DESIGN AND ANALYSIS OF MICROSTRIP PATCH ANTENNA OF MIDBAND FREQUENCY FOR 5G APPLICATIONS

PROJECT REPORT

OF PROJECT-I (EC-711)

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ACKNOWLEDGEMENT

On the very outset of this report, we would like to extend my heartful obligation towards all the personages who have helped us in completing this project. Without their support active guidance and encouragement. We would not have made headway in this project.

We are extremely thankful towards our faculty guide **Er. Nitasha Bist** for his continuous guidance and support for completion of this project.

We would also like to thank the Department of Electronics & Communication Engineering (J.N.G.E.C) for being a constant support in order to complete the project.

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CERTIFICATE

We hereby certify that the work which is being presented in the B.Tech. Project entitled **"design and analysis of microstrip patch antenna of midband frequency for 5g applications'"**, in partial fulfillment of the requirements for the award of the **Bachelor of Technology** in **Electronics & Communication Engg.** and submitted to the Department of Electronics & Communication Engineering of Jawaharlal Nehru Govt. Engg. College Sundernagar HP, is an authentic record of our own work carried out during a period from 8-9-2023 to 30-11-2023 under the supervision of **ER. Nitasha Bist, O.I.C**, E&CE Department.

The matter presented in this project has not been submitted by us for the award of any other degree elsewhere.

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ABSTRACT

The relentless evolution of wireless communication technologies, especially with the advent of 5G, demands innovative antenna solutions to meet the requirements of higher data rates, lower latency, and increased device connectivity. This project focuses on the design and

analysis of a microstrip patch antenna tailored for mid-band frequencies to cater to the specific needs of 5G applications.

The proposed microstrip patch antenna is optimized for mid-band frequencies, which are integral to the 5G spectrum. The design process involves the careful selection of substrate materials, dimensions, and feeding techniques to achieve the desired resonant frequency, impedance matching, and radiation characteristics. Advanced simulation tools, such as HFSS software, are employed for accurate analysis and optimization.

The project aims to address the challenges associated with 5G, including the need for compact, efficient, and high-performance antennas. The microstrip patch antenna's design considers factors such as bandwidth, gain, and radiation pattern, ensuring compatibility with the mid band frequencies allocated for 5G communication.

The analysis phase involves evaluating the antenna's performance metrics, including return loss, radiation efficiency, gain, bandwidth and directivity.

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INTRODUCTION

5G technology is characterized by its promise of ultra-fast data rates, low latency, and the ability to connect a vast number of devices simultaneously. To fully harness the potential of 5G networks, antennas must be adeptly designed to operate at specific frequency bands. Our project centres around the mid-band frequencies, typically ranging from 2 GHz to 6 GHz, which strike a balance between coverage and data capacity.

A microstrip patch antenna is most typically employed to radiate the electromagnetic wave into space in wireless communication.

Ground, substrate, patch, and feed are the four main components of a microstrip patch antenna. It comes in various shapes, including square, ellipse, circular, rectangular, and ring, and consists of a dielectric constant on one side and a ground plane on the other.

In a designing of microstrip antenna, calculate patch dimensions and antenna dimensions i.e., patch length(L) and width(W) including the length, and width of the ground, patch, substrate, and feed line. We discuss the design and simulation of a microstrip patch antenna for 5G applications. Microstrip line feeding technique is used

HFSS simulation software is used for designing, simulating, and analyzing microstrip antenna.

Ground plate is made of copper material. FR-4 substrate material is used having dielectric constant of 4.4. Substrate height is 1.6mm.

We design the microstrip patch with slot having 4 arrays.

After designing, we simulate the design and plots the graphs for return loss (S11), gain, bandwidth, directivity, radiation efficiency. Return loss should be less then -10db.

The primary objective of our minor project is to design and analyze a Microstrip Patch Antenna optimized for mid-band frequencies within the 5G spectrum. This involves a comprehensive exploration of various design parameters, such as substrate materials, dimensions, and feeding techniques, with the aim of achieving superior performance in terms of bandwidth, gain, and radiation pattern.

