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RESEARCH PAPER ON MINIATURIZED PATCH ANTENNA FOR BIO-MEDICAL APPLICATIONS

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Abstract: This paper presents an idea of using a small sized Antenna. In recent times, mobile and wireless communication has advanced considerably. Therefore, small-sized antennas like microstrip antenna are needed for effective transmission. An effective wide band Hexagonal microstrip patch antenna is suggested in this research. Because of its significant level of design, conformability, and shape flexibility, patch antennas are currently the subject of considerable scientific attention for their incorporation into implanted medical devices and radio-frequency (RF)-enabled biotelemetry. The development of implanted patch antennas has drawn a lot of interest since it addresses problems with biocompatibility, downsizing, patient safety, increased connection with monitoring/control devices outside the body, and insensitivity to detuning. Also very intriguing are numerical and experimental studies on implantable patch antennas. The primary objective of a wireless implantable device-based healthcare monitoring system is to transmit accurate information from within the human body to an external Base Station (PC or phone). The right transducers are used to gather physiological signals, which are then processed afterward and sent to monitoring and control equipment outside the body for operator analysis. In order to provide a trustworthy result, a biomedical telemetry system needs to have a number of components that work together to produce the required outcomes. Due to its small size, low profile, and simplicity of integration with various medical devices, microstrip patch antennas (MPAs) have grown to be a preferred option for biomedical applications. This study of the design, evaluation, and characterization of a microstrip patch antenna for biomedical applications is presented in detail in this paper. The proposed MPA has a small footprint of 25mm x 25mm and is intended to operate at 2.4 GHz in the medical band. The FR4 substrate material, which has a relative permittivity of 4.4, is used in the design of the MPA. The design features a coaxial feed that is positioned in the patch's centre and a rectangular patch with a partially exposed ground plane underneath. The Ansoft HFSS software is then used to characterize the planned MPA and analyze the electromagnetic behavior of the antenna.
2.4 GHz, 4.4% bandwidth, and 3.4 dBi gain are the resonant frequencies that the MPA exhibits, according to the modelling results. Analysis of the MPA's radiation pattern reveals a broadside radiation pattern with minimal sidelobes and strong directivity. The performance of the suggested MPA is then experimentally assessed. A vector network analyzer is used to verify the antenna after it has been constructed using conventional photolithography methods. A tissue-equivalent phantom is used to test the antenna's performance in a biological setting. The findings demonstrate that the suggested MPA is appropriate for biomedical applications and has a decent radiation pattern. The implanted antenna is a crucial component of the biotelemetry system; depending on the required application, it may be surgically implanted inside the human body or externally applied (wearable). Numerous antenna types have been proposed and tested during research, taking into account the characteristics of biological tissue, the location where the antenna should be installed, the frequency spectrum at which it should operate, and the intended use.

In conclusion, this research has constructed, examined, and characterised a microstrip patch antenna for biomedical purposes. In terms of return loss, bandwidth, gain, and radiation pattern, the suggested MPA performs admirably. The antenna may be integrated with many different medical applications and devices due to its small size and low profile. Numerous biomedical applications,

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including wireless capsule endoscopy, implantable medical devices, and remote health monitoring, can be carried out using the proposed MPA.

Index terms: *Biomedical engineering, wireless communication systems, miniaturization, implantable and wearable devices, frequency bands, and radiation efficiency.*

1. INTRODUCTION

Micro strip patch antennas are appealing for applications such as high performance aircraft, spacecraft, satellite, missile, and embedded applications due to their light weight, low profile, cheap manufacturing cost, dependability, and ease of fabrication and integration with wireless technology equipment. However, they have a relatively small frequency bandwidth, low power, high Q, and low radiation efficiency. The name of a microstrip patch antenna is based on the design of the radiating patch. Radiating patches come in a variety of shapes, including square, rectangle, circle, ellipse, triangle, Hexagonal ring, and ring sector. Microstrip patch antennas that are square, rectangular, and Hexagonal are simple to design and assess all of the antenna's properties. These qualities increase their prevalence. Since there is only one degree of freedom to regulate with a Hexagonal microstrip patch antenna as opposed to two with a rectangular microstrip patch (length and breadth), it is more straightforward. Additionally, at the same design frequency, the physical dimension of the Hexagonal patch antenna is 16% less than that of the rectangular microstrip antenna. A ground plane and a radiating patch are attached to one side of a dielectric substrate in a microstrip patch antenna, and the radiation of the antenna comes from fringing fields that exist between the patch's and ground plane's edges.Because of this, designing a Hexagonal microstrip patch antenna is easier and it is straightforward to manage its radiation. The first challenge in this study is to put forth a novel design-and-testing technique that optimises the design of straightforward implantable antennas to fit particular fabrication methods for prototypes. Metallization, glueing, and feeding factors are taken into account in the antenna design, and sensitivity tests are carried out to establish the maximum acceptable differences between numerical and experimental results. The second difficulty is in dealing with the prototype fabrication of small antennas, where tolerance to fabrication problems (such as solder bumps, glue thickness and permittivity uncertainties, etc.) is thought to be quite important. In order to best tune a novel tiny antenna's parametric model inside a particular fabrication/testing strategy, for validation reasons, the design-and-testing process is used. Antenna performance will be improved in terms of efficiency, bandwidth, and antenna performance with thicker substrates and low dielectric constants. However, they lead to higher antenna sizes. Conversely, thin substrates with high dielectric constants are ideal for microwave applications because their fields are firmly confined, resulting in a minimum amount of unwanted radiation and coupling. With its smaller size, it is actually highly favourable, but because of the increased losses, they will be less efficient and have narrower bandwidths.

