless communication technologies. Physiological signals are obtained by means of appropriate transducers and eventually transmitted to exterior monitor control equipment. Implantable medical devices (IMDs) are one of the most recent developments of biomedical telemetry. Various types of wearable sensors are mounted on or implanted into the human body in order to access human vital signs information such as body temperature, blood pressure, and heartbeat. The medical information is then sent through sensors to the receiver at low frequency. After the reception of medical information, all the data is collected from the sensors mounted on the human body and then, sent to an external device. The doctor in the hospital or any remote location can look after the situation of the patient and suggest medicines immediately to improve the quality of healthcare.

The recent work on the satellites based telemedicine services provides solutions for Tele-education, home care and numerous medical complications. Wireless Technologies play a vital role in facilitating medical statistics and services from one region to another location with marginal expenses. Wireless technologies such as satellites, 4G GSM, GPRS, Wireless LAN, WBAN and Optical Wireless Body Area Networks are utilized by clinics and hospitals in order to monitor the biological attributes of patients such as body temperature, respiratory rate, evaluation of R-R interval heart rate with Electrocardiogram(ECG), blood pressure, oxygen saturation in blood(SaO₂), Electromyogram(EMG), Galvanic Skin Response (GSR), Electroencephalogram(EEG) with substantial amount of quality services but the major challenge related to wireless monitoring of patients seems to be conveying information in emergency cases with full of accuracy.

Subsequently, precision can be achieved easily by using low profile antenna. There are also several hindrances associated with conventional monitoring systems as they are bulky, enlarged and the sensors used in those systems are also hefty. Therefore, in order to overcome these difficulties, the human body constituents must be diagnosed and updated reports must be transmitted wirelessly to remote stations, the data sensors must be enclosed into the fabric of the wearer.

There are two modes in telemedicine systems for Rectangular Yagi patch antenna: (a) off body mode in which the health parameters are controlled and transmitted to remote stations and (b) on body mode which establishes the interaction between transducer devices that are placed on the body of patients or can be placed inside the body.

- ❖ In section 1 antenna is introduced, followed by section 2 wearable antenna then, section 3 antennas for wearable devices and then, impact of human body on wearable antenna and vice versa. In section 5 telemedicine is introduced, section 6 gives about tele-health.

1.1 ANTENNA

An antenna is a device that is made out of a conductive, metallic material and has the purpose of transmitting and/or receiving electromagnetic waves, usually radio wave signals. The purpose of transmitting and receiving radio waves is to communicate or broadcast information at the speed of light. Basic Types of Antenna: The two main but basic types of antennas are: Transmitter antenna, Receiver antenna. Conventional reconfigurable antennas are generally developed using highly conductive metals such as copper, which results in highly efficient antennas, but lacks mechanical flexibility. Antennas come in all shapes and sizes from little ones that can be found on your roof to watch TV to really big ones that capture signals from satellites millions of miles away.

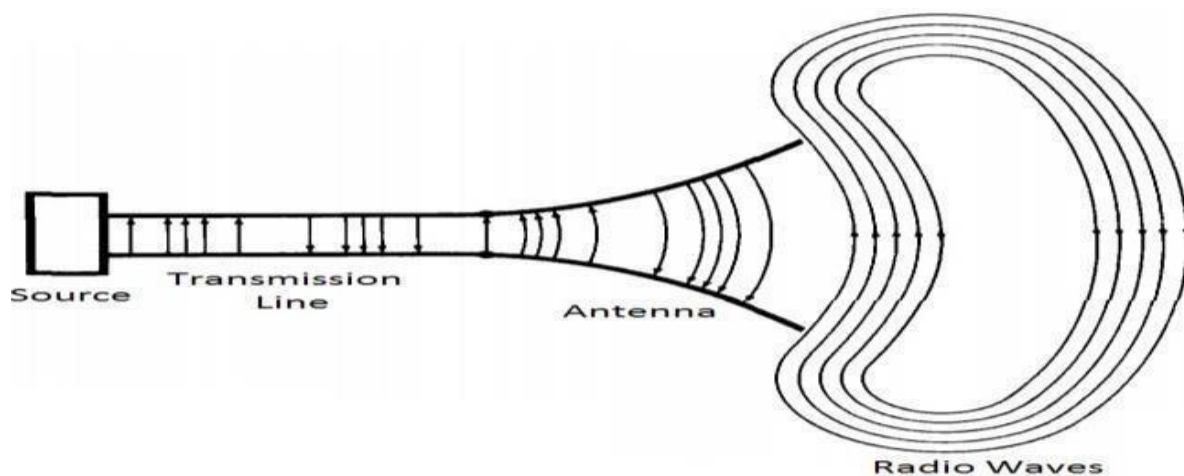


Fig: 1.1 Antenna (Electronics Hub, 2019)

There are several reasons as to why we need or why we use antennas, but an important reason as to why we use antennas is that they provide a simple way to transfer signals (or data) where other methods are impossible. For example, take the case of an aeroplane. The pilot needs to frequently communicate with the ATC personnel. It would not make any sense if we tie up a cable (of dynamically variable length) to the tail of the plane and connect it to the ATC. Wireless communication is the only possible option and Antennas are the gateway for that. There are many situations or applications where cables are preferred over wireless communication.

By now, we have a basic understanding of an antenna and how it is an essential component in a Wireless Communication system. The next important thing to understand is that the characteristics of a typical wireless communication system are dependent on the characteristics of the antenna used in the system. For example, the operational characteristics of a communication system find back its roots to the directional characteristics of the antenna. Irrespective of the application that an antenna is used in, all the antennas are associated with a few fundamental parameters.

These parameters are sometimes also called as Properties of Antenna or Characteristics of Antenna. Certain basic characteristics of antenna are listed below:

- Antenna Radiation Pattern
- Radiation Intensity
- Directivity and Gain
- Radiation Efficiency and Power Gain
- Input Impedance
- Effective Length
- Bandwidth
- Effective Aperture
- Antenna Polarization

1.2 WEARABLE ANTENNA

The body-worn antennas have become the emerging area for the research as it can be wearable and can be easily embedded into the clothing. A wearable antenna can be used to communicate between sensors and the human body. Wearable textile antenna is a medical device which is used to collect medical data without disturbing the patients whenever for telemedicine monitoring through Zig-Bee or Wi-Fi network. Due to its small and compact size, a wearable antenna is utilized in different applications such as for military, medical, healthcare, emergency services, and navigation. The requirements of wearable antenna are increasing due to the miniaturization process and the use of flexible devices. This chapter elaborates the comparative survey of different designs of wearable antenna design technology. The substrates used for antenna designs include different textiles or conventional substrates.

The effect of the change in the substrate material on the resonant frequency, bandwidth, gain, SAR, and radiation efficiency is presented. The antenna performance is highly affected in the vicinity of the human body and the location of the antenna on the human body. So, these effects are studied by analyzing the SAR parameter in different antenna designs. This survey is helpful in providing the insight knowledge of the antenna designs which can further help in the future wearable antenna design research to fulfill the requirements of best wearable electronics.

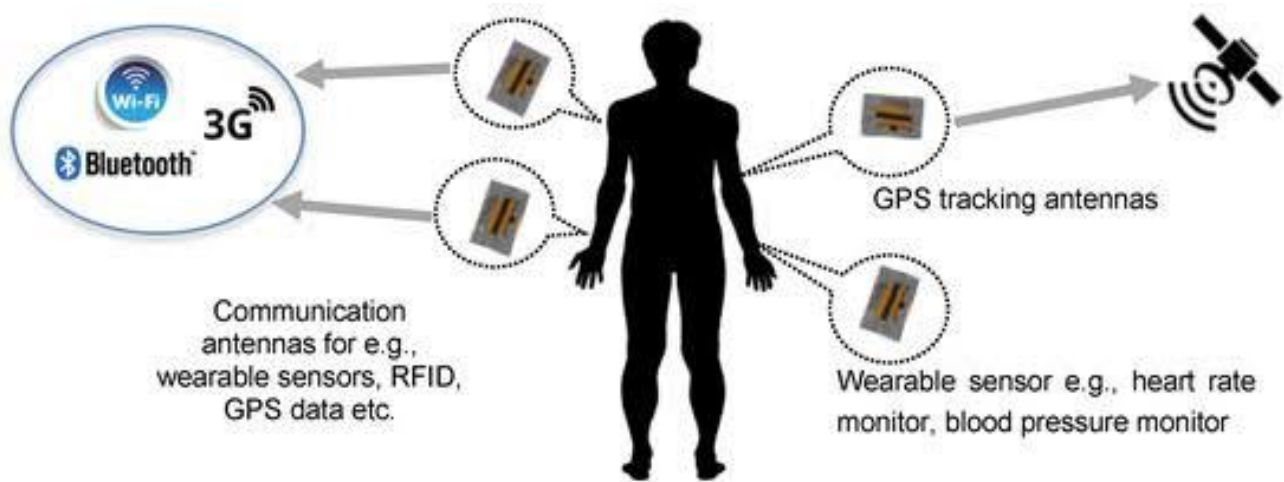


Fig: 1.2 Wearable Antenna (Yoshihide Yamada et al, 2019)

The health parameters that may be transmitted wirelessly to remote stations (off body mode) in telemedicine systems. In addition to off body applications, on body mode is also necessary for communication between sensors devices located on or within the patient's body. Therefore a reliable low profile antenna is required for best performance. Various types and design approaches of wearable antennas are being proposed including: Electro-textile, microstrip patches , buttons antennas, wearable MIMO systems, or hybrid systems based on one or more of such designs .wearable antennas are required to be small size, lightweight, but robust at the same time.

They also have to be comfortable and conformal to the body shape, yet they must maintain high performance in terms of reliability and efficiency. Electro textile based antennas seem to be a low profile low profile solution for wearable application; however, they are more prone to discontinuities in substrate material, fluids absorption, bending, twisting, and compression. Furthermore, microstrip button antennas offer favorable characteristics such as lower profile construction, low cost, ease of fabrication, capability of integration with clothing. The wearable antenna for telemedicine has proven to be better option for patient monitoring. Such antenna with specified parameter as can be simulated on antenna software such as CADFEKO, HFSS, CST Microwave studio , and then fabricated. Depending on the comparative study of result the antenna can be fabricated for optimum result.

1.3 ANTENNAS FOR WEARABLE DEVICES

1.3.1 *THE BODY IS THE ENEMY OF WEARABLE DEVICES*

Wearable devices such as smart watches, smart glasses and fitness monitors present a specific set of challenges for antennas. Firstly, they are by definition held very close to the body at all times, which poses a problem. Human tissue is very lossy, which changes the frequency response of the antenna and degrades its radiation efficiency. A wearable antenna therefore has to be immune to the near field effects of the body in order to avoid detuning. Maximising the distance between the antenna and the body can help, as can including a ground plane to isolate the antenna from the body. As well as the body's effects on the antenna, the antenna's effects on the body should be considered. The FCC

limits on radiated energy for partial-body exposure should be taken into account; this is currently a specific absorption rate of 1.6 Watts per kilogram of body tissue.



Fig: 1.3 Wearable Devices (JSP, 2016)

1.3.2 ANTENNA PERFORMANCE CAN DRASTICALLY AFFECT BATTERY LIFE

Battery life is important for wearable devices, but how can antenna design help?

The energy consumed during RF transmission can use up a high proportion of the device's power budget. A well-designed antenna subsystem can save power by not being sensitive to the body's near field, by decreasing the number of retransmissions and by having high gain or pattern diversity. Building in a level of re-configurability may be an additional solution to fine tune the antenna's performance for a given situation, since the optimum radiation pattern changes based on how the device is used.

1.3.3 WIRELESS MODULES ARE THE EASY OPTION. OR NOT THEY

For miniature designs like wearables, it is often quicker to use pre-certified wireless modules for connectivity; the design work is done for you and you know you have a reliable wireless subsystem for your design that's already been optimised for size and power efficiency. Using modules also means you have more time to focus on differentiating your product by concentrating on the other features. Typically these modules will come with a chip antenna already integrated into the design. On the other hand, the main concern with using

existing modules is the antenna performance can change depending on how the module is positioned in the wearable device.

For best results check with the manufacturer what the optimum position of the antenna is, but it's usually safest to place it as close to the edge of the system as possible, such as in a performance will be negatively affected since proximity to PCB traces, other components, or even plastic (which can act as a dielectric) can de-tune the antenna to lower frequencies.

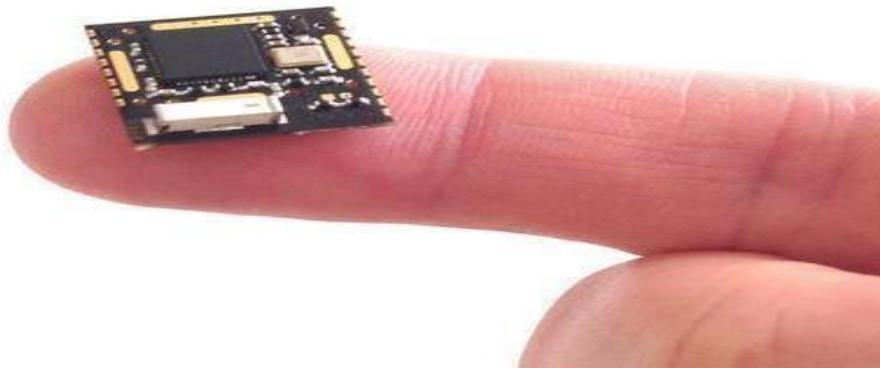


Fig: 1.4 Wireless Module (JSP, 2016)

1.3.4 CUSTOM ANTENNAS CAN HELP DIFFERENTIATE – BUT ONLY IF DONE RIGHT!

Rather than use standard chip antennas, some manufacturers are working on custom antennas to tackle the challenges wearable devices pose, such as body proximity, form factor, and metal cases. There are pros and cons to this approach; it means that the design of the whole device isn't centred around the performance of the standard chip antenna, and it can result in better, more reliable connectivity which make for a better overall user experience (if done right!). On the other hand, it can add a lot of design time and cost to a device in a market where time to market and price point are both crucial.

1.4 IMPACT OF HUMAN BODY ON WEARABLE ANTENNA AND VICE VERSA

In WBAN, the close proximity of human body poses significant challenges to the wearable antennas and vice-versa.

- Impact of electromagnetic radiations on human body and the reduced efficiency of the antenna due to electromagnetic immersion in body tissue, fragmentation of radiation pattern, impedance variations and frequency detuning.

These factors call for special attention during antenna design for wearable devices. Developers should focus on structural deformation, accuracy and precision in antenna fabrication methods and size during wearable antenna design.

1.4.1 EFFECTS OF ANTENNA ON HUMAN BODY

Unlike ionizing radiations, the non-ionizing radiations such as microwaves, visible light or sound waves may not have sufficient energy to ionize atoms or molecules in a body, however this energy can increase the cell temperature by moving atoms or make them vibrate. This rise in temperature due to dielectric heating, a thermal effect due to microwave radiation when a dielectric material is heated by rotations of polar molecules induced by the electromagnetic field, may have severe effects in human tissues. The Federal Communication Commission (FCC) introduced Specific Absorption Rate (SAR) limits for wireless devices to ensure acceptable radiations level in human body. The SAR limit is set to 1.6 W/kg averaged over 1g of actual tissue, while the limit is set to 2W/kg averaged over 10g of actual tissue by the Council of European Union. SAR is a parameter that is used to measure the rate at which RF (radiofrequency) energy is absorbed by human tissues. SAR values ensure that any wearable device or wireless smart gadget does not exceed the maximum permissible exposure levels.

Antennas without a ground plane exhibit higher SAR value since the SAR of on-body antennas relies on near-field coupling to the body. Hence, many of the methods to reduce SAR value rely on altering the ground plane. One of the techniques is to use Electromagnetic Band gap (EBG) structures, or Periodic Conductive Structures to filter electromagnetic waves within certain frequency bands. Similarly, using High Impedance Surfaces (HIS) help block electromagnetic waves within a certain frequency band. High Impedance Surfaces placed behind wearable antennas increase the front-to-back radiation ratio reducing the Specific Absorption Rate (SAR) in a human body.

HIS also prevents propagating surface waves and reflects electromagnetic waves with no phase reversal. Another effective method is to integrate Artificial Magnetic Conductor (AMC) ground plane, which serves as an isolator. The SAR reduction techniques such as integration of Ferrite Sheets and Meta-materials are also popular among antenna designers

1.4.2 EFFECT OF HUMAN BODY ON WEARABLE ANTENNA

The human body also has some effects on wearable antenna when it is in close proximity. The lossy, high dielectric constant characteristics of human body may result in the variation of input impedance, frequency shifts and reduced efficiency of Antenna. It disturbs the communication link between antenna and the external host device. Based on the application, various techniques can be adopted to address the effect of human body on antenna. One of the key aspects is the placement and orientation of antenna. An ideal position/orientation of the antenna, location and distance from the body significantly reduce the impact of human body on antennas. For high performance devices, automatic tunable circuits and reconfigurable antennas can also be implemented. Antenna designers also implement EBG ground plane and High Impedance Surfaces to address the impact of body on wearable antennas.

So that, Wearable Antenna is among the key emerging technologies, aiding several applications in health care, military, navigation, and entertainment. WBAN technologies, especially wearable antennas provide cost effective solutions for remote sensing and monitoring of several physiological parameters of human body. While considering the advantages of WBAN and wearable antennas, one should also be aware of its impact on a human body. Antenna designers should consider an appropriate RF technology for wearable designs, while ensuring least effect on the efficiency and gain due to electromagnetic immersion in human tissue. Selecting an appropriate antenna technology, from the numerous models available in the market, for a specific wearable application is a challenging task. Similarly, antenna design is also a complex process requiring high-end simulation tools and experienced RF antenna designers. Mistral's highly experienced RF team works directly with product developers to evaluate antenna design requirements, antenna characteristics and performance factors.