LITERATURE SURVEY

[1]Research Paper on: "AT 1.881 GHZ, Rectangular Micro strip Patch Antenna (RMPA) Using Split Rectangular Shape of Meta Material Structure for Bandwidth Improvement"

[2]Research Paper on: "Design of rectangular stacked microstrip antenna for Dual band". A dual band characteristic of single layer stacked rectangular microstrip antenna is experimentally studied. The variations of the length and width of the stacked rectangular patch antenna has been done and found dual resonance with increasing lower resonance frequency and almost constant upper resonance.

[3]Research Paper on: "A novel stacked e-shaped patch antenna. A novel stacked E shaped patch antenna is proposed in this paper. As compared to the E shaped microstrip patch antenna in which has an input impedance bandwidth

[4]Magneto-dielectric substrates have been widely utilized to miniaturize microstrip antennas due to magnetic substrates can provide wider bandwidths than dielectric substrates. Fractal geometries (topologies), which are composed by self-similar structures, have opened an alternate way for antenna miniaturization.

[5]The narrow bandwidth is one of the main drawbacks of these types of antennas. The direct method to improve the bandwidth can be done by increasing substrate thickness, but the major disadvantage of increasing thickness is the reduced efficiency since the large portion of the input power is dissipated in the resistor which takes away the available Power that can be radiated by antenna. Furthermore, reducing the height of the structure may appear to be a suitable solution, but it may lead to a reduced impedance bandwidth and lower radiation efficiency. This is often a tradeoff in realizing compact antennas while maintaining performance characteristics.

[6]Similarly, another problem to be solved is the low gain for conventional microstrip antenna element. Array topologies like dual patch antenna arrays, basically the term topology

optimization is often used to label the most general type of design optimization methods, in which the shapes as well as the connectivity of individual parts of the device are subject to design. The most common way of carrying out topology optimization is through the material distribution approach, in which the design domain is divided into small elements

[7]"Design and Implementation of Microstrip Patch Antenna for 5G applications" by John Colaco and Rajesh Lohani. This paper describes the basic concept of microstrip patch antenna and designing of microstrip patch antenna using HFSS software

[8]"Study, design, and stimulation for microstrip patch antenna" by Mohamed Abdulrahman AL Amoudi. Rectangular, square, circular, circular ring, triangle, parasitic, and polygon shapes of the patch of antenna have been discussed in this paper

[9]"Study the various feeding techniques of microstrip antenna using design and simulation using CST microwave studio" by Sourabh Bisht, Shweta Saini, Dr Ved Prakash, Bhaskar Nautiyal. This research paper presents a feeding technique of microstrip antenna.

CHAPTER- I

INTRODUCTION TO ANTENNAS

An antenna is a transducer that converts electrical signals into electromagnetic waves (or vice versa) and radiates (or receives) them into (or from) space. In simpler terms, an antenna is a device designed to transmit or receive electromagnetic waves, typically in the radiofrequency (RF) or microwave range, and is a fundamental component of communication systems, broadcasting, radar systems, and various wireless technologies

1.1 Antenna parameters

An antenna is an electrical conductor or system of conductors

Transmitter - Radiates electromagnetic energy into space Receiver - Collects electromagnetic energy from space

The IEEE definition of an antenna as given by Stutsman and Thiele is, "That part of a transmitting or receiving system that is designed to radiate or receive electromagnetic waves". The major parameters associated with an antenna are defined in the following sections.

1.1.1 Antenna Gain

Gain is a measure of the ability of the antenna to direct the input power into radiation in a particular direction and is measured at the peak radiation intensity. Consider the power density radiated by an isotropic antenna with input power $P0$ at a distance R which is given by $S = P0/4\pi R^2$. An isotropic antenna radiates equally in all directions, and its radiated power density S is found by dividing the radiated power by the area of the sphere $4\pi R^2$. An isotropic radiator is considered to be 100% efficient. The gain of an actual antenna increases the power density in the direction of the peak radiation:

Gain is achieved by directing the radiation away from other parts of the radiation sphere. In general, gain is defined as the gain-biased pattern of the antenna.