The feeding of a microstrip patch antenna can be done in a number of ways. Microstrip line, coaxial probe, and aperture coupling are the most often utilised types. There are contacting and non-contacting variations of the procedures. In the contacting approach, a microstrip line is used to supply RF power directly to the radiating patch. Electromagnetic field coupling is utilised to transfer power between the microstrip line and radiating patch in the non-contacting condition. A microstrip line feed is utilised in the Hexagonal patch antenna design that is being proposed. A conducting strip with a much smaller width than the patch is used in the contacting technique known as microstrip line feed (the width should be less than the patch thickness). Since the antenna's impedance is intended to be 50 Ohm, it is simple to design, match, and build. The patch's feed line placement needs to be altered to fit the impedance. Different slots can be etched inside the patch shape to improve the antenna's performance. Here, a modified Hexagonal microstrip patch antenna with a Hexagonal slot is built, and the software HFSS simulator was used to assess all of its antenna properties. Due to their ability to meet the demands of biocompatibility, compactness, patient safety, and high-quality connection with external equipment, implantable patch antennas have gained significant scientific interest. Experimental and numerical studies are also incredibly fascinating. The next section provides an overview of these issues and discusses how they have been addressed in this literature.

2. LITERATURE REVIEW

For medical wireless applications like implanted devices and on-body sensors to transmit and receive electromagnetic signals from the human body, an antenna is required. As a result, developing a trustworthy implanted antenna is essential for communication. Miniaturization and biocompatibility are an implanted antenna's two most important features. The requirements and restrictions that pertain to the creation of implanted patch antennas are as follows:

2.1 Biocompatibility-

Biocompatible implantable antennas are necessary for patient safety and to avoid implant rejection. In addition, human tissues are conductive and would cause a short circuit if they came into touch with the metallization of the implantable antenna. In the case of antennas designed for long-term implantation, biocompatibility and the avoidance of unfavourable short-circuits are particularly important. The most popular method for maintaining the antenna's biocompatibility while also keeping the metal radiator away from human tissue is to wrap the structure in a superstrate dielectric layer. Commonly used biocompatible materials include TEFL on (permittivity, εr=2.1, dielectric loss tangent, tanį = 0.001), εACτR (εr =6.1, tanθ = 0.005), and ceramic alumina (εr =9.4, tanθ = 0.006). However, it is crucial to emphasise that drilling and Hexagonal cuts do not come naturally to ceramic superstrates. Another described method insulates the implantable antenna with a thin layer of low-loss biocompatible coating. Zirconia (εr = 2; tanθ = 0) is one of the materials suggested for biocompatible encapsulation. Zirconia is a better potential material for biocompatible insulation from an electromagnetic perspective. The near fields of the antenna can concentrate inside the low-loss encapsulation layer thanks to high permittivity and low loss-tangent values, which reduces power loss. PEEK and Silastic MDX- 4210 Biomedical-Grade Base Elastomer, however, are significantly simpler to handle and produce. The biocompatible insulation layer's thickness plays a crucial role in the antenna design. Its optimal value computation is thought to be extremely important for reducing power loss without needlessly enlarging antenna size.

We divided our methods into two categories in order to guarantee the biocompatibility of implantable antennas:

a) Biocompatible Encapsulation:

The implanted antenna is housed in a kind of biocompatible material known as a biocompatible layer (bio-layer). In order to achieve the requisite biocompatible qualities, the antenna is covered in a biocompatible material, as depicted in Fig2.1(a).