With over 20+ years of experience designing embedded products featuring technologies such as Bluetooth, RFID, NFC and LoRa to multiband GSM, 3G, 4G/LTE, Wi-Fi and UWB systems, Mistral has the expertise to provide custom antenna designs of any complexity that cater to myriad product needs.

1.5 TELEMEDICINE

Telemedicine means literally medicine at a distance. New technologies in sensing, medical imaging and wireless data communications are allowing telemedicine to provide healthcare at a distance with much lower cost than in the past, enabling the development of new wide spread remote medicine initiatives. Researches categorize the telemedicine history into three eras. The first era can be named as telecommunications era of the 1970s Applications in this era were dependent on broadcast and television technologies where telemedicine application was not integrated with any other clinical data. The second era of telemedicine, dedicated era, started during the late 1980s as a result of digitalization in telecommunications and it grew during 1990s The transmission of data was supported by various communication mediums ranging from telephone lines to Integrated Service Digital Network (ISDN) lines.

The high costs attached to the communication mediums that can provide higher bandwidth became an important bottleneck for telemedicine. Dedicated era has turned into an Internet era where more complex networks are supporting the telemedicine. The third era of telemedicine is supported by the technology that is cheaper and accessible to an increasing user population. The enhanced speed and quality offered by Internet or 3G mobile telephony is providing new opportunities in telemedicine. Certain recent research projects include the use of satellite-based Telemedicine solutions. Satellite- based telemedicine services are used to solve tele-consultation, tele-education, home care, second opinion and other medical problems.

To make available a clinical health care from a distance, the useable telecommunication and information technology is telemedicine. To conquer distance barrier and to get better access to medical services, it has been used that would often not be consistently available in distant rural communities.

This system provides positive insight, promotes the need to find creative and economical technological solutions that could improve the cost effectiveness of health care. Telemedicine is a technology that's one of the vital approaches to reduce the social costs of health care, while providing the support needed for the elderly and guaranteeing a good quality of life. Emergency responses to natural disaster automatically records the information in telecommunication technology. But, use of telemedicine presenting medical offerings remotely via telecommunication- based exchanging digital information has been suggested especially on occasion. During the last decade, the navy, space communication, and diverse governmental corporations have progressively developed telemedicine applications and tested them in actual and simulated civilian disaster emergencies.

This manuscript opinions the records of telemedicine alertness at some point of real failures and associated conditions, offers insight into troubles that should be addressed, and summarizes improvements that are probable to improve future catastrophe results. Telemedicine systems goal to provide superior health care services to humans. In current scenario, Telemedicine plays a major role due to the inconvenience of remote monitoring of human health.

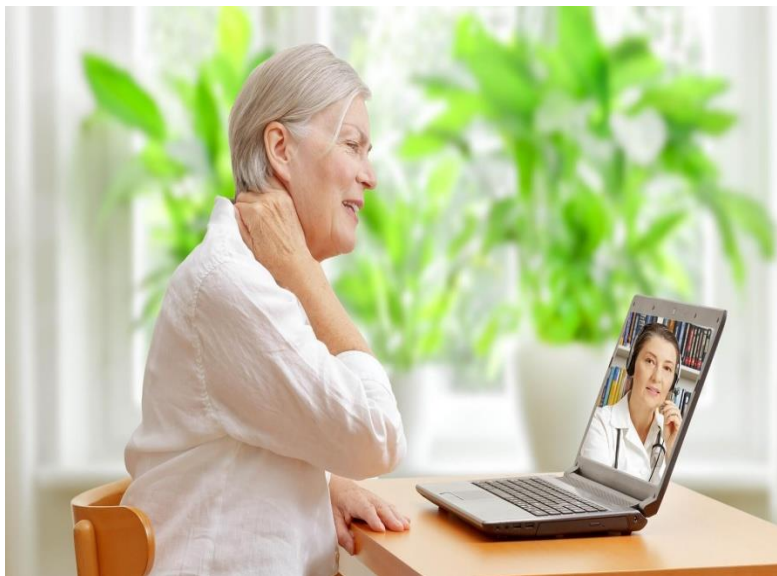


Fig: 1.5 Telemedicine (Hexaware Technologies, 2021)

1.5.1 APPLICATIONS OF TELEMEDICINE

1.5.1.1 TREATMENT OF CHRONIC ILLNESSES

Telemedicine offers a convenient and cost-effective way of monitoring patients with chronic illnesses. Patients can be equipped with home-monitoring systems to keep a daily record of their vitals like blood pressure, glucose levels, and heart rate. This kind of access will be immensely helpful for doctors to manage their patient's health and take immediate action in case of any health emergency.

1.5.1.2 FOLLOW-UPS

Telemedicine applications allow patients to follow remote follow-up visits with the doctor, who can ensure that the aftercare recommendations are being followed by the patient. It is also useful in cases where in-person follow-ups might not be necessary or urgent. As an added bonus, remote follow-ups will also reduce the number of last-minute cancellations and no-shows, thus increasing the profitability of a practice.

1.5.1.3 NO MISSED PRESCRIPTIONS

Since Telemedicine allows doctors to check in with patients more easily, they can ensure that the patient is conforming to the prescribed regimen. A reminder system can be established to remind the patients not to skip out and renew their prescriptions on time. The lesser the number of missed prescriptions, the easier it is to reduce any health risks associated.

1.5.1.4 FLEXIBLE PRACTICE

The perquisites of Telemedicine applications are plenty for both physicians and patients. With the ability to conduct remote health check-ups doctors are not required to comply with long working hours in the clinic. They can stay in direct contact with the patient without having to keep the clinic open. This prospect is equally appealing to both parties, along with reduced travel expenses.

1.5.1.5 OTHER HEALTH SERVICES

Telemedicine applications are further-reaching than just virtual monitoring and care of patients at home. It is helpful for people with mental health conditions, as shown by studies. In rural areas or in case of a natural disaster, people may not have access to getting the required care, they can use Telemedicine in such conditions.

1.6 TELEHEALTH

Tele-health is the delivery of health-related services and information via electronic communication - individuals are able to manage their health with remote support from healthcare workers. Technology is a key aspect of this service delivery but tele-health is not confined to one particular type of technology. While technology enables a clinical interaction to take place over any given spatial distance, the choice of technology can determine how these interactions take place.

1.6.1 TYPES OF TELEHEALTH TECHNOLOGY

The choice of technology will determine if tele-health is asynchronous or in real-time.

- Asynchronous Tele-health or Store and Forward (S&F).
- Information is recorded and transferred - can be stored locally or in a server, depending on the availability of connectivity.
- Programs Newer technology such as virtual reality or "wearables" use “store and forward” technology to transmit data back to the therapist.
- Viewing and comments of the data can be done at the participants' (client/patient or healthcare provider) convenience.
- Less dependent on connectivity, More difficult to administer.
- Software choice and interconnectivity standards play a role.
- Real-time or Synchronous Tele-health.
- Information provided by one part is received almost instantaneously by the second party (through audio/visual means).
- Information or data is transferred live.
- It is a convenient and easy form of tele-health:
 - requires high bandwidth
 - constant connectivity

- investment in related hardware
- Video conferencing between patient and healthcare provider is the prime example - physiotherapist and client can see and interact with each other in a live fashion.
- This is more prevalent in physiotherapy for heart and lung disease, diabetes management and musculoskeletal conditions for example osteoarthritis and for the rehabilitation of patients after orthopedic surgery.

CHAPTER - 2

LITERATURE SURVEY

The antenna used for medical applications are of two types namely, wearable antenna and implantable antenna. These antennas are studied in various journals and the survey mentioned below is mainly focused on wearable antenna, otherwise known as textile antenna.

Deepika S, Kavya Sree G, Sugunavathy S in 2020 paper titled "Design of wearable microstrip patch antenna for patient monitoring" published in journal named International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET). Where a wearable microstrip patch antenna for patient monitoring is proposed. This antenna is designed to operate at an unlicensed ISM band of 2.4 GHz. The design is built on denim (jean cloth) substrate with shieldIt as a conducting metal having a microstrip line feeding structure. The simulated performance of the proposed antenna is compared to rectangular patch antenna and some other shaped patch antennas. It is designed and simulated using Computer Simulation Technology (CST) tool. The dimension of the proposed design is 25 x 35 x 0.7 mm³. Its resonant frequency is 2.4 GHz with return loss of -27.01 dB. This paper also discusses the other antenna parameters like VSWR, Gain, Directivity, Efficiency and SAR.

Haider R. Khaleel, Hussain M. Al-Rizzo, Daniel G. Rucker, and Taha A. Elwi in 2010 published in University of Arkansas at Little Rock, Little Rock, AR 72204 with title "Wearable yagi microstrip antenna for telemedicine applications". This paper presents a button shaped antenna based on a microstrip Yagi array. The proposed antenna is suitable for Wireless Body Area Network (WBAN) and telemedicine applications operating at 2.45 GHz. Antenna properties, such as far-field radiation patterns, coupling coefficient, measured by the scattering parameter S₁₁, and gain are provided. Moreover, the simulated performance of the proposed antenna is compared to circular and rectangular patch button shaped antennas having similar sizes.

Design and simulations are performed using CST Microwave Studio software which is based on the Finite Integration Technique (FIT). The proposed antenna achieved a higher gain of 6.7 dB and front to back (F/B) ratio of 11.7 dB compared to the two antennas, in addition to the semidirectional radiation pattern which is preferred over the omni-directional pattern to overcome unnecessary radiation to the user's body and satisfies the requirement for on-body and off-body applications.

The objective of this paper titled "Simulation and design of wearable antenna for telemedicine application" was written by Sonia C. Survase, Prof. Vidya V. Deshmukh in 2013 and journal named International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering. This is to provide a better solution for telemedicine application. Various wireless technologies are used, but wearable antenna is the best solution. In this paper wearable antenna is designed. The design consists of microstrip yagi patch antenna. This antenna is simulated on High frequency structure simulation (HFSS). This simulation gives improved return loss, low front to back ratio. It operates at the frequency of 2.45 GHz. Dielectric constant used for this antenna is FR4 epoxy which is easily available in market. Here, Circular yagi patch antenna and Rectangular yagi patch antenna are compared to know that the performance parameter changes as change in geometry. The S11 plot for the circular yagi patch antenna which gives improved result as compared to previous one. It gives -24dB return loss. The rectangular yagi patch antenna which gives improved gain 7.8dB which is good. Moreover, the comparison of simulation on different software is also done which results that performance of antenna parameter vary with simulation software. HFSS gives the improved results.

In this a low profile wearable microstrip patch antenna is designed in 2018 by Saqib Hussain, Saima Hafeez, Sajjad Ali Memon, Nasrullah Pirzada and it was published as Article in International Journal of Advanced Computer Science and Applications and it titled as "Design of wearable patch antenna for wireless body area networks". It suggested for constant observation of human vital signs such as blood pressure, pulse rate and body temperature using wireless body area network (WBAN) technology.

The operating frequency of the antenna is taken as 2.45 GHz which lies in industrial, scientific and medical (ISM) frequency band. Polyester textile fabric with a relative permittivity of 1.44 and thickness of 2.85 mm is used as a substrate material. The proposed antenna is designed to achieve better return loss, VSWR, gain and low value of specific absorption rate (SAR) as compare to other existing wearable antenna. The measured SAR value on the 3-layer human phantom model at 2.45 GHz is 0.0640 W/Kg averaged over 1 gm of tissue. The radiation pattern of the simulated antenna was perpendicular to the axis of the wearer, which means that this antenna is feasible for wearable applications and cannot harm the human body tissues due to its high front to back(F/B) ratio. The achieved antenna return loss at 2.45 GHz is about -10.52 dB and gain of 7.81 dB. The VSWR value achieved at 2.45 GHz is 1.84, which is good in terms of good impedance matching. Other antenna field parameters like 2D and 3D gain, radiation pattern, and SAR value have been calculated. High-Frequency Structure Simulator (HFSS) is used to design and simulate the proposed antenna.

Md. Amanath Ullah, Mohammad Tariqul Islam, Touhidul Alam, Farhad Bin Ashraf in 2018 written paper titled “Paper-based flexible antenna for wearable telemedicine applications at 2.4 GHz ISM band” and was published in Centre of Advanced Electronic and Communication Engineering, Faculty of Engineering and built Environment. This paper demonstrates the performance of a potential design of a paper substratebased flexible antenna for intra body telemedicine systems in the 2.4 GHz industrial, scientific, and medical radio (ISM) bands. The antenna was fabricated using 0.54 mm thick flexible photo paper and 0.03 mm copper strips as radiating elements. Design and performance analyses of the antenna were performed using Computer Simulation Technology (CST) Microwave Studio software. The antenna performances were investigated based on the reflection coefficient in normal and bent conditions. The total dimensions of the proposed antenna are $40 \times 35 \times 0.6 \text{ mm}^3$. The antenna operates at 2.33–2.53 GHz in the normal condition. More than an 8% fractional bandwidth is expressed by the antenna. Computational analysis was performed at different flexible curvatures by bending the antenna. The minimum fractional bandwidth deviation is 5.04% and the maximum is 24.97%.

Moreover, it was mounted on a homogeneous phantom muscle and a four-layer human tissue phantom. Up to a 70% radiation efficiency with a 2 dB gain was achieved by the antenna. Finally, the performance of the antenna with a homogeneous phantom muscle was measured and found reliable and satisfactory for wearable telemedicine applications.

The objective of this paper is to design and optimization of implantable printed antennas in human body for medical telemetry was written by Saima Azzaz-Rahmani , Hadj Zerrouki , and Leila Dekkiche in 2021 and was published in Journal of Applied Science and Engineering with a title “Novel microstrip patch antenna for implantable medical telemetry devices”. The proposed antenna operates in the MICS band between 402 and 405 MHz. This frequency band is explored to design mobile and comfortable communication systems to support human life. The antenna is simulated using HFSS software. The proposed antenna resonates at 404 MHz with a return loss of -32.58 dB, bandwidth of 26 MHz and gain of 6.5 dB. The proposed design contains two concentric square elements and a metal pad placed between them with a coaxial feeder cable. Also shorting pin which connects the outer annular element to the ground plane plays critical role on miniaturization of the antenna. We have examined the effects of some important parameters on the proposed antenna performance. Such design results in noticeable reduction in antenna size. In comparison with the previously available designs operating in the MICS band. The antenna is simulated using HFSS software. Eventually it was shown that the antenna’s design can be used in wireless communication link for medical implantable systems according to the application wished to attain.

Faisal Ahmed Dahri , Riaz Soomro , Zeeshan Ali Memon in 2017 written paper titled “Design of wearable microstrip yagi array antenna aimed for telemedicine applications” and was published in ReachGates. In this paper, square shaped 2.45 GHz Wearable antenna on Microstrip Yagi array has been presented by developing compact size patch antenna as simulated with garments for telemedicine applications has been discussed, amid accomplished antenna suite sealed as a wearable device for wireless data transfer to remote locations.

With HFSS modeling, wearable antenna has been designed including simulation results of 7.9 dB as high gain, low reflection co-efficient of -27Db with 3D polar plot, well-matched impedance, low VSWR and reduced substrate thickness of 62mm. This shows that the power absorption for the wearable antenna is less than -10dB to grip the quantity of reflections in proposed design. Ultimately, due to reigning of reflected loss matching of impedance 50 Ω permits strong power levels from source to destination and the parameters used in antenna design are operating frequency of 2.45 GHz, Dielectric constant of 2.1, substrate thickness of 62mm and reflection dimension is 45mm *10mm. The proposed antenna configuration manifests the attributes of low power consumption, comfortable wearer material, compact module and washable fabric material.

This paper proposes a systematic design methodology for slotted wearable textile antenna for wireless telemedicine applications written by Mahendra Kumar, Nupur Gupta, Ravi Kanth Prasad in 2022 and was published in ResearchGate Square with a title “Slotted wearable textile antenna for wireless telemedicine applications”. A notch and slot loaded proposed textile antenna utilizes denim fabric as a substrate, whereas copper fixed as conducting patch proposed textile antenna with 50 Ω microstrip feed has been designed and fabricated. The proposed textile antenna covers the frequency range between 1.8–4.9 GHz which includes ultra-wide band. The proposed design has an enhanced bandwidth of 5–92% with a return loss of -39.16 dB at a resonance frequency of 3.58 GHz, which are remarkable results. Wearable textile antenna covers the wide frequency range between 1.80 GHz and 4.87 GHz for WLAN (2.42-2.484 GHz), Wi-MAX(2-11 GHz) and LTE(2.17 GHz) applications. These bands are used for wireless telemedicine, m-health, e-health application. The simulation of proposed antenna is performed using Mentor Graphics IE3D simulation software. Textile material is used as substrate of the proposed antenna where as copper tape is used for the radiating element and ground plane. This antenna has also an improved directivity from 3.43dBi to 5.17dBi, gain from 3.30dBi to 4.98dBi, antenna efficiency by 89.107%, radiation efficiency by 97.036% and it is simultaneously useful for wireless telemedicine applications.

Due to ultra-wide bandwidth range, its speed of transmitting data increases but range decreases therefore high amount of data can be transmit at low power and it find application in wireless communication, Wi-MAX and LTE applications.

This paper "Body worn antenna for telemedicine applications" from International Journal of Emerging Trends in Science and Technology was written by M.Anna Kamatchi, V.Keralshalini, A.Berlin in 2017. In this paper a technique used is coplanar waveguide feeding technique with inverted Double-U shaped connected slots on rectangular shaped radiating patch which is resonated at 1.85 GHz to regularly monitoring the human body. The antenna parameters are Radiation pattern, Gain & VSWR are analysed using HFSS tool for inverted Double-U shaped antenna. The used parameters are Radiation pattern, DoubleU shaped antenna. The compact size of antenna is 21mm*28mm*1.6mm provides the VSWR value as <2 and gain of about 1.0466 dB. In body area antenna with Double-U shaped FR4 substrate is 4.2 and a loss tangent of 0.008 at 3GHz and a thickness of 1.6mm. The reflection loss is about -20.0725 dB at 1.8 GHz to 5.2 GHz used for various wireless applications with a -20Db return loss. The result shows that the antenna produces good radiation pattern which is suitable for body area network. In future, the frequency of band can be increased to cover several applications by incorporating different shapes of patches on flexible substrate material. The body worn antenna shown a rapid growth in the research with huge developments in the measurement of human parameters such as heartbeat, movement of fetus recognition, blood pressure and temperature. There is a need of antennas which can be worn and part of clothing defined as wearable micro strip patch antennas.