1.1.2 Antenna Efficiency

The surface integral of the radiation intensity over the radiation sphere divided by the input power P0 is a measure of the relative power radiated by the antenna, or the antenna efficiency. where Pr is the radiated power. Material losses in the antenna or reflected power due to poor impedance match reduce the radiated power.

1.1.3. Effective Area

Antennas capture power from passing waves and deliver some of it to the terminals. Given the power density of the incident wave and the effective area of the antenna, the power delivered to the terminals is the product.

For an aperture antenna such as a horn, parabolic reflector, or flat-plate array, effective area is physical area multiplied by aperture efficiency. In general, losses due to material, distribution, and mismatch reduce the ratio of the effective area to the physical area. Typical estimated aperture efficiency for a parabolic reflector is 55%. Even antennas with infinitesimal physical areas, such as dipoles, have effective areas because they remove power from passing waves.

1.1.4. Directivity

Directivity is a measure of the concentration of radiation in the direction of the maximum.

Directivity and gain differ only by the efficiency, but directivity is easily estimated from patterns. Gain—directivity times efficiency—must be measured. The average radiation intensity can be found from a surface integral over the radiation sphere of the radiation intensity divided by 4π.

This is the radiated power divided by the area of a unit sphere. The radiation intensity separates into a sum of co- and cross-polarization components:

Both co- and cross-polarization directivities can be defined:

Directivity can also be defined for an arbitrary direction radiation intensity divided by the average radiation intensity, but when the coordinate angles are not specified.

1.1.5. Path Loss

We combine the gain of the transmitting antenna with the effective area of the receiving antenna to determine delivered power and path loss. Antenna 1 transmits, and antenna 2 receives. If the materials in the antennas are linear and isotropic, the transmitting and receiving patterns are identical. When we consider antenna 2 as the transmitting antenna and antenna 1 as the receiving antenna,

1.1.6 Input Impedance

The input impedance of an antenna is defined as "the impedance presented by an antenna at its terminals or the ratio of the voltage to the current at the pair of terminals or the ratio of the appropriate components of the electric to magnetic fields at a point". Hence the impedance of the antenna can be written as given below.

1.1.7. Antenna Factor

The imaginary part, Xin of the input impedance represents the power stored in the near field of the antenna. The resistive part, Rin of the input impedance consists of two components, the radiation resistance Rr and the loss resistance RL. The power associated with the radiation resistance is the power actually radiated by the antenna, while the power dissipated in the loss resistance is lost as heat in the antenna itself due to dielectric or conducting losses Antenna Factor

The engineering community uses an antenna connected to a receiver such as a spectrum analyzer, a network analyzer, or an RF voltmeter to measure field strength E. Most of the time these devices have a load resistor ZL that matches the antenna impedance.

The incident field strength Ei equals antenna factor AF times the received voltage Vrec. We relate this to the antenna effective height:

AF has unit meter^{-1}but is often given as dB(m^{-1}). Sometimes, antenna factor is referred to the open circuit voltage. We assume that the antenna is aligned with the electric field.

This measurement may be corrupted by a poor impedance match to the receiver and any cable loss between the antenna and receiver that reduces the voltage and reduces the calculated field strength.

1.1.8. Return Loss

It 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. Simply put it is the S11 of an antenna. A graph of s11 of an antenna vs frequency is called its return loss curve. For optimum working such a graph must show a dip at the operating frequency and have a minimum dB value at this frequency. This parameter was found to be of crucial importance to our project as we sought to adjust the antenna dimensions for a fixed operating frequency