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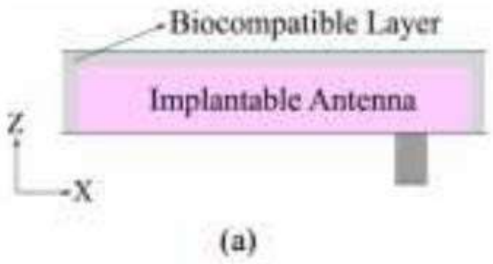

Fig2.1(a) antenna with biocompatible layer

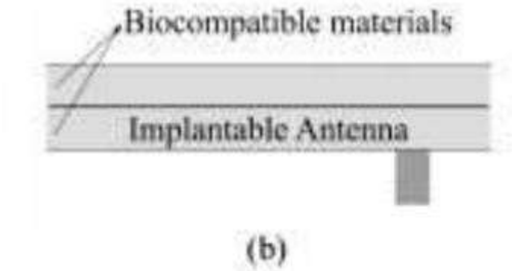

Fig2.1(b) antenna with biocompatible substrate/superstrate

b) Biocompatible Substrate and Superstrate: The antenna construction itself is made from biocompatible grade materials, as seen in Fig2.1(b).

2.2 Miniaturization-

Different strategies have been suggested to construct effective tiny antennas because the dimensions of regular antennas make these antennas impracticable for implantable applications. The planar inverted f-antenna is an example of how to bend an antenna's contour to make it appear longer than it actually is by restricting the current's ability to go down lengthy paths (PIFA). There are many methods for making something smaller, including improving the geometry, employing ground planes, high dielectric substrate materials, and loading the antenna with lumped parts. It is not possible to create extremely efficient antennas alone by miniaturisation; instead, the structure must be further improved in order to produce multiband radiating antennas with high gain and efficiency.

(a)- A number of additional strategies for downsizing are possible when patch designs are used for implanted antennas. At a specific operating frequency, it is desired to lower the antenna's size while maintaining appropriate electromagnetic performance. The literature suggests the following strategies for implantable patch antennas' miniaturisation: Utilizing dielectric (substrate/superstrate) materials with high permittivity For implantable patch antennas, high permittivity dielectrics are chosen (such as ceramic alumina, Rogers 3210).

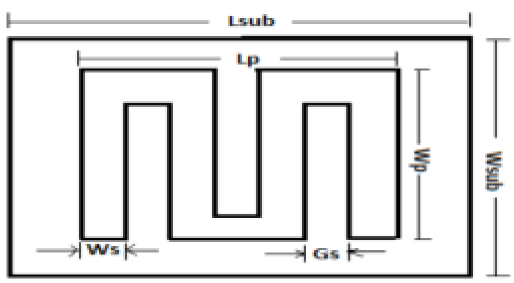

Fig2.2 Geometry of miniaturized patch Antenna

(b)- Longer effective current-flow routes excited on the radiating patch can lower the resonance frequency and result in a smaller implantable antenna by lengthening the current-flow path on the patch surface. The insertion of shorting pins: Given a particular operating-frequency scenario, putting a shorting pin between the ground and patch planes increases the effective size of the antenna and, as a result, decreases the necessary physical dimensions. The method often results in a planar inverted-F antenna (PIFA) with the same resonance performance as a double-sized antenna without the shorting pin, much as how a ground plane twice the height of a monopole antenna.

2.3 Patient Safety

The implantable antenna's maximum permissible power incident is constrained by patient safety concerns. The most suitable dosimetric measure is usually agreed to be the Specific Absorption Rate (SAR), the size linked with the size of electromagnetic radiation absorption by biological tissues, and compliance with international standards is evaluated. which the established acceptable exposure limits for electromagnetic radiation for frequencies greater than 1 MHz. The power density, or the power of the radiation incident on the unit surface, is frequently employed in place of the SAR because it cannot be measured directly.

$$SAR = \int_{sample}^{h} \frac{\sigma(r)|E(r)|^2}{\rho(r)} dr$$

Where: σ is the electrical conductivity of the tissue (S/m)

E is the RMS electric field

ρ is the sample density (Kg/m^3)

It relies on a number of variables, including:

(i) The radiation properties (frequency, polarization, intensity)

(ii) biological item features, geometry (size and shape), and

(iii) internal organisation. the separation between biological items and the radiation source (near or distant field). the surroundings' characteristics.

$$P_{abs} = \frac{1}{2} \int \sigma |E|^2 dV$$

Equation describing the power absorbed by the human body in the presence of an incident electromagnetic field suggests that this power is connected to the electric field, with greatest SAR values being measured in regions with the highest electric-field intensities. The conclusion that high near fields produce peak averaged SAR values allows for the construction of innovative implanted patch antennas that strive for reduced electric-field intensities. Larger implanted antennas have more consistent electric field and current density distributions over larger patches of surface area, resulting in lower SAR values.

2.4 Far field gain

The implantable medical device and an external monitoring/control device, which are positioned at some distance (usually 2 m) from the body, make up medical implant communication systems. Biotelemetry links can be used to transmit stored data, change device parameters, and transmit critical monitoring data in real time. Thus, regardless of any power restrictions, the implantable antenna should transmit a signal that is potent enough to be picked up by the external device.