CHAPTER - 3

EXISTING AND PROPOSED METHODOLOGY

3.1 EXISTING WORK

A reliable wearable microstrip patch antenna for patient monitoring is proposed. This antenna is designed to operate at an unlicensed ISM band of 2.4 GHz. The design is built on denim (jean cloth) substrate with ShieldIt as a conducting metal having a microstrip line feeding structure. The simulated performance of the proposed antenna is compared to rectangular patch antenna and some other shaped patch antennas. It is designed and simulated using Computer Simulation Technology (CST) tool. The dimension of the proposed design is 25 x 35 x 0.7 mm³. Its resonant frequency is 2.4 GHz with return loss of -27.01 dB. This paper also discusses the other antenna parameters like VSWR, Gain, Directivity, Efficiency and SAR.

The patch of the antenna is mounted on 0.7 mm thick denim substrate. Its dielectric constant is 1.6 and loss tangent is 0.02. Conducting patch is placed over denim substrate and desired shape is attained by etching the remaining area in the radiating element. The antenna structure with its dimensions. The proposed system uses length of 9 mm microstrip feed where a radiating strip is connected directly to the edge of microstrip patch. The main advantage of this technique is simple to design and fabricate.

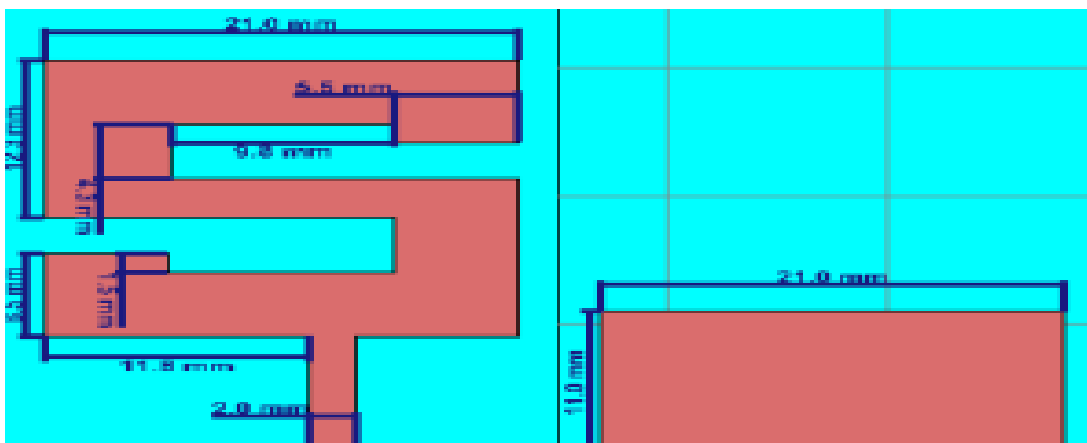


Fig: 3.1 S-Shaped Antenna (a) Radiating patch (b) Ground plane
(Deepika.S etal, 2020)

3.1.1 SIMULATION RESULTS OF EXISTING ANTENNA

- The reflection coefficient (S-parameter) of simulated design. From this we can infer that the antenna resonates at 2.4 GHz. The performance of the antenna will be better if the return loss is less than -10dB. Since the obtained return loss of is -27.01 dB the antenna will perform better.
- Directivity gives the ratio of power density between direction of strongest emission of the antenna and ideal isotropic radiator. The directivity of an antenna is 2.24 dB.
- Gain is the ability of the antenna to radiate in any direction. The gain of designed antenna is 1.66 dB.
- Efficiency is the ratio of power radiated by an antenna to the power supplied to an antenna. It can also be represented as the ratio of gain of an antenna to its directivity. The efficiency of the designed antenna is 74%.
- Voltage standing wave ratio describes the reflected power from the antenna. The performance of an antenna will be better when VSWR value is less. Ideal value of VSWR is unity and maximum value can be 2, which is an acceptable value of any antenna. The designed wearable antenna has better VWSR of 1.09 at 2.4 GHz.

3.1.2 BLOCK DIAGRAM OF EXISTING ANTENNA

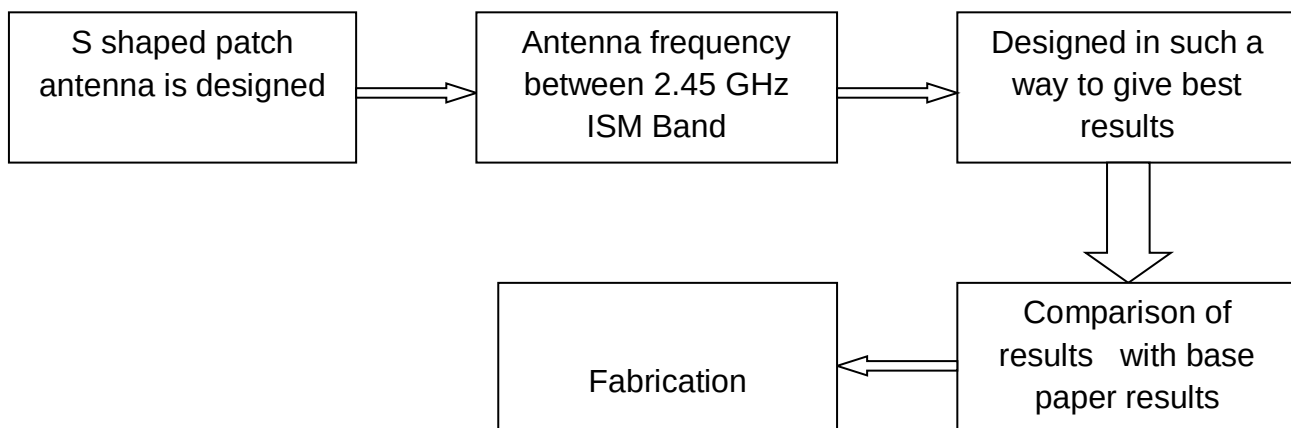


Fig: 3.2 Flow Chart of Existing Work

3.2 PROPOSED WORK

Now we are going to design a **Parallel L slot with closed loop array antenna** for patient monitoring system. This antenna is designed to operate at an 4.25 GHz as a wearable textile antenna. This covers the wide frequency range between 1.80 GHz to 4.87 GHz at this range of frequencies they are used for wireless telemedicine, M-health, E-health applications. It is designed and stimulated using high frequency structure stimulation software (HFSS) tool. The design is going to be built on Cotton, Fr4_epoxy, Teflon and Jeans as a substrate with copper as a conducting metal having a micro strip line feeding structure. The simulated performance of the proposed antenna with different substrate materials is compared and the best among them is going to be chosen. The dimensions of this proposed design is $16.6 * 16.6 * 1.6 \text{ mm}^3$. From this antenna some of the parameters like gain, vswr, return loss, directivity, and reflection coefficient etc, are measured so show that our proposed antenna is better compared to the existing antenna.

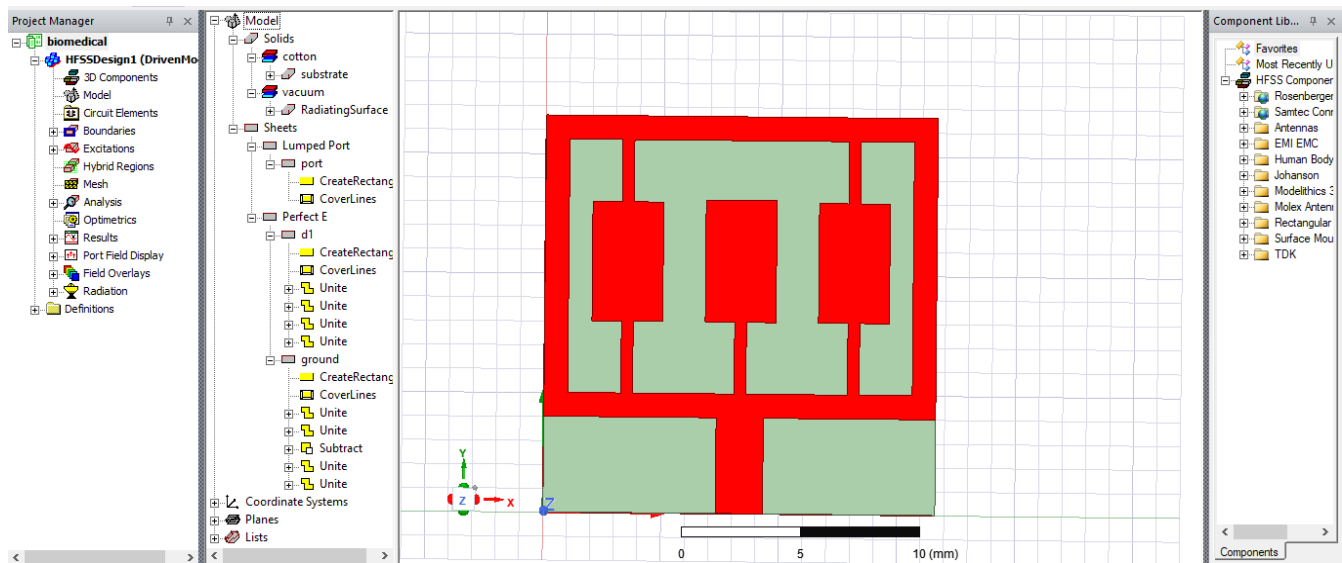


Fig: 3.3 Parallel L Slot with Closed Loop Array Antenna

Since the antenna is designed based on square patch antenna, hence the design calculation of square patch is applicable. To obtain the dimensions of patch antenna we need to specify the dielectric constant and the desired frequency. We proposed the square patch antenna because of it is easy to access the even distribution process, we can predict

reflection coefficient in an easy manner.

3.2.1 SQUARE PATCH ANTENNA

- Wavelength

Wavelength is the distance between identical points in the adjacent cycles of a waveform signal propagated in space or along a wire.

$$\lambda = \frac{c}{f} \text{ mm/sec} \longrightarrow (3.2.1.1)$$

where,

λ =wavelength of the proposed frequency

c =velocity of light in space i.e. 3.8×10^6 km/sec

f =frequency that we proposed

- Length and Width

The length and width mean the horizontal and vertical length of the antenna. The larger the trace width is, the lower the impedance will be. The thinner the trace width, the more impedance is offered. Increasing the board thickness increases the impedance while reducing it will decrease the impedance

$$L=W= \frac{\lambda}{2} \sqrt{\frac{2}{\epsilon_r}} \text{ mm} \longrightarrow (3.2.1.2)$$

- Fringing effect

The bending of the electric flux lines towards the edge of parallel plate capacitors is known as fringing. Fringing is frequently referred to as the "edge effect.". In most capacitors, the flux lines are homogeneous and parallel.

$$\epsilon_{\text{reff}} = \frac{\epsilon_r + 1}{2} \longrightarrow (3.2.1.3)$$

- Thickness

It gives the height of the substrate and it give potential strength to the antenna to hold

$$h = \frac{0.0606\lambda}{\sqrt{\epsilon_r}} \text{ mm} \longrightarrow (3.2.1.4)$$

- Ground and Substrate Dimensions

Substrate is a base or container on which microstrip patch (metallic sheet) antenna is fabricated and it plays important role in microstrip antenna functioning. The substrate in microstrip antennas is principally needed for the mechanical support of the antenna. To provide this support, the substrate should consist of a dielectric material, which may affect the electrical performance of the antenna, circuits and transmission line. A substrate must, therefore, simultaneously satisfy the electrical and mechanical requirements, which is sometimes difficult to meet.

The Ground Plane its principal purpose is to allow the flow of return current there should be a minimum of interruptions to it, and for this reason ground planes are more successful on a multilayer board where an entire layer can be devoted, one to the power plane and one to the ground

$$L_g = L + 6h \text{ mm} \longrightarrow (3.2.1.5)$$

$$W_g = W + 6h \text{ mm} \longrightarrow (3.2.1.6)$$

- Feed

The antenna feed system or antenna feed is the cable or conductor, and other associated equipment, which connects the transmitter or receiver with the antenna and makes the two devices compatible

$$L_f = \frac{\lambda_g}{4} \text{ mm} \longrightarrow (3.2.1.7)$$

$$W_f = \frac{2h}{\pi} \{ (B - 1 - \ln(2B - 1) + (\frac{\epsilon_r - 1}{2\epsilon_r})) \} \times \{ \ln(B - 1) + 0.39 - (\frac{0.61}{\epsilon_r}) \} \longrightarrow (3.2.1.8)$$

$$B = \frac{60\pi^2}{Z_0\sqrt{\epsilon_r}} \longrightarrow (3.2.1.9)$$

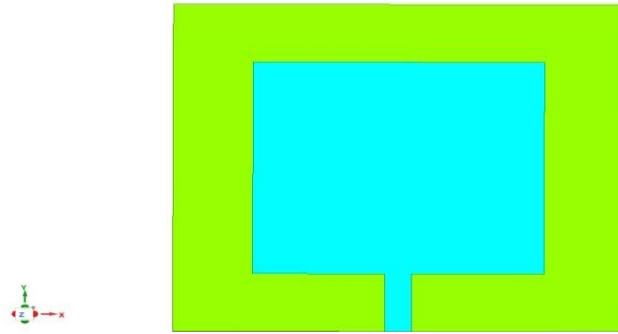


Fig: 3.4 Square Patch Antenna (Everything RF, 2020)

3.2.2 BLOCK DIAGRAM

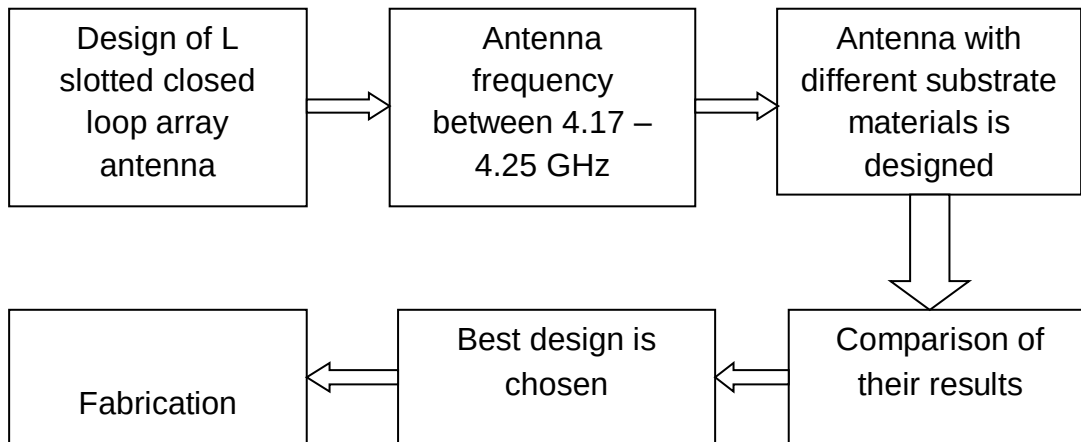


Fig: 3.5 Flow Chart of Proposed Work

CHAPTER - 4

EXPERIMENTAL OR MATERIALS AND METHODS

4.1 HFSS SOFTWARE TOOL

Ansys HFSS is a high-frequency structure simulator that can be used to design and simulate high-frequency electronic items. Multipurpose, full wave 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. Ansys HFSS software is used by engineers all over the world to develop high-frequency, high-speed electronics that can be found in communications networks, advanced driver assistance systems (ADAS), satellites, and internet-of-things (IoT) devices.

- Component-to-System EM Workflow
- Encrypted 3D Design Share
- Coupled EM System Solver
- Automatic Adaptive Meshing

The benefits of simulating a circuit's high frequency behavior with high accuracy on a computer reduces the final testing and verification effort of the system as well as mitigating the necessity of building costly multiple prototypes, saving both time and money in product development. HFSS captures and simulates objects in 3D, accounting for materials composition and shapes/geometries of each object. HFSS is one of several commercial tools used for antenna design, and the design of complex radio frequency electronic circuit elements including filters, transmission lines, and packaging.

4.1.1 INSTALLATION PROCESS OF HFSS TOOL

Before installing the Ansys software:

1. Start CADpass Client and log in using your CMCS Microsystems Username and Password.
2. Double-click Ansys Campus Solutions (Research) and download the installer archive.
3. Extract the archive into a separate temporary folder.

To install the Ansys software:

1. In the extracted Electronics directory, double-click autorun.exe.
2. In the window that is displayed, click Install Electro-magnetics Suite, as shown in Fig 4.1.



Fig: 4.1 Ansys Electro-Magnetics Installation Shell

In the pop-up dialog, you are prompted to close all Windows programs before starting the installation.

3. Close the programs and click Next. At this point, you are prompted to read the license agreement carefully to ensure that you understand your obligations.
4. If you agree to the terms, click Yes.
5. In the next pop-up dialogue, choose your installation directory and click Next.
6. Choose a default temporary directory for simulation work, either solo or group, and click Next.
7. Choose a location for common libraries containing individual or group material and click Next.
8. If you already have other Ansys 2021 software installed, you may choose to integrate Ansys Electromagnetics Suite with it by clicking Yes.
9. Note: For simplicity, you can click No, and return to the integration step later.
10. In the following window, you are prompted for your license location.
11. Choose I want to specify a license server and click Next.

12. Enter the information for the Ansys license server: TCP/IP port number is 6624 and Server 1 is a2.cmc.ca
13. To complete the rest of the installation process, click Next. When the executable has completed its task, the dialogue InstallShield Wizard Complete is displayed.
14. Click Finish.