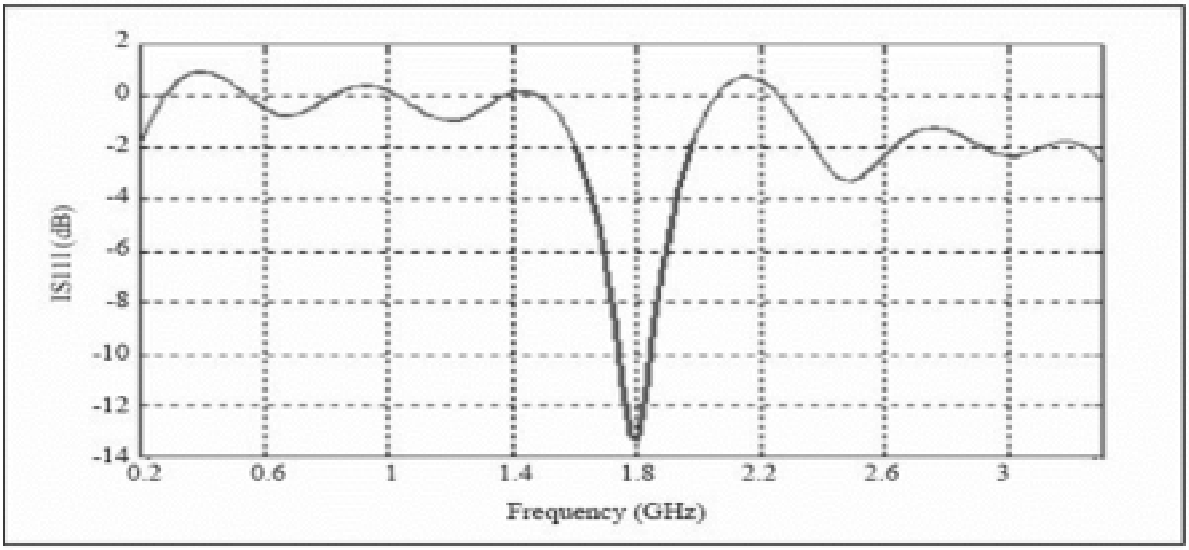


Figure 1.1: - Return loss

1.1.9 Radiation Pattern

The radiation pattern of an antenna is a plot of the far-field radiation properties of an antenna as a function of the spatial co-ordinates which are specified by the elevation angle (θ) and the azimuth angle (φ). More specifically it is a plot of the power radiated from an antenna per unit solid angle which is nothing but the radiation intensity. It can be plotted as a 3D graph or as a 2D polar or Cartesian slice of this 3D graph. It is an extremely parameter as it shows the antenna's directivity as well as gain at various points in space. It serves as the signature of an antenna and one look at it is often enough to realize the antenna that produced it.

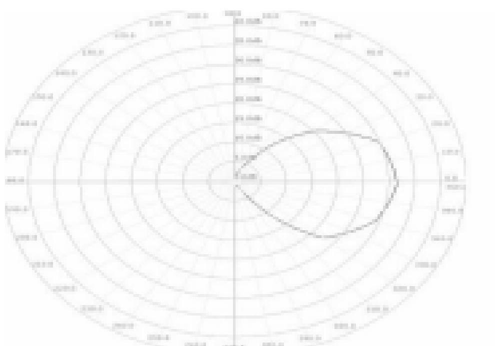


Figure 1.2 – 2D Polar Plot for a Yagi Antenna

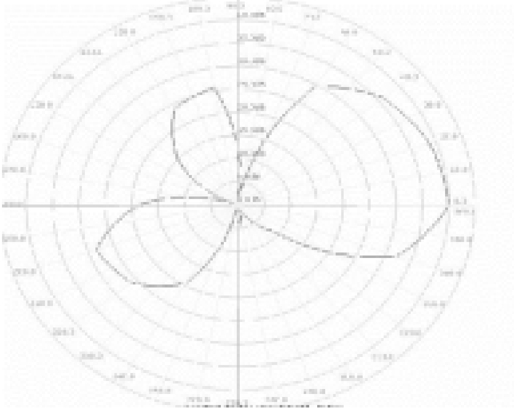


Figure 1.3: – 2D Polar Plot for a Helical Antenna

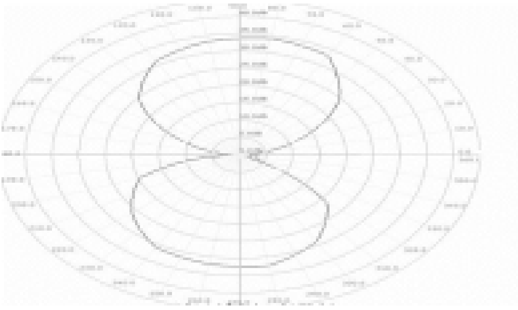


Figure 1.4 – 2D Polar Plot for a Rhombus Patch Antenna

1.1.10. Beamwidth

Beamwidth of an antenna is easily determined from its 2D radiation pattern and is also a very important parameter. Beamwidth is the angular separation of the half-power points of the radiated pattern.