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Accordingly, the far field radiation pattern of the antenna is affected by the symmetry of the implantation tissue model. In symmetrical tissue models, omnidirectional monopole-like radiation is seen, however in irregular and inhomogeneous anatomical tissue models, asymmetrical radiation is shown.

2.5 Low Power Consumption

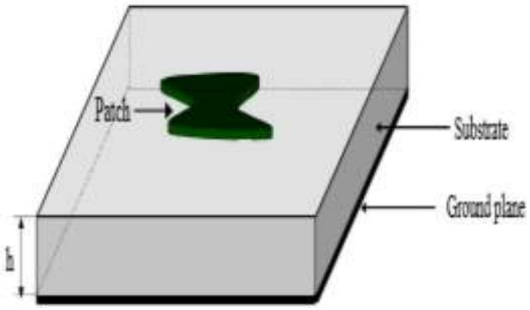
The transceiver of an implantable medical device will use up a lot of energy if it is continuously used, which will shorten the device's lifespan. There are a few ways to recharge the battery (e.g., via an inductive-loop approach). It would be much better to only use the biotelemetry link when it is absolutely necessary.

3. **Miniaturized Patch Antenna** Since the Microstrip antenna was created 50 years ago, demand for its use has grown significantly, notably over the last 20 years. Because of the numerous distinctive and alluring features of the Microstrip antenna (such its tiny weight, low price, and ease of usage), They will definitely continue to have a wide range of applications in the future due to their ease of manufacture and compatibility with integrated circuits.

Numerous numerical analysis approaches have been created and transformed into computer- aided design tools in order to better understand the performance of the Microstrip antenna and to streamline its design process. Some of these analysis methods also give the designer a physical understanding of the electrical workings of the antenna. This section discusses and places emphasis on a few of the technical characteristics, physical operation, and radiation mechanism of the microstrip antenna, as well as its benefits and drawbacks.

3.1 Basic Structure of Patch Antenna

In its most basic form, a Microstrip antenna consists of a ground plane on one side of a dielectric substrate and a radiating patch on the other.



Patch: a radiant conductive element that can appear in a variety of shapes and is often made of copper or gold, two conductors, although it can take on any shape that is imaginable.

Substrate: It enables isolation of both permittivity defined conductive planes.

Ground plane: The conductor below the circuit that the substrate is positioned on.

The fringing fields between the patch edge and the ground plane are principally responsible for the radiation of microstrip patch antennas. A thick dielectric substrate with a low dielectric constant is preferred for optimal antenna performance because it offers better efficiency, a wider bandwidth, and better radiation. A thick dielectric substrate with a low dielectric constant is ideal for superior antenna performance and is desirable for higher bandwidth, better efficiency, and better radiation leading to a bigger antenna size. This research describes the impact of changing patch height on efficiency.

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3.2 Types of Microstrip Antenna

Patch antennas are another name for microstrip antennas. The feed lines and radiating elements are typically photo etched onto the dielectric substrate. The radiating patch can be round, elliptical, square, rectangular, narrow strip (dipole), or any combination of these.

(d) Circular (e) Elliptical (a) Square (b) Rectangular (c) Dipole

The most popular shapes are square, rectangular, dipole (strip), and Hexagonal due to their simplicity in analysis and manufacture as well as their appealing radiation properties, particularly low crosspolarization radiation. Microstrip dipoles are desirable because they have a broad bandwidth by nature and take up less area, making them desirable for arrays. Microstrip antenna arrays and single elements can both produce linear and Hexagonal polarisations.

To add scanning capabilities and obtain higher directivities, arrays of Microstrip components with one or more feeds may also be employed. Overall, the radiation, bandwidth, and polarisation of Microstrip antennas are better when they are rectangular or Hexagonal in shape

4.1 **Antenna Specifications and Features** The fundamental antenna parameters are gain, directivity, return loss, and input impedance. Every antenna has properties that are unique to a certain application type and not to others. Therefore, it can only be described by its most basic characteristics:

Return Loss: The power supply input's reflection is represented by the reflection loss S11. As a result, a high return loss is preferred because it leads to a smaller insertion loss.

Input Impedance: An important factor to take into account when choosing an antenna for a transmitter or a receiver is input impedance. An antenna's input impedance is, by definition, the impedance as seen from the feed line. The following formula yields it.

$$Z_{in} = Z_0 \frac{1+S_{11}}{1-S_{11}}$$

Gain: A poorly radiating antenna has a low gain. The gain makes it possible to compare an antenna's radiation output to that of a dipole as a reference antenna. The directivity (D) and return loss(η) both have an impact on the gain.

$$G(\vartheta, \varphi) = \eta \times D(\vartheta, \varphi)$$

Radiation Pattern: A fixed or constant distance from the antenna, the radiation or antenna pattern describes the relative strength of the emitted field in various directions from the antenna. The major lobe receives the most radiation, whereas the secondary lobes receive the least. Knowing the antenna's radiation model is crucial for ensuring that the principal lobe is pointing in the desired direction for communication.