4.2 PROCESS OF DESIGNING AN ANTENNA

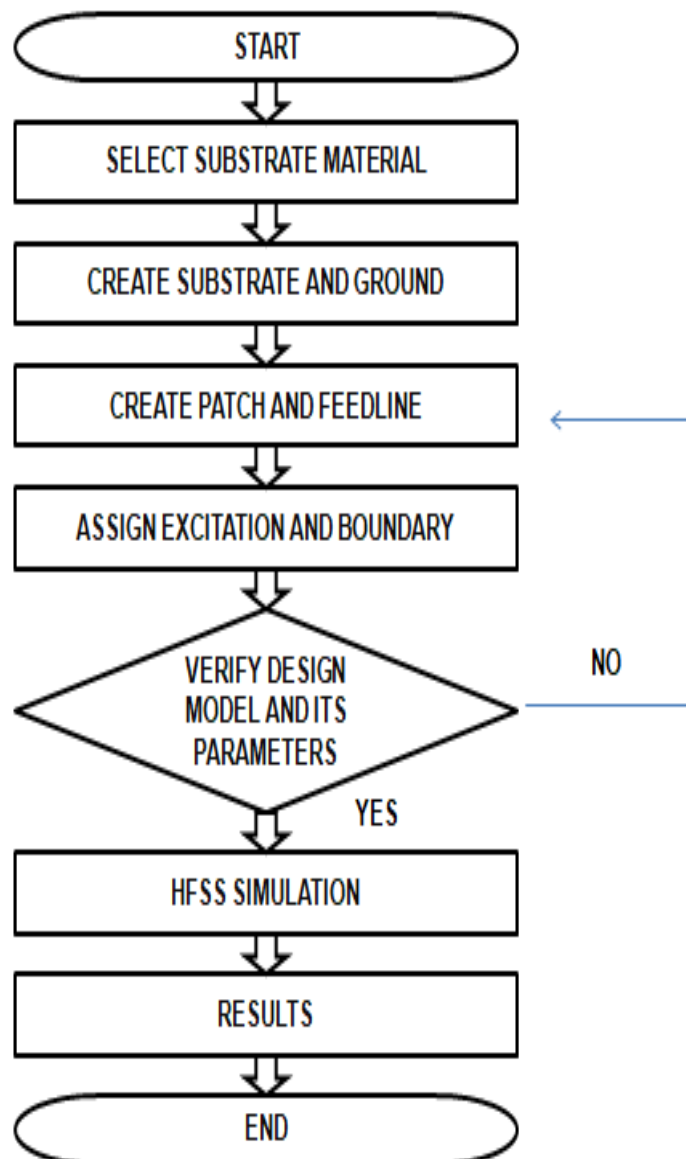


Fig: 4.2 Antenna Simulation Flowchart in HFSS

The proposed antenna is designed and simulated using the High-Frequency Structure Simulator (HFSS). The suggested antenna is a parallel L slot closed loop array antenna, therefore its design in HFSS needs some geometrical and simulation parameters. The geometrical parameters of the proposed antenna are calculated using microstrip equations discussed earlier. However, the major simulation parameter of an antenna is a frequency that can be defined according to the application of the proposed antenna. After the computation of geometrical parameters, the design of the suggested antenna can be modeled in the HFSS.

4.2.1 STEPS FOLLOWED AS IN 4.1.1

STEP 1: START

Initially when the HFSS software tool is opened. We need to insert HFSS as shown in fig 4.2.1. Then we will start to place one after the other accordingly as shown in the flow chart.

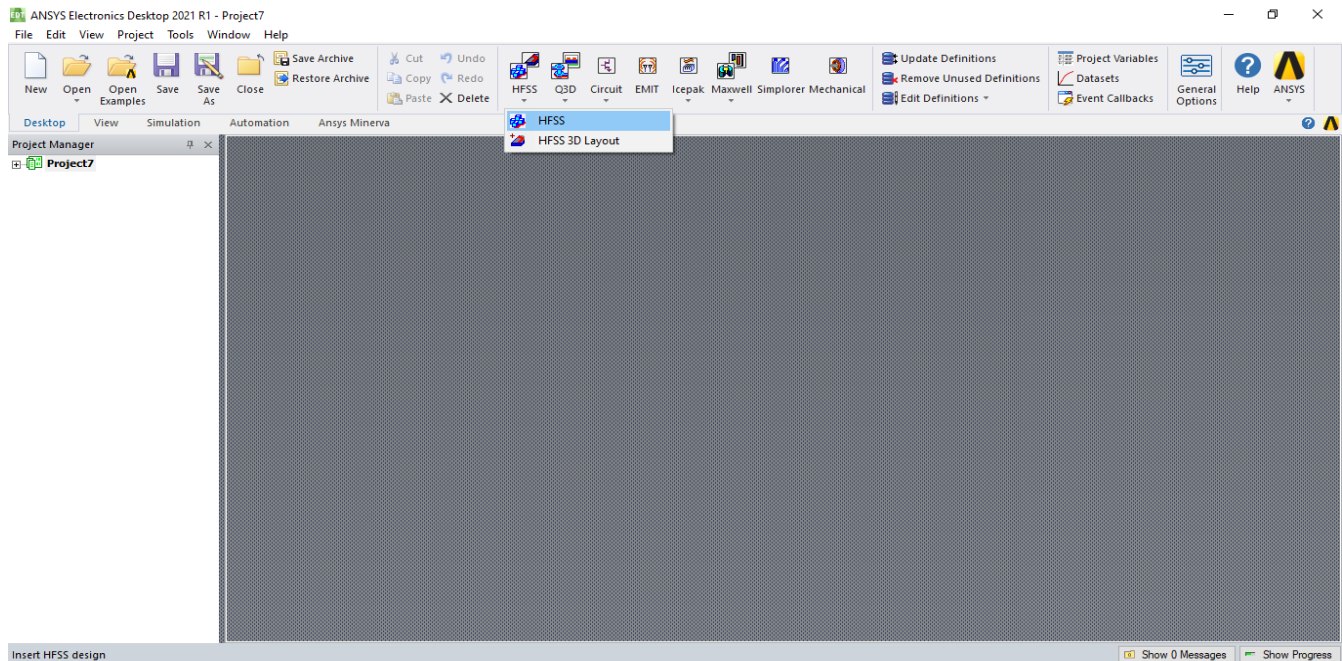


Fig: 4.3 HFSS Layout

STEP 2: SELECT SUBSTRATE MATERIAL

Substrate material is selected based on your choice. There are many materials that can be used as substrate but few are mostly used and useful. When it comes to the proposed antenna we have used the four different materials as substrate they are Fr4_epoxy, Jeans, Cotton and Teflon. Parameters of this antenna with different substrate material will be

measured the best antenna with optimum results will be taken into consideration and taken to the fabrication.

STEP 3: CREATE SUBSTRATE AND GROUND

Substrate is a base or container on which microstrip patch (metallic sheet) antenna is fabricated and it plays important role in microstrip antenna functioning. The substrate in microstrip antennas is principally needed for the mechanical support of the antenna. To provide this support, the substrate should consist of a dielectric material.

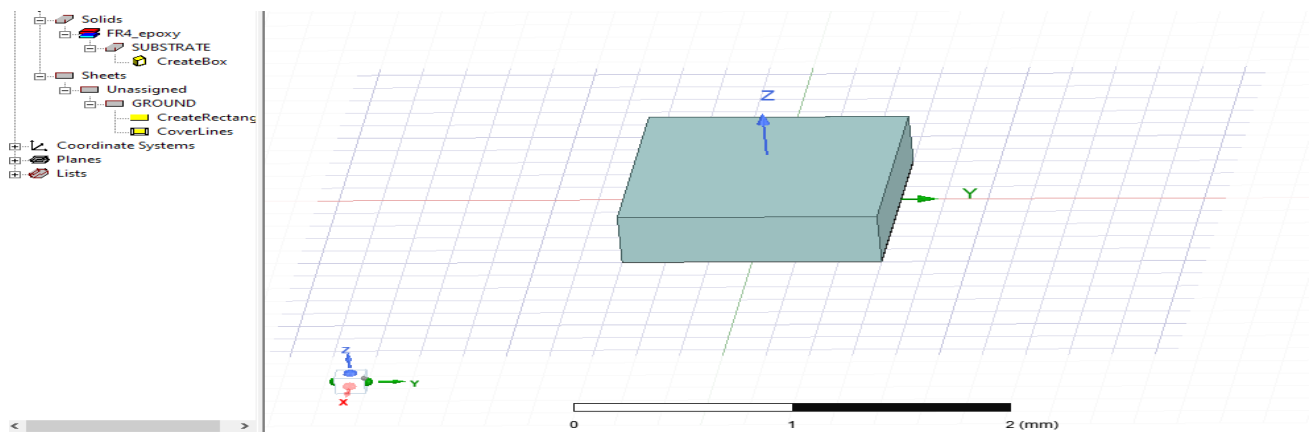


Fig: 4.4 Substrate

The ground plane isolates the feedline from the radiating element. The length of the slot and the width of the feedline permits controlling. It is the most difficult method to feed the antenna. This is so because the two dielectric substrates cause difficulty in fabricating the microstrip in the structure.

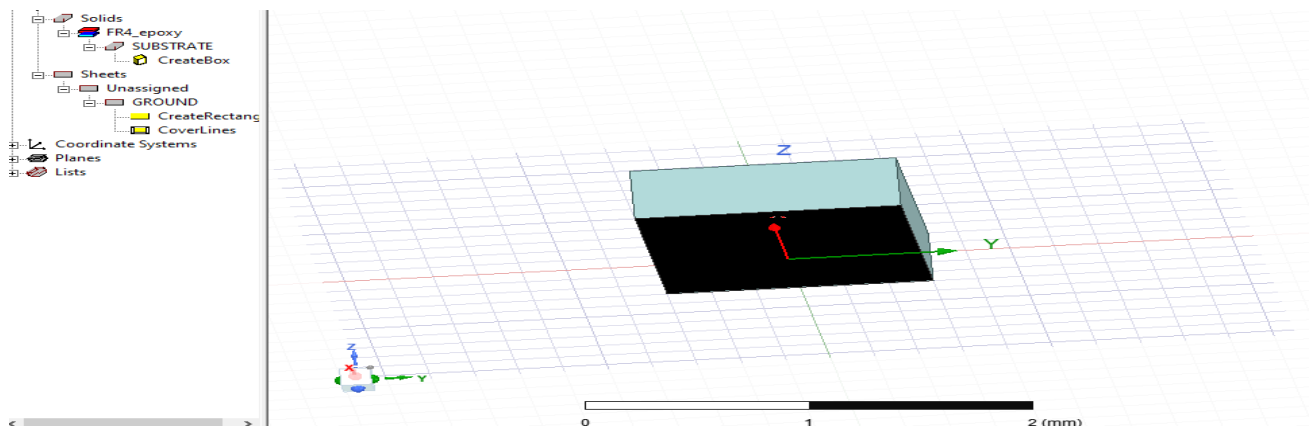


Fig: 4.5 Ground

STEP 4: CREATE PATCH AND FEEDLINE

A patch antenna is a type of antenna with a low profile, which can be mounted on a surface. It consists of a planar rectangular, circular, triangular, or any geometrical sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane.

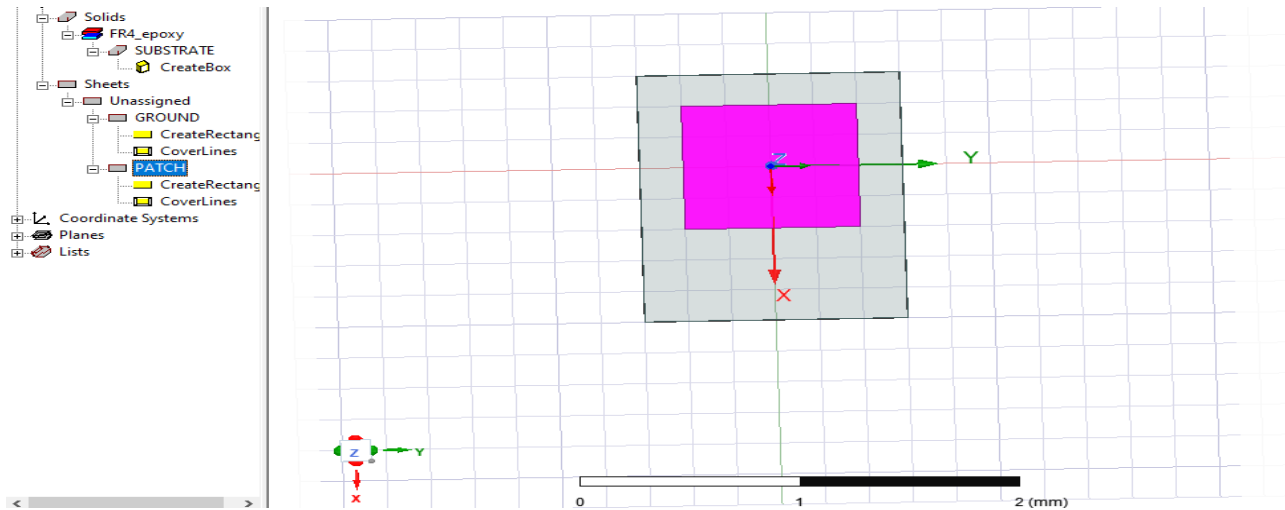


Fig: 4.6 Patch

A Feedline is a conducting strip is connected directly to the edge of the Microstrip patch as shown in Fig 4.2.1. The patch is wider than the conducting strip. Thus the feed can be etched on the same substrate to provide a planar structure.

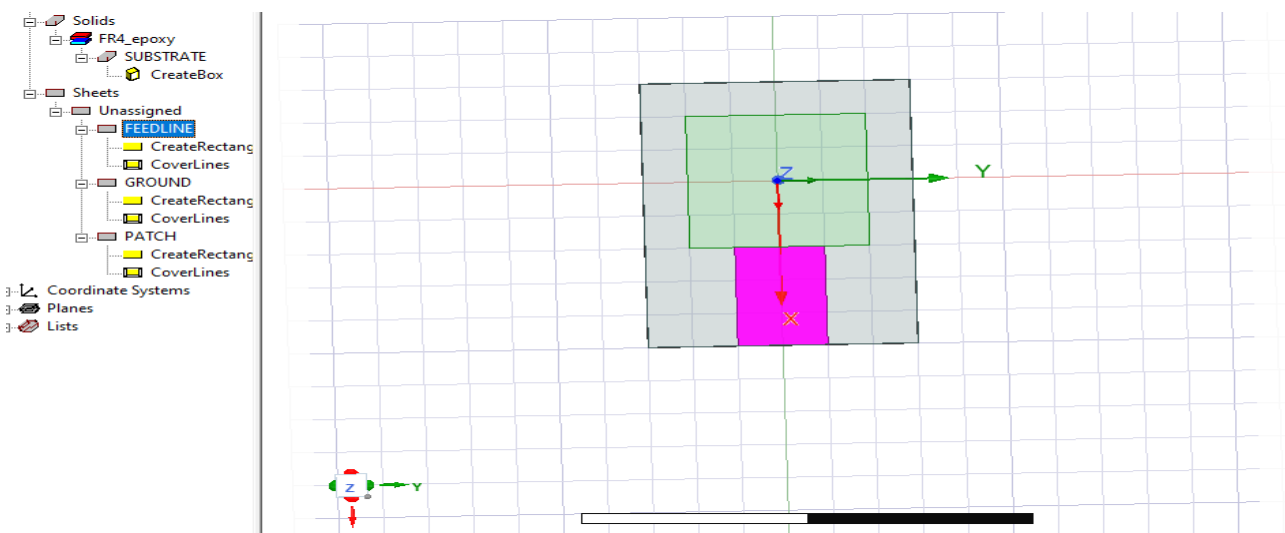


Fig: 4.7 Feed line

STEP 5: ASSIGN EXCITATION AND BOUNDARY

Select the object face to which you want to assign the port.

Click HFSS>Excitations>Assign>Wave Port.

The HFSS default boundary on all outer surfaces is a perfect electric conductor boundary. This is a result of the fact that the solution space is enveloped by an automatically created object called the background. There are no fields calculated within this background object as it is defined as a perfect conductor.