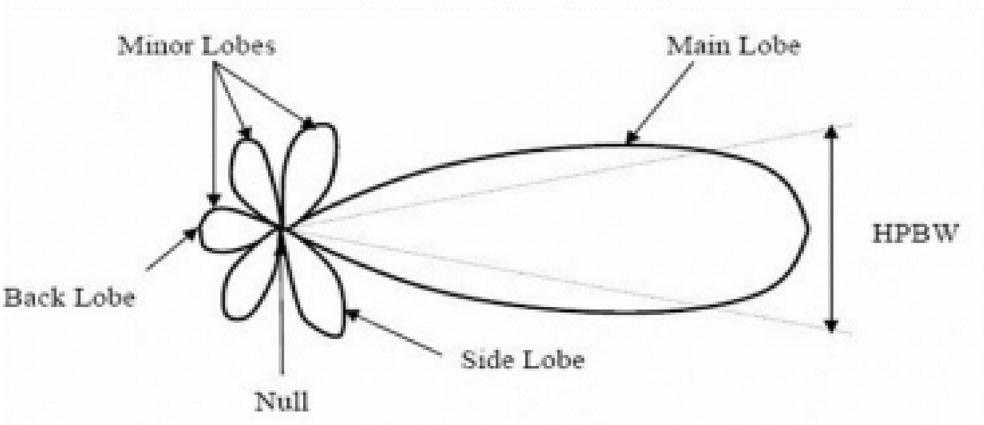


Figure 1.5 – Determination of HPBW from radiation pattern

1.2 Types of Antennas

Antennas can be classified in several ways. One way is the frequency band of operation. Others include physical structure and electrical/electromagnetic design. Most simple, non-directional antennas are basic dipoles or monopoles. More complex, directional antennas consist of arrays of elements, such as dipoles, or use one active and several passive elements, as in the Yagi antenna. New antenna technologies are being developed that allow an antenna to rapidly change its pattern in response to changes in direction of arrival of the received signal. These antennas and the supporting technology are called adaptive or "smart" antennas and may be used for the higher frequency bands in the future. A few commonly used antennas are described in the following sections.

1.2.1 Dipoles and Monopoles

The vertical dipole—or its electromagnetic equivalent, the monopole—could be considered one of the best antennas for LMR applications. It is omni directional (in azimuth) and, if it is a half-

wavelength long, has a gain of 1.64 (or G = 2.15 dBi) in the horizontal plane. Although this is a simple antenna, it can be difficult to mount on a mast or vehicle. The ideal vertical monopole is illustrated in figure 1.8 (b). It is half a dipole placed in half space, with a perfectly conducting, infinite surface at the boundary.

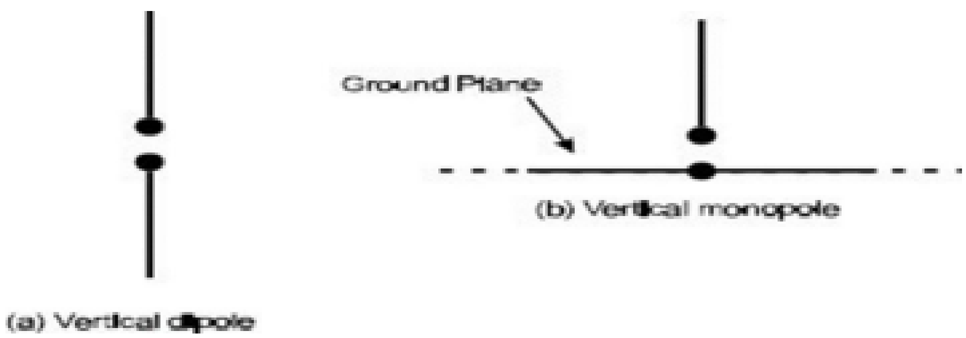


Figure 1.6: - The vertical dipole and its electromagnetic equivalent, the vertical monopole