Radiation Mechanism: The radiation mechanism Understanding the Microstrip antenna requires taking into account Fig4.1, which depicts a cutting of the Microstrip antenna with distinct sections based on the type of electromagnetic field. As a result, propagation occurs without radiation, and a transmission line or one of its derivatives is the resulting structure (junction, bend, etc). As a result, the structure exhibits antenna behaviour. Since the surface currents virtually circulate on the interior

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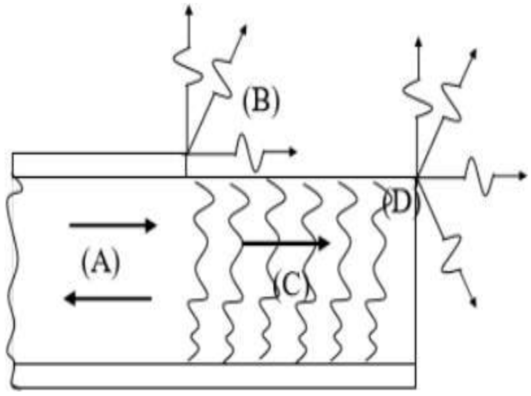

face of the conductor in question, it appears that radiation is released at the ends (discontinuities). In fact, a dispersed field exists at this level of the structure and is the source of radiation.

Fig-4.1 Configuration of principle regions of a microstrip antenna

The length of the patch, which is around half the wavelength (λ/2) in traditional microstrip patches, is where the electric field varies, assuming that there are no variations along the width and thickness of the Microstrip structure. As seen in Fig4.2 , the fringing fields at the radiator's open circuited borders are mostly responsible for radiation. The normal components of the bordering fields would be out of phase with one another and cancel out if they were separated into their parallel and tangential components with respect to the ground plane

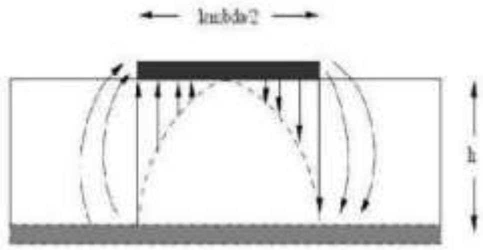

Fig4.2- Radiation Mechanism of Microstrip Patch Antenna

5.1 **Feeding Techniques**

Numerous approaches can be used to feed microstrip patch antennas. These methods can be divided into contacting and non-contacting categories. In the contacting approach, a connecting component, such as a Microstrip line, is used to supply the RF power directly to the radiating patch. Electromagnetic field coupling is used in the noncontacting method of feeding to transmit power between the Microstrip line and radiating patch. Microstrip line, coaxial probe (both contacting schemes), aperture coupling, and proximity coupling are the four most common feeding approaches (both non-contacting schemes).

The Microstrip Line Feed:

Feed lines can provide microstrip antennas, as seen in Figure. Line feed is simple to model, simple to manufacture, and easy to match by adjusting the inset feed location. The fact that this feed arrangement is etched on the same substrate ensures that the overall structure is planar. However, surface waves and spurious feed radiation grow with substrate thickness, hence limiting the bandwidth (usually 2-5%). This causes the cross polar level to rise. The size of the feed line is comparable to the patch size in the millimetre wave band as well, increasing unwanted radiation.

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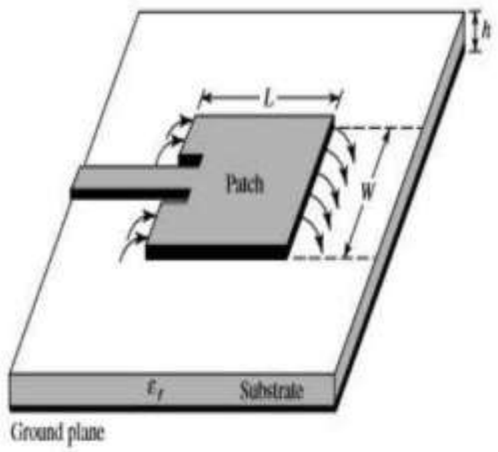

Fig 5.1 Microstrip Line feed

Coaxial Probe Feed (Coplanar Feed)

The centre conductor of the coaxial connector is soldered to the patch in the coaxial or probe feed figure. This feed's main benefit is that it can be positioned wherever you like inside the patch to match the input impedance. The connector protrudes outside the bottom ground plane, preventing the substrate from being fully flat, therefore a hole must be bored in the substrate.