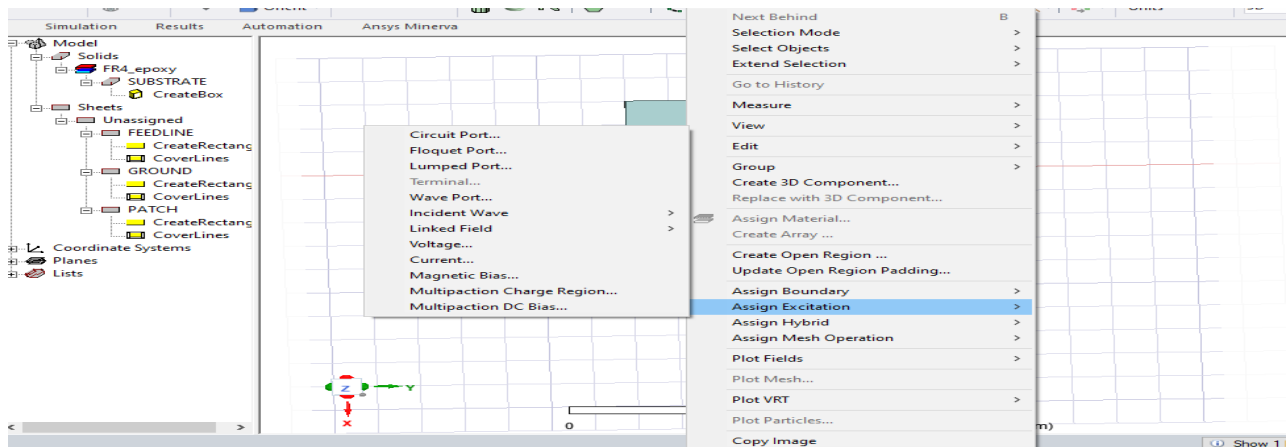


Fig: 4.8 Assign Excitation

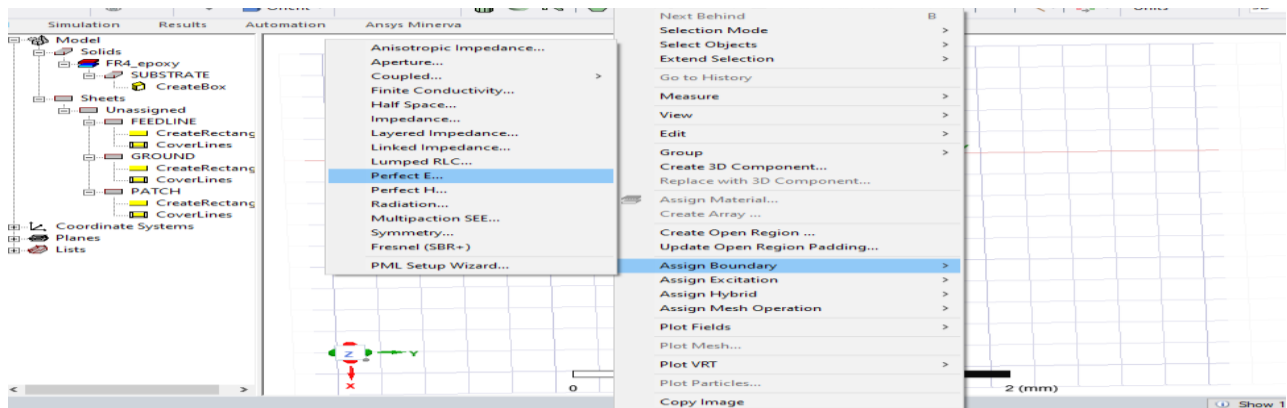


Fig: 4.9 Assign Boundary

STEP 6: VERIFY DESIGN MODEL AND ITS PARAMETERS

Final design of our antenna is designed by following the above steps. We have designed a parallel L slot closed loop array antenna.

To verify the design we need to click on stimulation then validate the design. If the validation is successful without any errors then we can click on analyze all and analyze the design. After this the hole process parameters can be created in the results to see the stimulated results of the parameters.

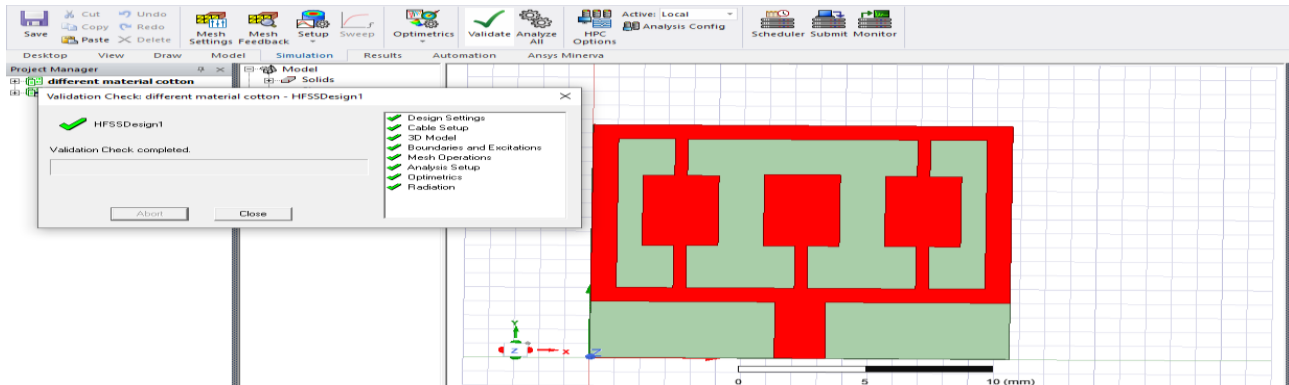


Fig: 4.10 Final Design Validation Check

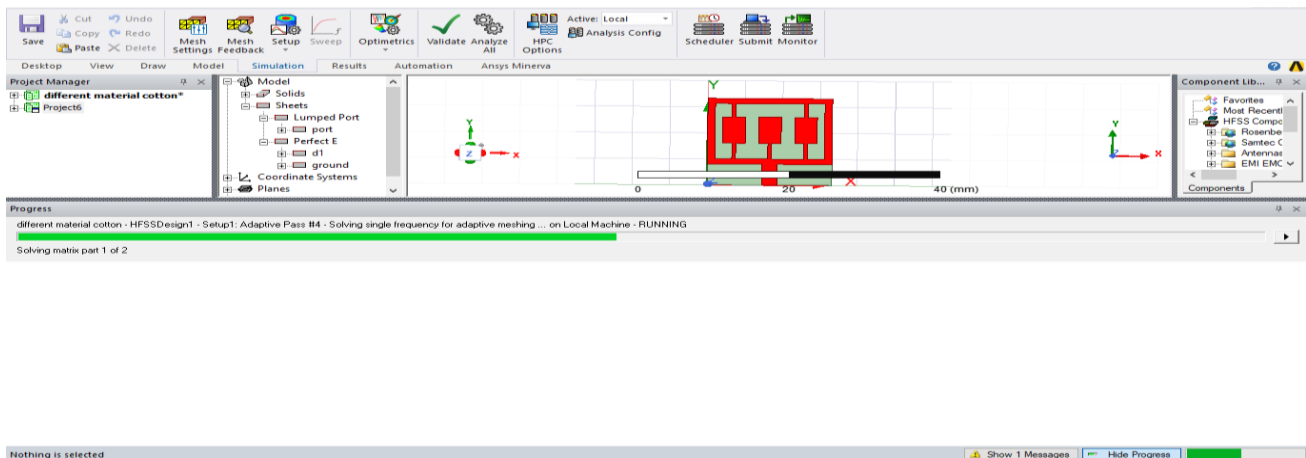


Fig: 4.11 Analyze All Design

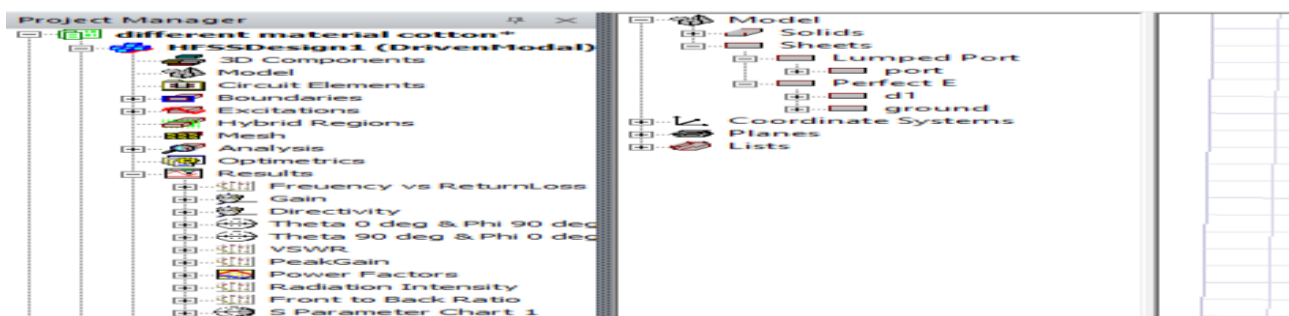


Fig: 4.12 Parameter Results

STEP 7: HFSS SIMULATION

If analyze all is successful then the parameters can be created and the stimulation is successful.

STEP 8: RESULTS

The results of the antenna with different substrate material will be obtained and those results will be compared in the upcoming chapters. The best among them will be taken and will be chosen as our final design for fabrication. The designed antenna is designed in such a way that has many advantages over the existing antenna.

STEP 9: END

The end is the successful completion of the antenna design which is an wearable antenna for telemedicine applications.

4.3 MICROSTRIP PATCH ANTENNA

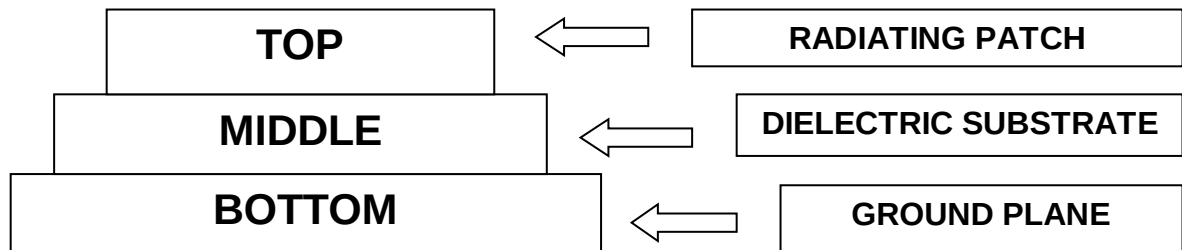


Fig: 4.13 Layers in Antenna

Basically microstrip antenna consists of area of metallization support above the ground plane, that's named as patch. The supporting elements of the patch are called substrate material which is placed between the patch and the ground plane. The microstrip antenna can be fabricated with low cost lithographic technique or by monolithic integrated circuits technique. In majority of the cases the performance characteristics of the antenna depends on the substrate material and its physical parameters. This unit will give the basic picture regarding microstrip antenna configurations, methods of analysis and some feeding techniques.

The basic microstrip patch antenna consists of a metal patch printed on a grounded dielectric substrate. To increase the radiation efficiency of the antenna the dielectric substrate should have lower permittivity. To get higher bandwidth, width of the antenna must be larger than the length.

4.3.1 WORKING OF MICROSTRIP PATCH ANTENNA

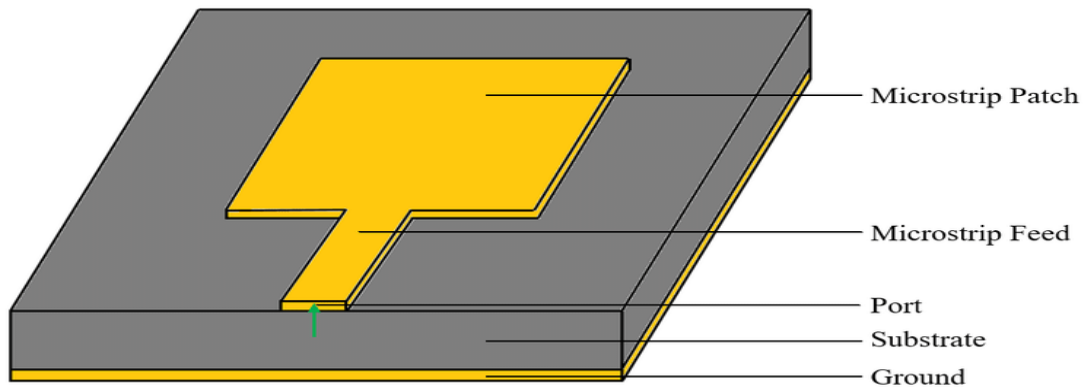


Fig: 4.14 Microstrip Patch Antenna

A microstrip or patch antenna operates in a way that when current through a feed line reaches the strip of the antenna, then electromagnetic waves are generated. The waves from the patch start getting radiated from the width side. But as the thickness of the strip is extremely small thus the waves that are produced within the substrate get reflected by the edge of the strip. The continuous structure of the strip along the length does not permit the emission of radiation. Furthermore, on experiencing a sudden discontinuity in the structure of the patch, radiations are again emitted from the second width side of the patch. As this discontinuous structure favours reflections, thus the patch antenna radiates only a small fraction of supplied incident energy. This makes the antenna inefficient, that rather displaying the characteristics of a good radiator, it somewhat acts as a cavity. The low radiating ability of microstrip antenna allows it to cover the only small distances of wave transmissions like local offices, stores or any indoor locations. As such inefficient transmission is not supportable at a centralized location in an extremely large area.

4.4 MATERIAL DESCRIPTION

4.4.1 CONDUCTING MATERIAL

Copper has high thermal conductivity. Use copper and get it up in the air, and don't rely on SWR solely being an indicator of a good, efficient antenna. Conductors with high resistivity and high permeability will have high effective resistance. The properties of this radiating element are given in the Table 4.1

Table: 4.1 Properties of Copper

PARAMETERS	VALUES
Electrical Conductivity	59.52
Permittivity	3.18
Permeability	1
Resistivity	0.0168

This shows that copper has less resistivity with high electrical conductivity value. It makes an excellent choice as an antenna material. The increased electrical efficiency means more of your RF energy will go up and out the antenna and not be trapped, creating heat energy.

4.4.2 SUBSTRATE MATERIAL

Substrate is a base or container on which microstrip patch (metallic sheet) antenna is fabricated and it plays important role in microstrip antenna functioning. The substrate in microstrip antennas is principally needed for the mechanical support of the antenna. To provide this support, the substrate should consist of a dielectric material, which may affect the electrical performance of the antenna, circuits and transmission line. A substrate must, therefore, simultaneously satisfy the electrical and mechanical requirements, which is some times difficult to meet. Right substrate selection is a must on the basis of cost, efficiency and

size. Patch antenna is fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane.

Substrate (dielectrics) are used for improved electrical and mechanical stability. They are used to reduce the size of the antenna (higher permittivity, lower size) and can help to produce displacement current which produces time varying Magnetic Field (by Ampere's Law). This can in turn produce time varying Electric Field (by Faraday's law) and a propagating EM field is created. Hence, a substrate can enhance antenna's radiation capability. In order to design a microstrip patch antenna at first the designer is to select the substrate material and its thickness. So, if the designer has a clear conception about the effect of changing substrate material and its thickness on the performance of the antenna, it will be easier to design an antenna. Appropriate selection of dielectric material and its thickness is an important task for designing a microstrip patch antenna.

4.4.2.1 COTTON SUBSTRATE

The main advantage of selecting the cotton material as a substrate is its flexibility. Furthermore, it is used in daily life fabric and readily available in the market. It is having higher efficiency when compared to that of the efficiency of Resin fabric. Its various properties are provided in the Table 4.2.

Table: 4.2 Properties of Cotton

PARAMETERS	VALUES
Permittivity	3.18
Permeability	1

4.4.2.2 FR4_EPOXY SUBSTRATE

FR4 substrates have excellent thermal, mechanical, and electrical properties making them a perfect choice for a wide range of electronic applications.

The contribution of substrate FR 4 plays an important role in increasing the bandwidth of the antenna. The structure and shape of the substrate in the design of the antenna is the main parameter such as the dielectric constant and loss tangent. Its various properties are provided in the Table 4.3.

Table: 4.3 Properties of Fr4_epoxy

PARAMETERS	VALUES
Permittivity	4.4
Permeability	1

4.4.2.3 DENIM SUBSTRATE

Denim cloth (jeans) is chosen as substrate because it has lower dielectric constant. A Substrate with low dielectric constant not only reduces surface wave loss but also improves the antenna bandwidth and impedance matching. Its various properties are provided in the Table 4.4.

Table: 4.4 Properties of Denim

PARAMETERS	VALUES
Permittivity	1.6
Permeability	1

4.4.2.4 TEFLON SUBSTRATE

Flexible Materials like Teflon is the substrate which is used to design the patch antenna. Its most versatile feature is that it can be applied to almost anything without compromising the integrity or shape of the coated item. Teflon material can be used in textile antenna for high data rate communications because of its wider bandwidth. Its various properties are provided in the Table 4.5.

Table: 4.5 Properties of Teflon

PARAMETERS	VALUES
Permittivity	2.1
Permeability	1

4.5 FABRICATION

This section reviews the currently available methods for fabrication of flexible and wearable antennas.

4.5.1 SCREEN PRINTING

Screen printing is one of the simplest and most cost effective techniques used by electronics manufacturers. This technique is based on a woven screen that has different thicknesses and thread densities. To produce a printed pattern, a squeegee blade is driven down forcing the screen into contact with the affixed substrate. This in turn forces the ink to be ejected through the exposed areas of the screen on the substrate, and thus, the desired pattern is formed. Polyester and stainless steel are the most common materials used in this technology.

Three different screen printing methods are currently used: flat bed, cylinder, and rotary. Flat bed is the simplest and most common screen printing method. Cylinder screen printing is quite similar to the flat bed except the pattern is deposited as the substrate rotates while attached to the screen roll. In rotary screen, ink and squeegee assembly are rotated inside a rolled screen where impression cylinder produces pressure to substrate. Rotary screen enables much higher throughput capacity than flat bed screen; hence, it is often integrated into a roll to roll production line.

4.5.2 CHEMICAL ETCHING

Chemical etching often accompanied by photolithography is the process of fabricating metallic patterns using a photo-resist and etchants to mill out a selected area corrosively.

This technique has emerged in the 1960s as a branch-out of the Printed Circuit Board (PCB) industry. Chemical etching gained a wide popularity since it can produce highly complex patterns with high resolution accurately. Photo-resist materials are organic polymers whose chemical characteristics change when exposed to ultraviolet light. When the exposed area becomes more soluble in the developer, the photo-resist is positive. While if it becomes less soluble, the compound is considered a negative resist.

4.5.3 FLEXOGRAPHY

Flexography is a type of relief printing. An image is produced by a printmaking process where a protuberating surface of the printing plate matrix is inked while the recessed areas are free of ink. Image printing is a simple process since it only involves inking the protruding surface of the matrix and bringing it in contact with the substrate. Due to its relatively fine resolution, low cost, and high throughput, flexography gained a great interest by RFID antenna manufacturers. Moreover, this technique requires a lower viscosity ink than screen printing inks, and yields imaged (printed) dry films of a thickness of less than 2.5 μm . Hence, flexography inks need to possess higher bulk conductivity than those used in screen printing to compensate for the increase in sheet resistance since the efficiency of printed antennas depends mainly on the electrical conductivity of the traced pattern. Substrate parameters like surface porosity, hydrophobicity, and surface energy have a direct influence on the ink film thickness of the printed trace. The consistency in ink film thickness and line width has also a profound impact on the sheet resistance.