A monopole over an infinite ground plane is theoretically the same (identical gain, pattern, etc., in the half-space above the ground plane) as the dipole in free space. In practice, a ground plane cannot be infinite, but a ground plane with a radius approximately the same as the length of the active element, is an effective, practical solution. The flat surface of a vehicle's trunk or roof can act as an adequate ground plane. Figure 1.9 shows typical monopole antennas for base-station and mobile.

Figure 1.7: - Typical monopole antennas for (a) base-station applications and (b) mobile applications

1.2.2. Corner Reflector

An antenna comprised of one or more dipole elements in front of a corner reflector, called the corner-reflector antenna.

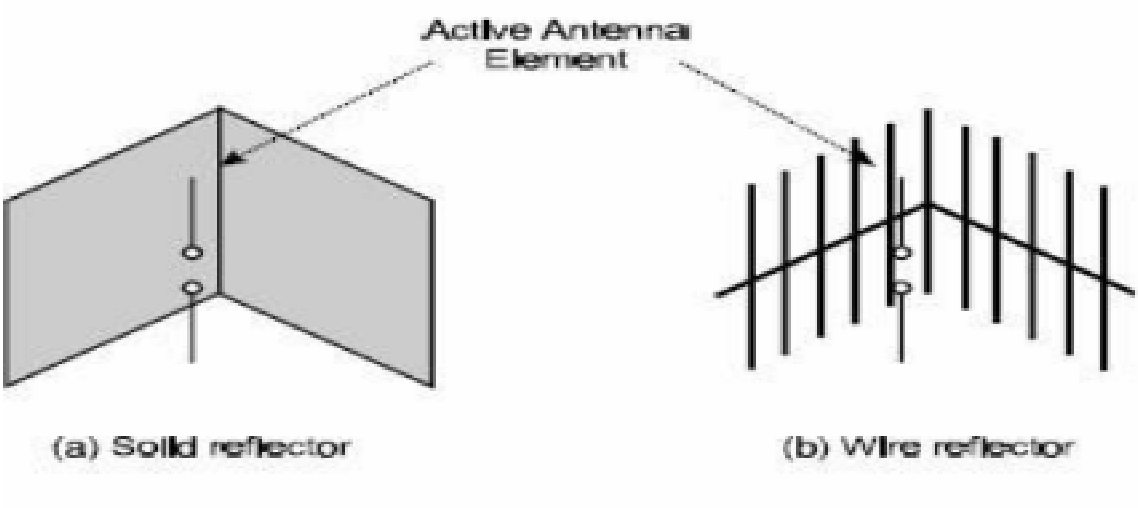


Figure 1.8 - Corner-reflector antennas

This antenna has moderately high gain, but its most important pattern feature is that the forward (main beam) gain is much higher than the gain in the opposite direction. This is called the front-to-back ratio and is evident from its radiation pattern shown in figure 1.11.