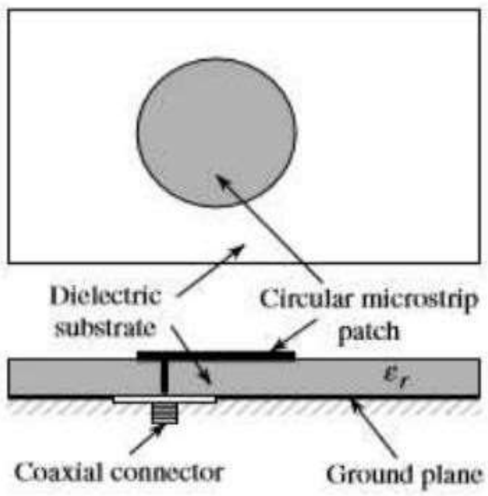

Fig 5.2 Coaxial Probe feed

Aperture Coupled Feed

The aperture coupled arrangement of Figure has the narrowest bandwidth and is the most challenging to construct of the four. The field isconnected from the Microstrip line feed to the radiating patch by an electrically small aperture/slot cut in the ground plane, however it is simpler to model and exhibits mild spurious radiation.

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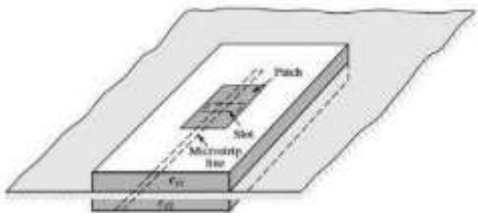


Fig 5.2 Aperture Coupled feed

Due to the symmetry of the design, the coupling aperture is typically centred beneath the patch, which results in less cross polarisation. The aperture's size, shape, and location determine how much of the feed line is coupled to the patch. The slot aperture may or may not have resonance. In order to enhance bandwidth at the expense of increased back radiation, the resonant slot offers a second resonance in addition to the patch resonance.

6.1 HEXAGONAL PATCH ANTENNA

In the proposed work, a 2.45 GHz hexagonal microstrip antenna was created. A microstrip antenna's lower bandwidth is a key drawback. In order to achieve minimum return loss with optimal efficiency, the design concentrated on increasing the bandwidth. The aforesaid issues are addressed with a Hexagonal microstrip antenna.

Figure 6.1 depicts a Hexagonal patch with a radius of design. A Hexagonal patch with dimensions of 25*25mm and a thickness of 1mm is put on a FR-4 epoxy substrate (r =4.4). The substrate's thickness should not exceed 0.003λ mm<h< 0.05λ mm. Microstrip line feed is used to power the intended Hexagonal microstrip antenna. The line feed's width should be smaller than the patch's thickness.

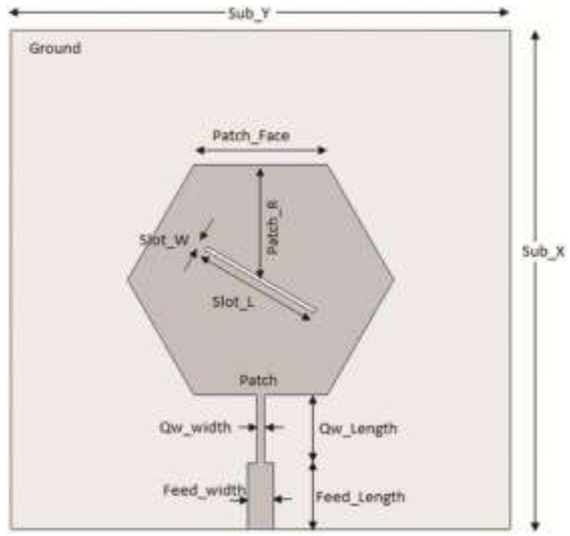


Fig 6.1 Hexagonal microstrip Patch Antenna

Since it only has one parameter to manage, namely radius, as opposed to rectangular microstrip, which has two, namely length and width, Hexagonal microstrip patch antenna (CMSA) is more straightforward than rectangular microstrip patch antenna. Utilizing a FR-4 epoxy substrate, the modified Hexagonal microstrip patch antenna was created. The dielectric constant of FR-4 epoxy is 4.4. By selecting this substrate, you can get improved antenna performance and lower loss tangent. The height of the substrate was assumed to be 1mm in this design. The radius determined was

6.96mm based on the Hexagonal microstrip patch antenna design formulae.

$$\text{Circular patch radius } a = \frac{F}{\left\{1+\frac{2h}{\pi\varepsilon_r}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right\}^{\frac{1}{2}}}$$

$$9.791\times10^{9}$$

ε_r -Dielectric constant of substrate
h- Height of substrate
a- Radius of the patch
f_r - Resonant frequency

where;

The information required to design the Antenna are:

- The dielectric constant of the substrate (εr = 4.4 for FR-4 substrate)
- Height of substrate (h = 3.6mm)
- Resonant frequency(fr = 2.45GHz)