4.5.4 INK JET PRINTING

Inkjet printing of RF circuits and antennas using highly conductive inks have become extremely popular in recent years. New inkjet material printers operate by depositing ink droplets of a size down to few pico liters, and hence, these high resolution printers can produce compact designs with tiny details accurately. This new technology utilizes conductive inks based on different nano-structural materials such as silver nano-particle based ink, which is widely used due to its high conductivity. This type of printing technique can be categorized into two types: drop-on-demand and continuous inkjet. Drop on demand print heads apply pressurized pulses to ink with either a piezo or thermo element in which drives a drop from a nozzle when needed. Most printed electronics manufacturers utilize the piezo pulse type.

Printing quality depends mainly on the ink characteristics such as viscosity, surface tension, and particle size. The surface topology of the substrate, the platen temperature and the print head parameters are also important factors. Printing processes and setups are completely controlled from the user's computer, and do not require a clean-room environment which reduces the levels of environmental contamination. Unlike photolithography, which is a subtractive method since it involves removing unwanted pattern from the substrate's metallic/conductive side; inkjet printing deposits a controlled amount of ink droplets from the nozzle to the specified position. Hence, no waste or byproduct is produced resulting in an economical, clean, and fast solution.

4.5.5 BENCHMARKING PROTOTYPE

To benchmark the performance of flexible antennas, a single band printed monopole is presented in this section which has the merits of light weight, ultra low profile (50.8 μm), large bandwidth, robustness, compactness, and high efficiency. The antenna design which is fabricated using the inkjet printing technology covers the ISM 2.45 GHz and fed by a CPW feed. Moreover, the performance of the antenna is evaluated under bending effects in terms of impedance matching and shift in resonant frequency. Finally, the characteristics of the antenna under study are compared to several flexible antenna types reported in the literature.

Note: From all this different fabrication techniques the one which is suitable for our designed antenna will be used for fabrication.

CHAPTER - 5

RESULTS AND DISCUSSION, PERFORMANCE ANALYSIS

5.1 RESULTS

Various antenna parameters of the designed antenna are measured and recorded. Now these antenna parameters are analyzed. The parameter to be analyzed are return loss, VSWR, gain, directivity, efficiency, radiation intensity, power, SAR and average current surface.

5.1.1 COMPARISON OF FREQUENCY

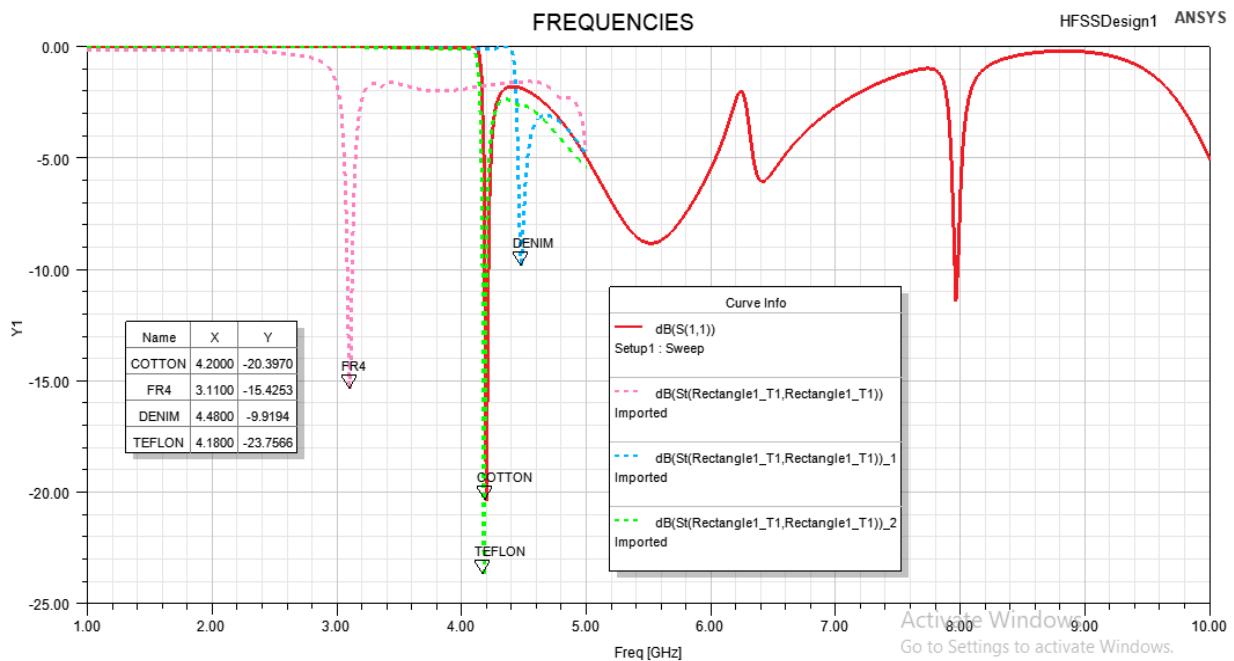


Fig: 5.1 Comparison of Frequency with Different Substrate Materials

Here the below table shows the frequencies of the antenna with different substrate materials like cotton, fr4, denim and teflon. When this frequencies are compared with each other the frequency of cotton(4.2 GHz) is same as the frequency that is been using for designing the antenna(4.2 GHz), so this is chosen as best among the other substrate material.

Table: 5.1 Frequency with Different Substrate Materials

MATERIAL	COTTON	FR4	DENIM	TEFLON
FREQUENCY(GHz)	4.2	3.11	4.48	4.18

5.1.2 VARIOUS MATERIAL CHARACTERISTICS ANALYSIS

Table: 5.2 Parameters with Different Substrate Materials

PARAMETERS	COTTON	FR4	DENIM	TEFLON
RETURN LOSS	-20.39 Db	-15.42 dB	-9.9194 dB	-23.7566 Db
VSWR	1.6646	1.4077	1.9376	1.1388
GAIN (dB)	4.1	1.43	5.2	3.7
DIRECTIVITY	4.0	3.37	5.1	3.8
BANDWIDTH	4.19-4.22	3.09-3.13	-	4.17-4.20
SMITH VALUE	1.1844	0.7175	1.5080	0.9782
EFFICIENCY	99.29%	64.4%	99.48%	94.87%

In the above table, different parameters results like Return loss, Gain, VSWR and Directivity are compared with different substrate material. In table 5.1.1.1 we have concluded that cotton has the obtained frequency same as the operating frequency. Same when compared with other parameters results also cotton has comparatively good results than other materials results.

So, Finally cotton is chosen as the best substrate material among the other substrate materials for the antenna we have designed at 4.2GHz that is UWB band.

5.1.3 PARAMETER RESULTS OF COTTON

5.1.3.1 RETURN LOSS

Return loss is a parameter which indicates the amount of power that is “lost” to the load and does not return as a reflection. Hence the RL is a parameter to indicate how well the matching between the transmitter and antenna has taken place. For an ideal antenna, the expected return loss should be below -10dB. It is the measure of loss of power in the signal reflected by a transmission line to a load. The two major cause of return loss are discontinuity and impedance mismatching and it is expressed in decibel.

$$RL \text{ (dB)} = 20 \log [1/S_{11}]$$

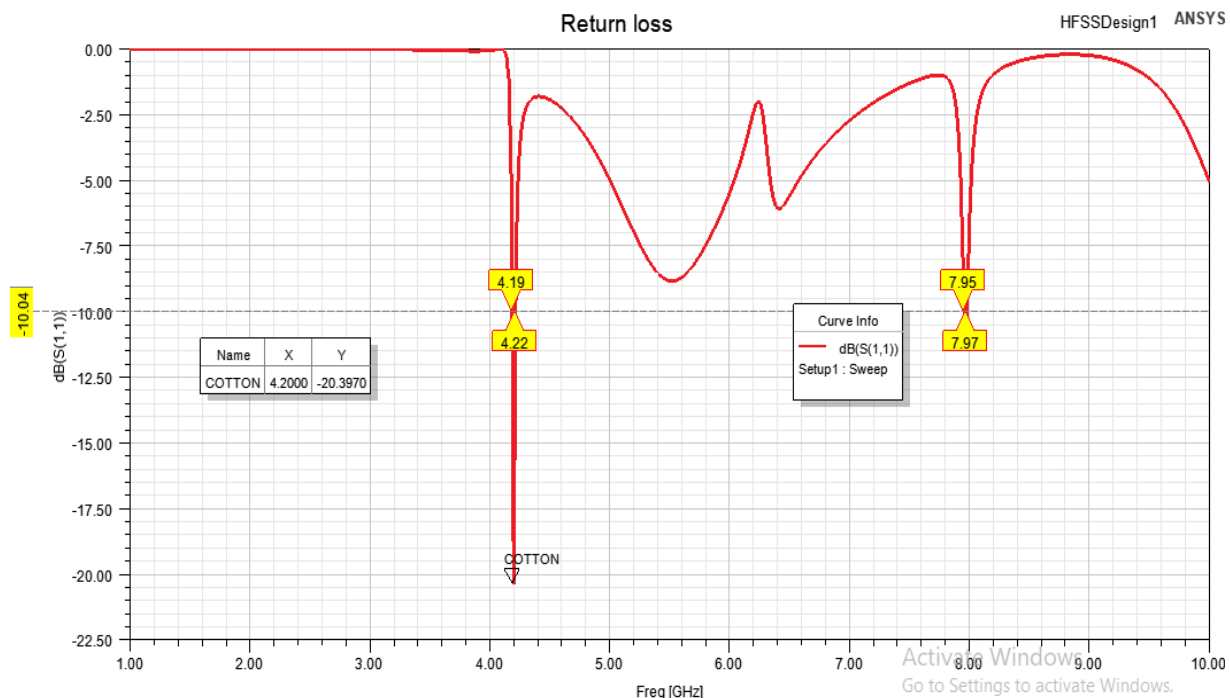


Fig: 5.2 Return Loss Plot

Here, the return loss is less than -10 dB. From the above graph, it is concluded that the Return loss of our proposed antenna is **-20.3970**.

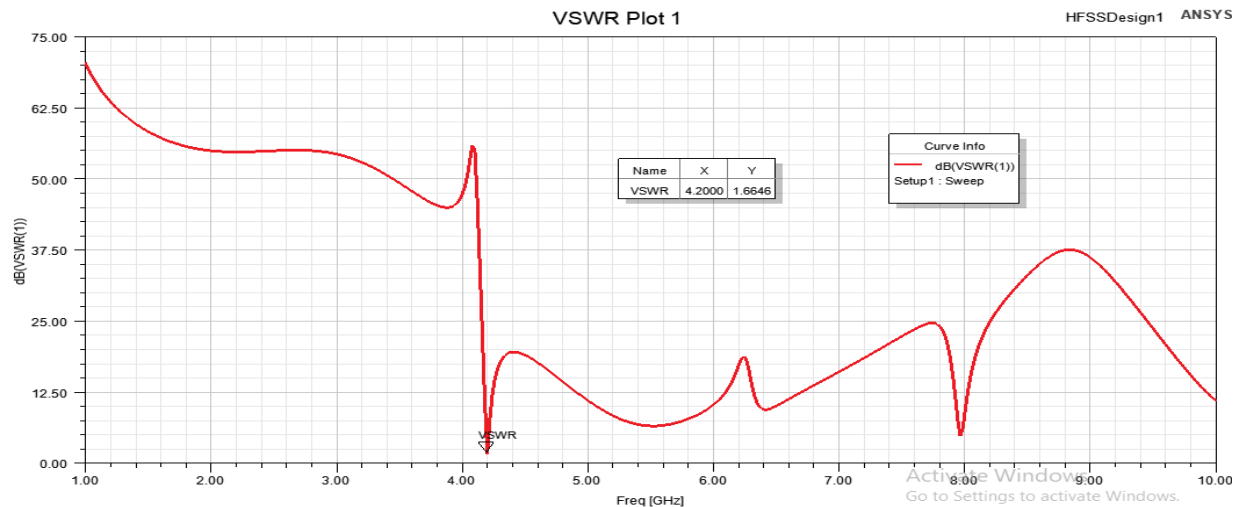
Table: 5.3 Return Loss and Mean's

RETURN LOSS IN Db	WHAT IT MEANS
0	100% reflection, no power into the antenna, all reflected back
1	80% reflection, 20% power into the antenna
2	63% reflection, 37% power into the antenna
3	50% reflection, 50% power into the antenna
5	32% reflection, 68% power into the antenna
6	25% reflection, 75% power into the antenna
8	16% reflection, 84% power into the antenna
10	10% reflection, 90% power into the antenna
15	3% reflection, 97% power into the antenna
20	1% reflection, 99% power into the antenna

5.1.3.2 VSWR

VSWR can be expanded as voltage standing wave ratio. It is a measure of how efficiently the RF power is transmitted from power source. If the given signal is completely radiated by the antenna without any reflection, then the antenna has a unit value of VSWR. The numerical value of VSWR ranges from 0 to 1 and so the antenna has no impedance mismatch. It is also a measure that numerically describes how well the antenna is impedance matched to the radio or transmission line it is connected to. VSWR is directly related to return loss and reflection coefficient. Higher VSWR means a higher reflection coefficient which in return causes maximum reflection loss. For example, VSWR of 4 has 36% of the power delivered to the receiver being reflected antenna. Hence VSWR of 1(perfectly matched) to 2 is ideal and a VSWR of less than 3 is acceptable during antenna design. In addition to reflection loss, VSWR incorporates insertion loss as well. From the below graph, it is concluded that the VSWR of our proposed antenna shows the best figure of **1.6646**.

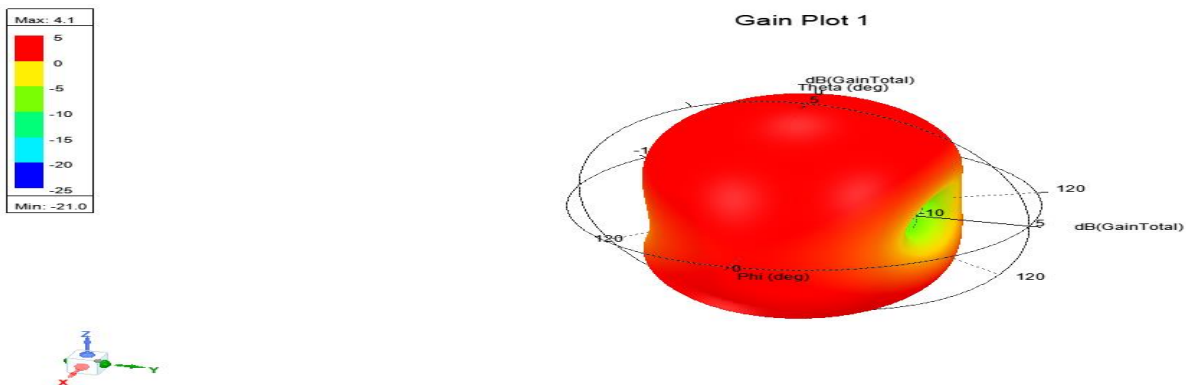
$$\text{VSWR} = \left| \frac{1 - r}{1 + r} \right|$$



5.1.3.3 GAIN

Antenna Gain is the measure how strong the signal of an antenna can transmit or receive in a particular direction. The term antenna gain describes how much power is transmitted in the direction of peak radiation to that of an isotropic source. Antenna gain is specified in the antenna specification sheet because it takes into account the actual losses that occurred. For example, antenna with 3dB gain means that the power received far from the antenna will be 3dB higher than what would be received from the lossless isotropic antenna. Here the proposed patch antenna shows a gain of **4.1dB**.

Gain = (Total Power Radiated)/(Input Power) (dB)



5.1.3.4 DIRECTIVITY

Directivity is the measure of the antenna's radiation pattern in a particular direction. It is a fundamental antenna parameter. It is the measure of how 'directional' an antenna radiation pattern is. An antenna that radiates equally in all directions would have effectively zero directionality, and the directivity of this type of antenna would be 0dB. Increased directivity implies a more focused or directed antenna. Larger antennas such as horn antenna and dish antenna have a directivity of range 10-40dB whereas short dipole antenna has a directivity of 1.76 dB. The directivity of the patch antenna ranges from 2 to 10 dB. Hence patch antennas are mostly used in Bluetooth, Wi-Fi, and ZigBee applications. Here the Square patch shows the directivity value of **4.0dB**.

$$D = Ae4\pi/\lambda^2$$

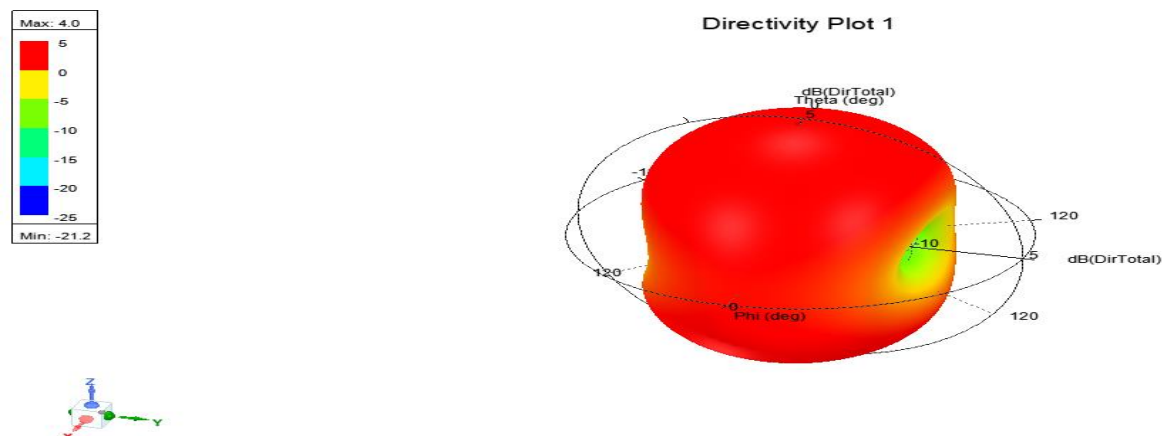


Fig: 5.5 Directivity Plot

5.1.3.5 EFFICIENCY

The efficiency of an antenna is the ratio of the power delivered to the antenna relative to the power radiated from the antenna. A high-efficiency antenna has most of the power present at the antenna's input radiated away. A low-efficiency antenna has most of the power absorbed as losses within the antenna or reflected away due to impedance mismatch. From the obtained value of gain and directivity, the efficiency of the antenna is calculated and it is expressed in terms of percentage (%).