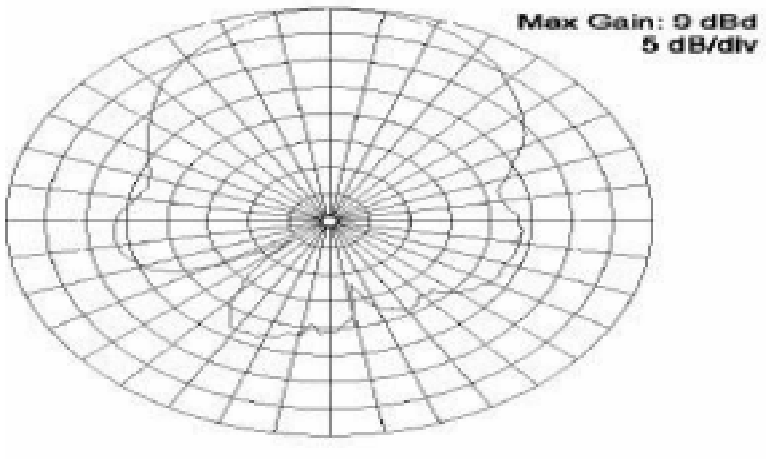


Figure 1.9 - A corner-reflector antenna horizontal-plane pattern

1.2.3. Yagi Antenna

Another antenna design that uses passive elements is the Yagi antenna. This antenna, illustrated in figure 1.12, is inexpensive and effective. It can be constructed with one or more (usually one or two) reflector elements and one or more (usually two or more) director elements.

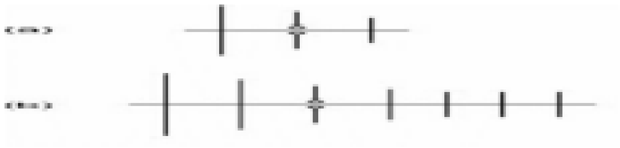


Figure 1.10 - The Yagi antenna — (a) three elements and (b) multiple elements

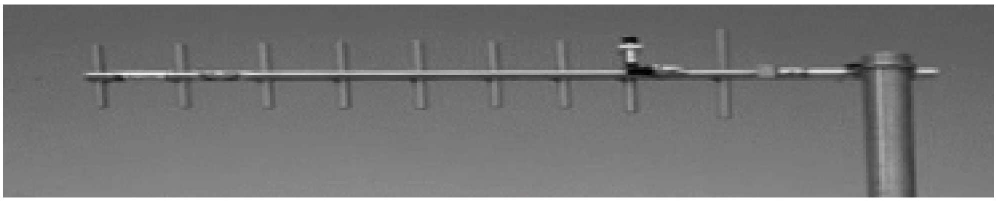


Figure 1.11 - A typical Yagi antenna

Figure 1.11 is the typical radiation pattern obtained for a three element (one reflector, one active element, and one director) Yagi antenna. Generally, the more elements a Yagi has, the higher the gain, and the narrower the beamwidth. This antenna can be mounted to support either horizontal or vertical polarization and is often used for point-to-point applications, as between a base station and repeater-station sites

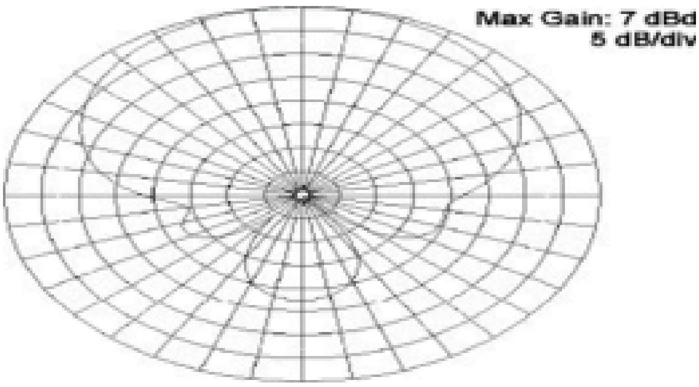


Figure 1.12 - A Yagi antenna horizontal plane patter

CHAPTER-II

MICROSTRIP PATCH ANTENNA

If you want a light-weight, low cost, conformal antenna, then the microstrip patch antenna are the best for such a requirement. Weather you need to integrate it with strip-line printed networks or be it any active device, microstrip patch antennas are much sought after. The most extensively used microstrip designs are the rectangular and circular patch. The age of miniaturization has brought in several advances in design of conformal microstrip patch antennas. These antennas have recently become very popular due to their various properties that win over other antenna designs overcoming several of its own disadvantages.

2.1. Introduction

A microstrip patch antenna is used for generally narrowband applications. It has a wide-beam which is made by etching the design pattern on the metallic surface over a dielectric insulating base. A continuous metal layer in the opposite side of the strip forms the ground plane.