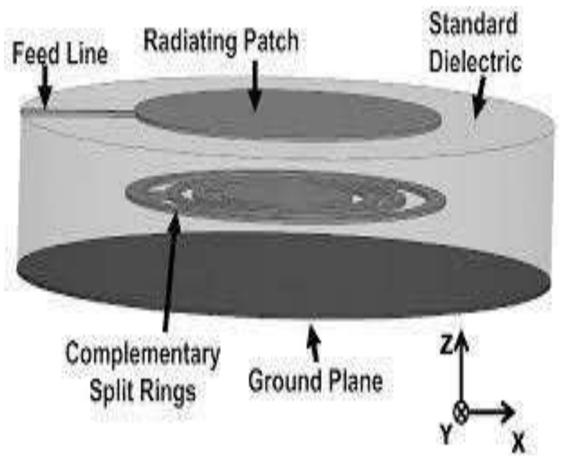


Fig 6.2 Hexagonal Patch Antenna in 3D Plane

6.2 E-shaped Patch Antenna Design

The E-shaped patch antenna is a type of microstrip antenna that consists of a rectangular patch with an "E" shaped slot on its surface. The slot helps in enhancing the bandwidth of the antenna and provides a more uniform radiation pattern. It is a compact and low-profile antenna that is suitable for applications in wireless communication systems and satellite communication. The E-shaped patch antenna also offers good impedance matching and radiation efficiency.

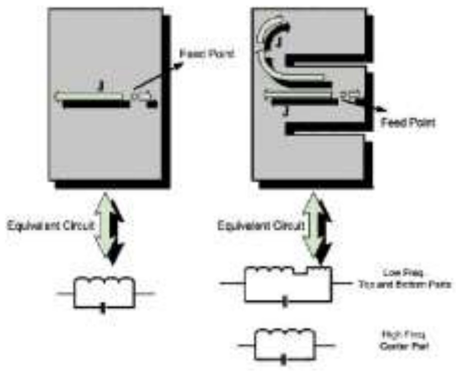


Fig 6.3 E shaped Patch Antenna structure

A modified variant of the standard E-shaped patch antenna is the E-shaped patch antenna with slots. It comprises of a rectangle patch with additional slots and a "E" shaped slot on its surface. In order to increase the antenna's bandwidth and give better impedance matching, the slots are placed carefully. To ensure correct radiation and minimise undesired radiation, the structure additionally has a ground plane underneath the patch. The slots add more resonant modes, increasing the antenna's bandwidth and enabling it to be used for GPS, RFID, and wireless communication systems, among other things. The antenna's slotted design offers more flexibility when adjusting its performance.

7.1 **Designing Hexagonal Patch Antenna Using HFSS Software**

The Hexagonal patch antenna is designed using HFSS Software. Hexagonal patch antenna is designed using FR-4 substrate which can be fed using microstrip fed lines. After designing we can check the active S parameter, Radiation pattern, VSWR plot, 3D gain plot and Directivity Plot. The advantages of replicating a circuit's high frequency behaviour with high precision on a computer lower the system's final testing and verification work and mitigate the need for expensive multiple prototypes, saving time and money during the product development process.