The efficiency of our proposed antenna is **99.29%**, which means that the antenna is working perfectly without giving any harm to the patient.

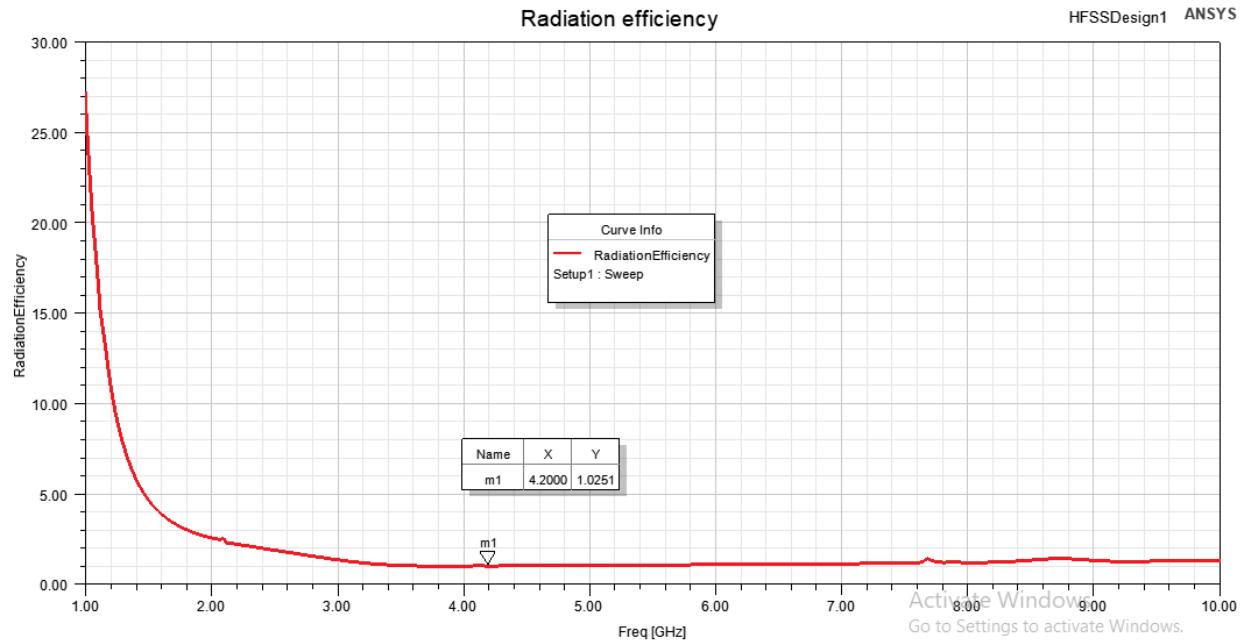


Fig: 5.6 Radiation Efficiency Plot

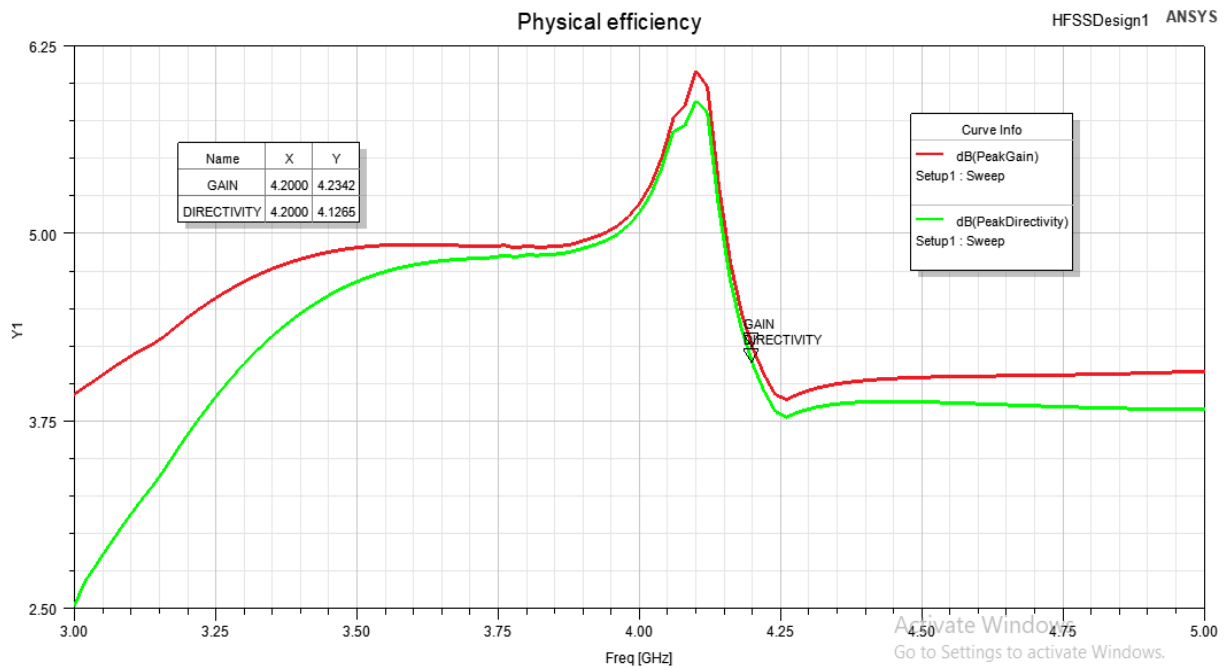


Fig: 5.7 Physical Efficiency Plot

5.1.3.6 RADIATION INTENSITY

Radiation intensity is defined as the power per unit solid angle. Radiation emitted from an antenna which is more intense in a particular direction, indicates the maximum intensity of that antenna. The emission of radiation to a maximum possible extent is nothing but the radiation intensity.

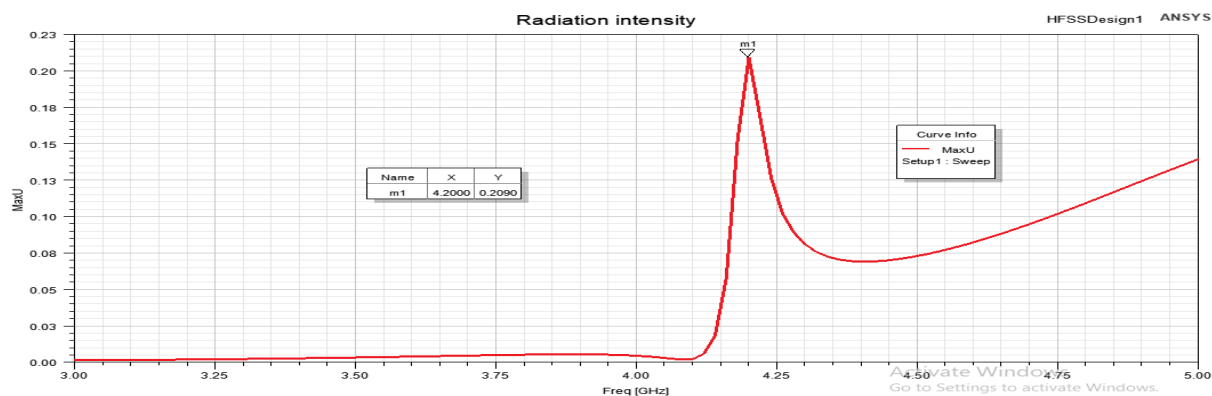


Fig: 5.8 Radiation Intensity plot

5.1.3.7 FRONT TO BACK RATIO

The Front to Back Ratio (F/B Ratio) of an antenna is the ratio of power radiated in the front/main radiation lobe and the power radiated in the opposite direction (180 degrees from the main beam). This ratio tells us the extent of backward radiation and is normally expressed in dB. A great, long-range directional antenna will have a Front to Back Ratio (gain) of 15dBi or higher: The high gain of the antenna gain raises the signal above the "signal noise" that exists in almost every environment - thereby increasing signal strength.

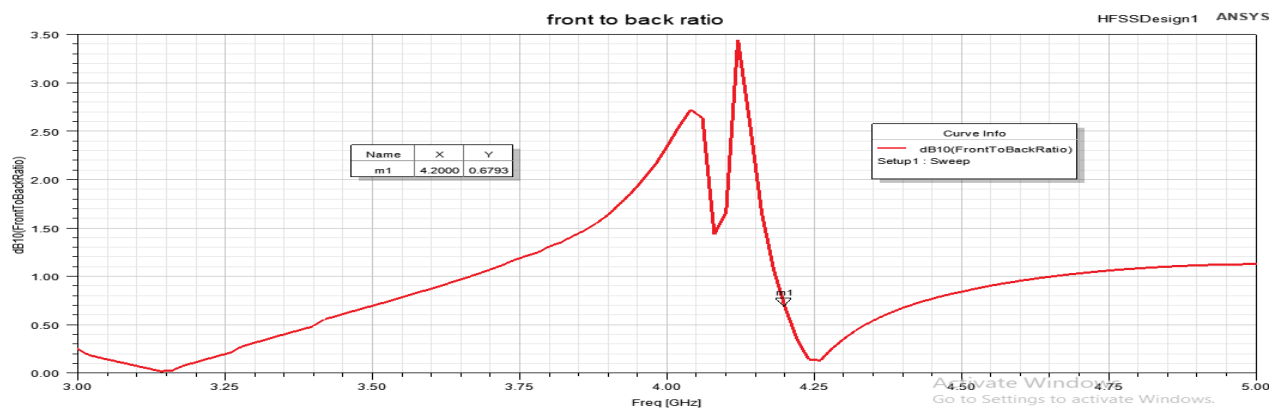


Fig: 5.9 Front to Back Ratio plot

5.2 DISCUSSION

The simulated and measured reflection coefficients of the proposed antenna were analyzed. In the simulated result, the resonance frequency is 4.2 GHz, and in the measured result, the resonant frequency is found to be 4.2 GHz, which seems to be in good harmony with the computational result. EBG structure is used as a part of an antenna to improve the performance such as gain and radiation pattern. In common antenna design, the antenna designer uses this structure to suppress the surface wave current which lead to increase the gain and efficiency of an antenna. However, by using EBG structure, the antenna size will be increased as it is used as a super substrate which also leads to complexity in antenna design and so we designed an antenna without this structure.

Table 5.4 Result Comparison with Existing Design

Design Structure	Frequency (GHz)	Return Loss(dB)	VSWR	Gain (dB)	Directivity (dB)	Size (mm ²)	Efficiency
O-shaped patch	2.4	-19.96	1.3834	7.51	6.9	50*23.5	91.87%
C-shaped patch	2.45	-36	1.7442	1.24	1.7	36*38	72.94%
L-shaped patch	2.4	-35	1.4651	2	3.1	75*75	64.1%
Rectangle Shape	2.4	-21.74	1.9277	1.66	1.99	70*66	83.41%
S-shaped patch	2.4	-27.01	1.0921	1.66	2.24	25*35	74%
Proposed Design	4.2	-20.39	1.6646	4.1	4.0	16.6*16.6	99.29%

5.3 PERFORMANCE ANALYSIS

The proposed antenna is designed iteratively by varying the structural parameters like length, width, feeding position etc., Hence various antenna design has been obtained for different resonating frequency. Graph is plotted by considering

operating parameters like return loss, gain and VSWR for obtained respective operating frequency. The parameters of proposed antenna are plotted finally (dotted) for better comparison with previous design. It is shown in the fig.5.3.1. For an antenna to be ideal the return loss should be less than -10 dB, gain must be high and VSWR should be unity. The proposed antenna meets out all the requirement.

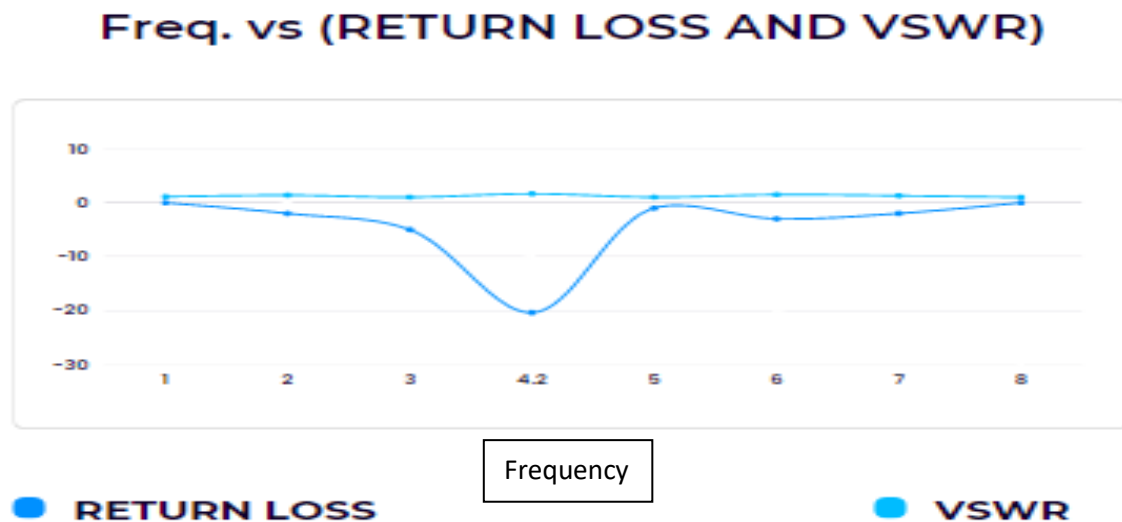


Fig: 5.10 Parameter Analysis

CHAPTER - 6

CONCLUSION

This paper proposes a wearable antenna that can be used for various applications such as monitoring of patients, navigation, and military applications. The parallel L slotted closed loop array antenna based on the injective resistive feed technique has been designed on the textile material known as Cotton. The substrate thickness is taken as 1.6 mm. The relative permittivity and permeability values are 3.18 and 1 respectively. The overall antenna dimensions are 16.6×16.6 mm². The measured return loss achieved at 4.2 GHz is -20.39 dB and a gain of 4.1 dB is obtained to ensure the efficient health monitoring. The antenna is feasible for wearable applications and cannot harm the human body tissues due to its high front to back ratio. Also, the wearable antenna is the best way to be applied for wireless local area network communication and it has vast applications to provide real-time health monitoring.

The antenna's performance based on different types of substrates such as Cotton, FR4, Denim, Teflon is analyzed with frequencies ranging between UWB (3.1 – 10.6). The minimum return loss achieved for the for the mentioned resonant frequency range is -20.39dB for Cotton and the corresponding gain is 4.1 dB, which represents the optimum results among the four substrates. Textile material is used as a substrate of the proposed antenna whereas copper tape is used for the radiating element and ground plane. Wearable textile antenna covers the wide frequency range between 1.80 GHz and 4.87 GHz for WLAN (2.4-2.484 GHz), Wi-MAX (2–11 GHz) and LTE (2.17 GHz) applications. These bands are used for wireless telemedicine, m-health, e-health application.

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APPENDIX

A. CERTIFICATION



B. SCREEN SHOTS

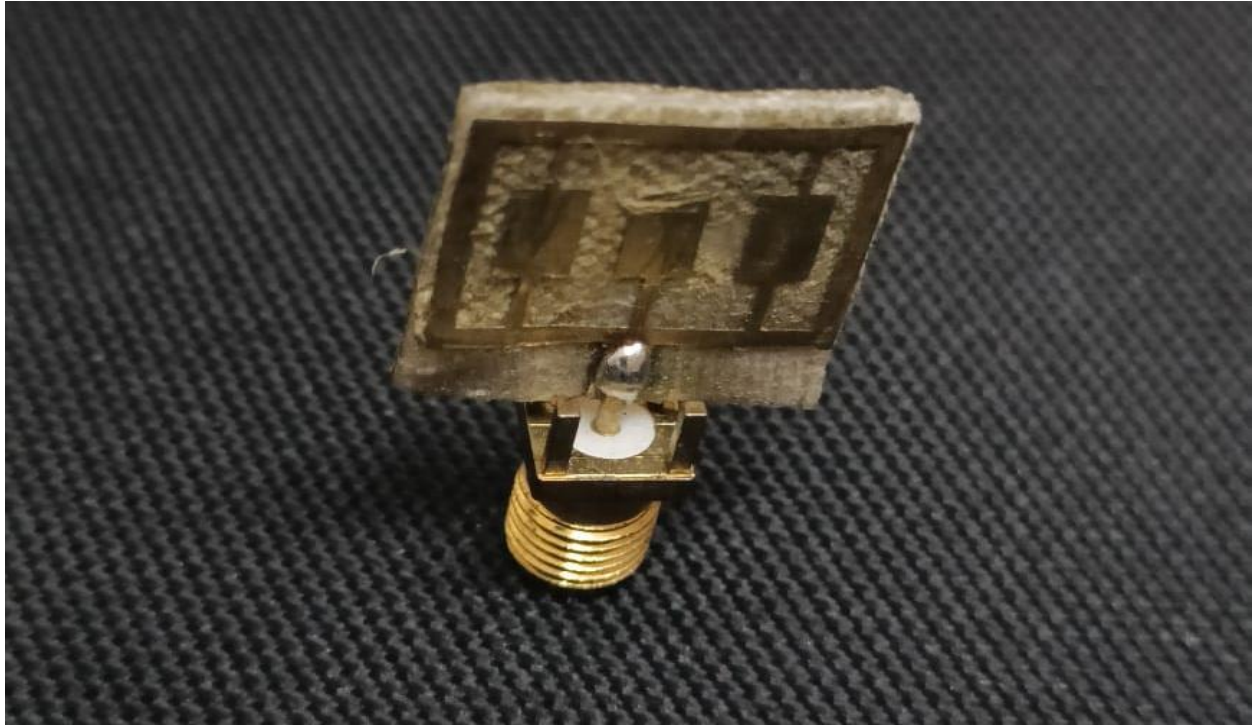
ANTENNA FABRICATION (COTTON SUBSTRATE MATERIAL)



FRONT VIEW



BACK VIEW



SIDE VIEW (FRONT)



SIDE VIEW (BACK)

DESIGNING A WEARABLE ANTENNA FOR TELEMEDICINE APPLICATIONS

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Abstract— For telemedicine applications, a low-profile cloth antenna is suggested in this study. Telemedicine is the delivery of live, interactive video medical services to distant areas using telecommunications technology as a medium. The goal of telemedicine and other medical technology is to provide high-quality health monitoring system remotely. The objective of this study is to offer a telemedicine application solution that is more practical. Although there are various wireless technologies in use, a textile antenna is the best option. In this study, a wearable antenna is developed. It uses a microstrip patch as the antenna. This antenna is simulated using high-frequency structural modeling (HFSS). The front-to-rear ratio and return loss are decreased as a consequence of this simulation. In telemedicine systems, the health indicators can be wirelessly transmitted to remote stations (off-body). The on-body mode is required for communication between sensory devices on or within the patient's body in addition to off-body applications. For the optimum performance, a reliable low-profile antenna is necessary.