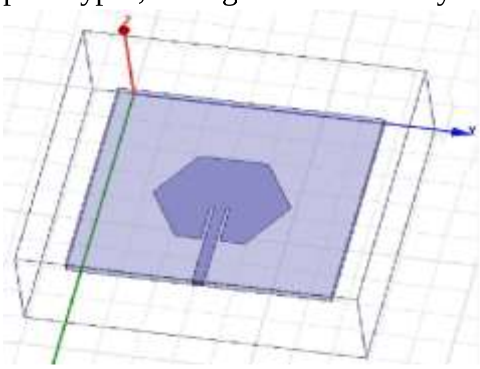


Fig 7.14- The Hexagonal Patch Antenna Design using HFSS

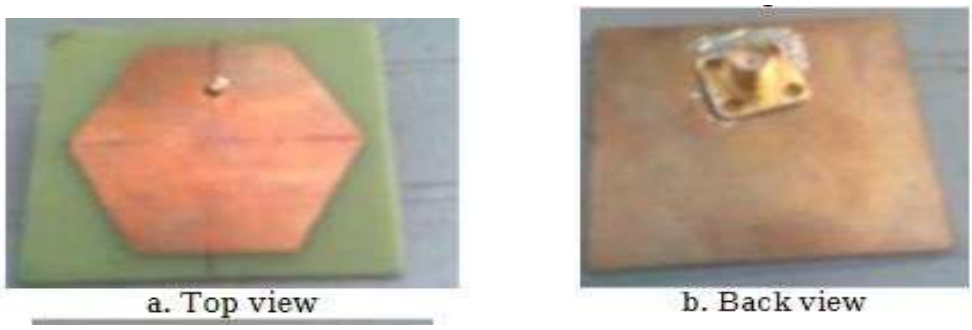


Fig 7.15- Top view and Back view of Patch Antenna Design

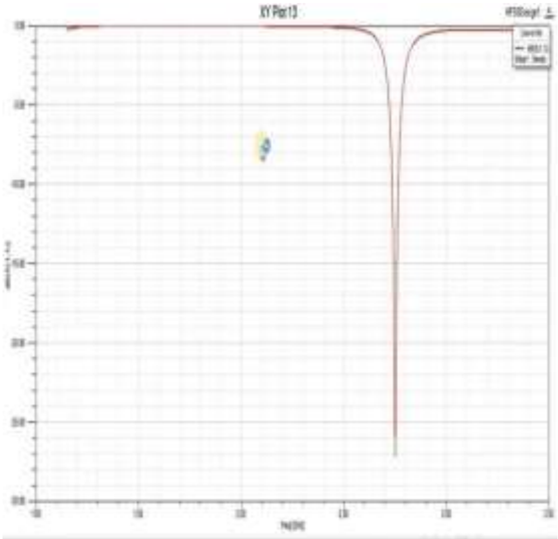
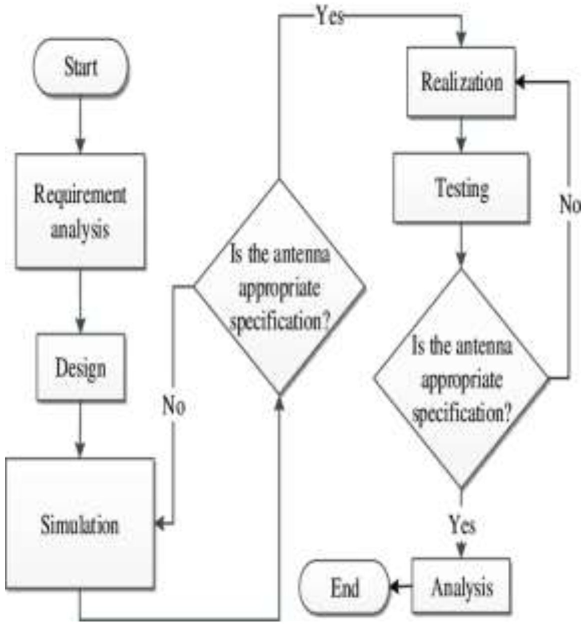


Fig 7.17-Frequency Response of Hexagonal Patch Antenna

8.1 FLOW CHART

The workflow of project is as follows:



The analysis of the requirements comes first, then the design simulation. After that, we determine if Antenna satisfies the necessary requirements. If the antenna doesn't satisfy the requirements, we revise the design; if it does, we proceed to realisation and testing. Following testing, more analysis is used to fine-tune the parameters of the antenna design. When an antenna design meets its requirements, the design process is complete.

9.1 CONCLUSION

HFSS Software was used to design the Hexagonal miniaturised patch antenna. We were successful in creating a patch implanted antenna with ISM band capabilities. Such implanted antennas were built with the aid of extraneous parts to enhance their functionality. By transmitting data gathered by sensors to target devices in order to detect trends and forecast the severity of diseases or complications, the antenna created can be utilised with sensors and equipment in biomedical applications to monitor illness and healthcare quality. When an antenna is designed, it is also ensured that the materials employed won't have any negative effects on the host's body.

To start the design process, the overall dimensions of the antenna are first estimated using a common mathematical formulation for patch antennas. The final patch antenna dimensions are then optimised with the aid of the HFSS software.

In this study, we address the problem of restricted bandwidth by proposing a Hexagonal micro strip antenna with cut-out rectangular slot. The parametric analysis shown that only by carefully selecting the parameters can wideband features be obtained with a smaller antenna. The suggested antenna has a large return loss and a broader bandwidth at 2.45GHz. As a result, this antenna is suitable for many embedded high data rate applications. This antenna's physical integration with embedded devices enables it to operate in a wider range of applications. The performance of the antenna will be enhanced using a technique for dispersing the current around the capsule antenna. After being modelled with HFSS software, these antennas will be built and tested in the lab. A three-layer human body model (skin, fat, and muscle) is used to build subcutaneously implanted antennas, and a liquid body phantom is used to create the capsule.

Advantages

Implantable devices, for instance, enhance healthcare quality by reducing the likelihood of specific diseases' consequences by continuously monitoring certain illness changes. Additionally, it reduces the cost of healthcare because patients can be regularly checked without being admitted to the hospital.

Disadvantages

Devices with implantable antennas are essential for medical applications, but designing them is quite challenging. We must also make sure that no implantable antenna component will have an adverse effect on the human body. The possibility of a health danger is always present with implantable technology.

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