Keywords— *Physiological Parameters, Wireless Sensor Network, Remote Monitoring Station, Wearable Monitor, Data Acquisition Hardware.*

I. INTRODUCTION

In recent years, communication and medicine have worked closely together. Real-time health monitoring greatly benefits from the development of wearable antennas for telemedicine applications. The biomedical, consumer electronics, military, and smart home industries all have interesting applications for wearable communication systems. In these networks, wearable antennas are utilized to transmit and receive data for medical technology. It is used in military applications to establish communication channels between soldiers, enabling the sharing of photos and videos, location tracking, and army defense. Medical applications can also communicate with one another and the outside world while analyzing and tracking a patient's health indicators.

Coverage, reliability, and monitoring quality are a few of the issues with wireless patient monitoring. Wireless telemetry system for home EEG epilepsy monitoring Development of Bluetooth-based systems for digitalized ECGs, hospital-wide mobile monitoring systems, mobile telemedicine, and real-time home patient monitoring are all examples of the patient monitoring work done. The reliability of message transmission, especially for emergency warnings, is one of the most difficult problems with patient monitoring using wireless networks. Many hospitals and nursing homes are implementing infrastructure-oriented wireless networks in telemedicine systems that range from straightforward blood glucose levels and ECG wave patterns to simple heart rate,

blood pressure, and body temperature measurements. A reliable low-profile antenna is necessary to solve coverage problems for optimal performance. The organization of this essay is as follows.

Antennas are one of the different fields of telecommunications. These are required to ensure the operation of electromagnetic wave emission or reception in the Earth's atmosphere or in space. Printed antennas have such a broad range of applications that they are used in medicine. Since its completion, a study in this subject has evolved in order to capitalize on the unique advantages of this form of antenna. Combining telecommunications and medicine has shown to be both intriguing and useful to both patients and nursing personnel.

Recent research on satellite-based telemedicine systems offers options for tele-education, home care, and a variety of medical issues. Medical data and services may be sent across locations at a minimal cost thanks in large part to wireless technology. Clinics and hospitals use wireless technologies like satellites, 4G GSM, GPRS, Wireless LAN, WBAN, and Optical Wireless Body Area Networks to monitor patients' biological characteristics like body temperature, respiratory rate, R-R interval heart rate with Electrocardiogram (ECG), blood pressure, oxygen saturation in the blood (SaO₂), and Electromyogram (EMG), Galvanic Skin Response (GSR), and Electroencephalogram (EEG).

As a result, accuracy may be readily attained by employing a low-profile antenna. There are also various drawbacks to traditional monitoring devices, such as their size and weight. To address these challenges, human body components must be diagnosed and updated reports must be wirelessly supplied to remote stations, and data sensors must be integrated into the wearer's fabric.

II. WEARABLE ANTENNA

Body-worn antennas have emerged as an interesting study subject because they are wearable and easily inserted into garments. A wearable antenna can connect with sensors and the human body. Wearable textile antennas are medical devices that capture medical data without bothering patients while monitoring telemedicine through Zig-Bee or Wi-Fi networks. A wearable antenna is used in a variety of applications due to its tiny and compact size, including military, medical, healthcare, emergency services, and navigation. Because of downsizing and the usage of flexible technologies, the need for wearable antennas is expanding.

On resonance frequency, bandwidth, gain, SAR, and radiation efficiency, the impact of substrate material variations is explored. When the antenna is put on the human body or is in close contact to the body, its performance diminishes significantly. Examining the SAR parameter in various antenna layouts allows us to better understand these effects. This study is valuable for revealing information about antenna designs that may be applied to wearable antenna design research in the future to satisfy the demands of the best wearable electronics.

III. TELEMEDICINE

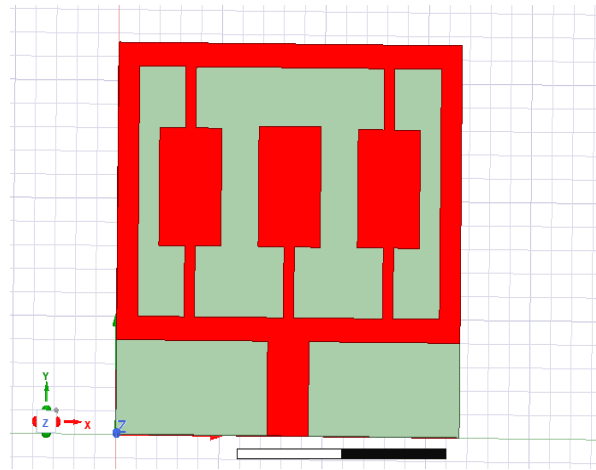
Telemedicine literally refers to distant medical care. With the development of new, widely used remote medicine programs, new sensing, medical imaging, and wireless data transmission technologies are making it possible for telemedicine to provide healthcare at a distance at a price that is far lower than in the past. Researchers have identified three distinct stages in the history of telemedicine. The 1970s telecommunications era might be considered the beginning of the period. Telemedicine apps at the time were not linked to other healthcare data, and applications depended on broadcast and television technologies. Due to the digitalization of telecommunications, the dedicated era of telemedicine started in the late 1980s and peaked in the 1990s. Data was made available through a variety of communication routes, including telephone lines and Integrated Service Digital Network (ISDN) connections.

The expensive cost of communication tools that can provide more bandwidth has turned into a major barrier for telemedicine. The devoted period has given way to the Internet era, in which telemedicine is made possible by ever-complicated networks. Technologies that are more affordable and widely available have ushered in the third age of telemedicine. Wireless telemetry system for home EEG epilepsy monitoring Development of Bluetooth-based systems for digitalized ECGs, hospital-wide mobile monitoring systems, mobile telemedicine, and real-time home patient monitoring are all examples of the patient monitoring work done. The reliability of message transmission, especially for emergency warnings, is one of the most difficult problems with patient monitoring using wireless networks.

IV. ANTENNA DESIGN

For the patient monitoring system, a Parallel L slot with a closed loop array antenna was constructed. This antenna is intended to function as a wearable textile antenna at 4.25 GHz. This includes the broad frequency range from 1.80 GHz to 4.87 GHz, which is utilized for wireless telemedicine, mobile health, and electronic health applications. It is designed and simulated using high-frequency structure simulation software (HFSS) tool. The design is going to be built on Cotton, Fr4_epoxy, Teflon, and Jeans as a substrate with copper as a conducting metal having a microstrip line feeding structure. The simulated performance of the proposed antenna with different substrate materials is compared and the best among them will be chosen.

The dimensions of this proposed design are 16.6 * 16.6 * 16.6 mm³. Some parameters like gain, VSWR, return loss, directivity, and reflection coefficient are measured from this antenna to show that our proposed antenna is better than the existing one.



A. SQUARE PATCH ANEANNA

Wavelength:

The wavelength, which may be measured in either space or along a wire, is the separation between similar places in subsequent cycles of the waveform signal.

$$\Lambda = \frac{c}{f} \text{ MM/SEC}$$

Where,

Λ = Wavelength of the proposed frequency.

C = Velocity of light in space i.e.,

$3.8 \times 10^6 \text{ km/sec.}$

f = frequency that we proposed.

Length and Width:

The antenna's length, both horizontally and vertically, is indicated by its length and breadth. The impedance will be lower the wider the trace is. More impedance is given when the trace width is narrower. While a thinner board will have a lower impedance, a thicker board will have an increased impedance.

$$L = W = \frac{\lambda}{2} \sqrt{\frac{2}{\epsilon_r}} \text{ MM}$$

Fringing effect:

Fretting is the term for the bending of the electric flux lines in the direction of the edge of parallel plate capacitors. The term "edge effect" is commonly used to describe fringe. The flux lines are typically homogenous and parallel in capacitors.

$$\epsilon_{REFF} = \frac{\epsilon_r + 1}{2}$$

Thickness:

It gives the height of the substrate and it gives potential strength to the antenna to hold.

$$H = \frac{0.0606\lambda}{\sqrt{\epsilon_r}} \text{ MM}$$

Ground and substrate Dimensions:

The substrate, a foundation or container used to produce microstrip patch (metallic sheet) antennas, is crucial to the proper operation of these antennas. In microstrip antennas, the substrate is mostly required for the mechanical support of the antenna. To offer this support, the substrate should be constructed of a dielectric

material; however, doing so may degrade the electrical performance of the antenna, circuits, and transmission line. A substrate must therefore meet both the electrical and mechanical requirements at once, which may be difficult.. Because the ground plane's main function is to enable the return current to flow, there should be as few interruptions as possible. Because of this, ground planes work better on multilayer boards where one layer may be devoted to the ground plane and another to the power plane.

$$L_G = L + 6H \text{ MM}$$

$$W_G = W + 6H \text{ MM}$$

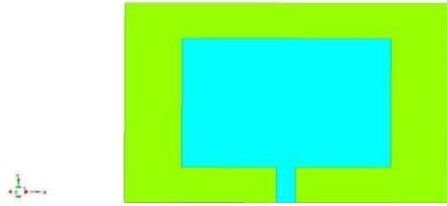
Feed:

The antenna feed system or antenna feed is the cable or conductor, and other associated Zent, which connects the transmitter or receiver with the antenna and makes the two devices compatible.

$$L_F = \frac{\lambda_g}{4} \text{ MM}$$

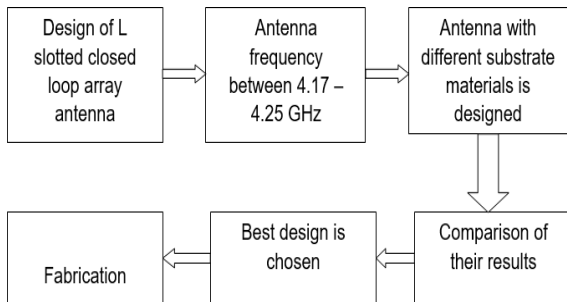
$$W_f = \frac{2h}{\pi} \left\{ (B - 1 - \ln(2B - 1)) + \left(\frac{\epsilon_r - 1}{2\epsilon_r} \right) \right\} \times \left\{ \ln(B - 1) + 0.39 - \left(\frac{0.61}{\epsilon_r} \right) \right\}$$

$$B = \frac{60\pi^2}{Z_0\sqrt{\epsilon_r}}$$

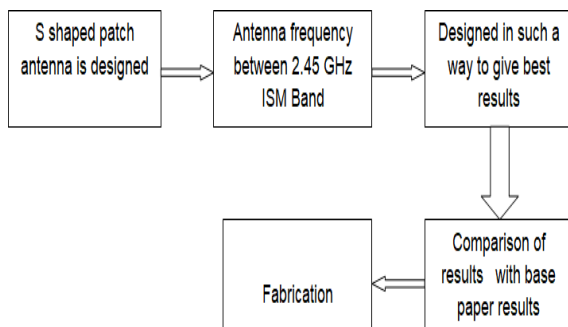


Square Patch Antenna (Everything RF, 2020)

A. BLOCK DIAGRAM OF PROPOSED WORK

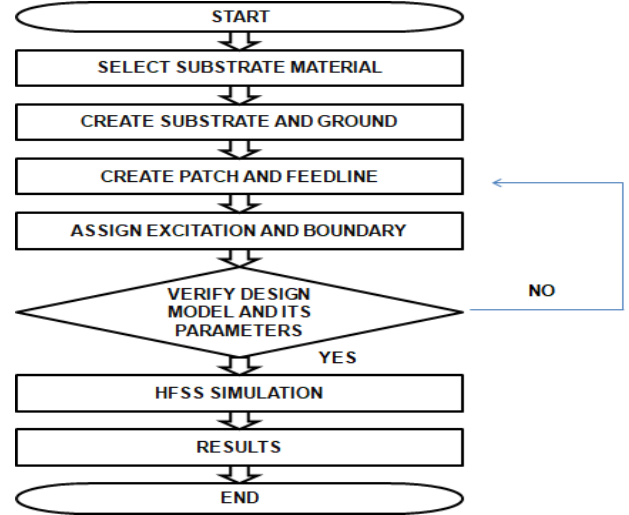


B. BLOCK DIAGRAM OF EXISTING WORK



V. ANTENNA DESIGNED IN HFSS TOOL

The High-Frequency Structure Simulator was used to design and model the suggested antenna (HFSS). For the HFSS design of the proposed antenna, numerous geometrical and simulation parameters are necessary because it is a parallel L slot closed loop array antenna. The aforementioned microstrip equations are used to calculate the geometrical characteristics of the proposed antenna. However, a frequency that can be determined based on the proposed antenna's application is the main modeling parameter for an antenna. The suggested antenna design may then be modeled in the HFSS after the geometrical parameters have been determined.



VI. MATERIAL DESCRIPTION

A. CONDUCTING MATERIAL

Heat conductivity in copper is high. Don't rely on SWR as the only metric for a successful, effective antenna; use copper and get it in the air. The effective resistance will be high for conductors with high resistivity and permeability. Table 1 in this article provides information on this radiating element's characteristics.

PARAMETERS	VALUES
Electrical Conductivity	59.52
Permittivity	3.18
Permeability	1
Resistivity	0.0168

Table.No: 1

This demonstrates copper's higher electrical conductivity value and lower resistance. As an antenna material, it is a fantastic choice. More RF energy will exit the antenna up and out due to the improved electrical efficiency as opposed to being trapped and turning into heat energy.

B. SUBSTRATE MATERIAL

The substrate, which acts as a foundation or host for the microstrip patch (a metallic sheet) antenna, is essential for the microstrip antenna to function correctly. The substrate is mostly needed in microstrip antennas to support the antenna mechanically. The electrical performance of an antenna, circuits, and transmission line may be affected by the substrate's employment of a dielectric material to provide this support. A substrate must therefore simultaneously meet the mechanical and electrical requirements, which might be difficult. Selecting the proper substrate is crucial in terms of price, effectiveness, and size. The design of the antenna element is etched onto a metal trace, which is then constantly attached to an insulating dielectric substrate on the opposite side to produce a patch antenna.

Dielectrics are utilized as a substrate to improve mechanical and electrical stability. They can help produce displacement current, which produces a magnetic field that varies over time according to Ampere's Law, and they are used to minimize the size of the antenna (greater permittivity, smaller size). Applying Faraday's law, can result in a time-varying electric field, which in turn creates a propagating electromagnetic field. Consequently, a substrate can improve an antenna's radiating capacity. The designer must first decide on the substrate material and thickness before beginning to construct a microstrip patch antenna.

Therefore, if the designer has a good understanding of the effects of changing the substrate material and its thickness on the performance of the antenna, it will be simpler to construct an antenna. Selecting the appropriate dielectric substance.

- **Jeans substrate**

Because denim fabric's (jeans') lower dielectric constant makes it a good substrate, The antenna bandwidth and impedance matching are both enhanced by a substrate with a low dielectric constant, which also lowers surface wave loss. Table 2 lists its different characteristics.

PARAMETERS	VALUES
Permittivity	1.6
Permeability	1

Table.No: 2

- **FR4_epoxy substrate**

FR4 substrates are an ideal choice for a variety of electronic applications because of their excellent thermal, mechanical, and electrical characteristics. In order to increase the antenna's bandwidth, the contribution of substrate FR 4 is crucial. The primary factor, along with the dielectric constant and loss tangent, in the antenna design is the structure and form of the substrate. Table 3 provides information on its many features.

PARAMETERS	VALUES
Permittivity	4.4
Permeability	1

Table.No: 3

- **Teflon substrate**

The substrate for the patch antenna is made of flexible materials like Teflon. It can be applied to nearly anything without affecting the quality or shape of the coated item, which is its most adaptable quality. Teflon material's greater bandwidth makes it suitable for use in textile antennas for high data rate communications. Table 4 provides information on its many features.

PARAMETERS	VALUES
Permittivity	2.1
Permeability	1

Table No: 4

- **Cotton substrate**

Flexibility is the primary benefit of using cotton as a substrate. It is also widely accessible on the market and utilized in fabric for everyday usage. Its efficiency is higher than the efficiency of cloth made of resin. Table 5 lists its different features.

PARAMETERS	VALUES
Permittivity	3.18
Permeability	1

Table.No: 5

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