Microstrip patch antennas can be found in many shapes as shown in figure 2.1. Common shapes are regular like square, rectangular, circular, triangular etc. but in fact any irregular but continuous shape is possible. Regular shapes are generally chosen because of ease of analysis, ease of fabrication, attractive radiation characteristics and low cross radiation properties. Instead of dielectric substrate, dielectric spacers are used so that the structure becomes less rugged but a wide bandwidth.

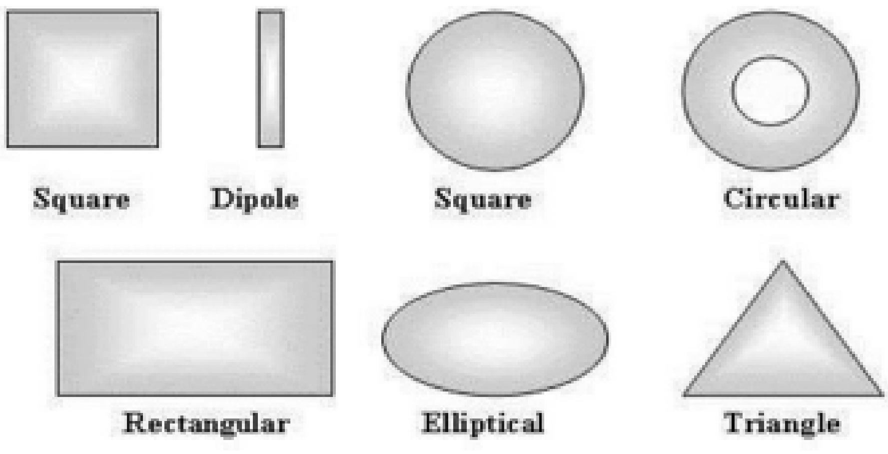


FIGURE 2.1: Different shapes of Microstrip Patch Antenna

2.1.1. Advantages and Disadvantages

The low-profile nature and its compatibility with embedded systems in wireless devices like mobile phones, PDAs etc. has immensely popularized microstrip patch antennas. In warfare antennas need to be placed over missiles for communication and telemetry. Such antennas need to be thin and conformal which can be only made possible by microstrip patch antenna. Apart from many advantages Microstrip patch antennas suffer from far more drawbacks in comparison to conventional antennas. Some of the advantages and disadvantages are compared in the table below.

S. NO	ADVANTAGES	DISADVANTAGES
1. 2	Low profile planar configuration that can be easily made conformal to host . surface	Low efficiency
2. 3	Low fabrication cost, hence can be . manufactured in large quantities.	Low Gain
3. 4	Supports both, linear as well as . circular polarization.	Extraneous radiation from feeds and junctions.
4. 5	Can be easily integrated with microwave integrated circuits . (MICs).	Poor end fire radiator except tapered slot antennas
5. 6	Capable of dual and triple frequency . operations.	Low power handling capacity.
6. 7	Mechanically robust when mounted . on rigid surfaces	Surface wave excitation.

TABLE 2.1: Advantages and Disadvantages of Microstrip Patch Antenna

2.2. FEEDING TECHNIQUES

Microstrip patch antennas suffer an increasing loss in radiated wave with increasing substrate thickness. Substrate is expected to be thick for larger bandwidth. This unwanted surface wave power loss gets scattered and causes degradation of antenna radiation. Some other problems like low power gain and low power handling capacity can be overcome by other method Feeding Methods

Microstrip patch antennas can be fed using varieties of techniques. The feed-line can be either be in direct contact or without any contact. In direct contact, the power is fed directly to the patch using feed-line made of connecting elements like microstrip line. In indirect contact, a coupling is done between the feed-line and the radiating patch. The most popular feeding techniques used are microstrip line and coaxial probe which come under direct contact schemes and again aperture coupling and proximity coupling that come under indirect contact.

2.2.1. MICROSTRIP LINE

Here the conducting strip is attached directly to one edge of the microstrip patch as shown in the figure 2.2. The width of this strip is smaller than the patch and is conducting in nature.

Thus, it provides a planar structure for feed arrangement. It provides an ease of fabrication and simple modelling. With inset feed precision can be achieved at impedance match

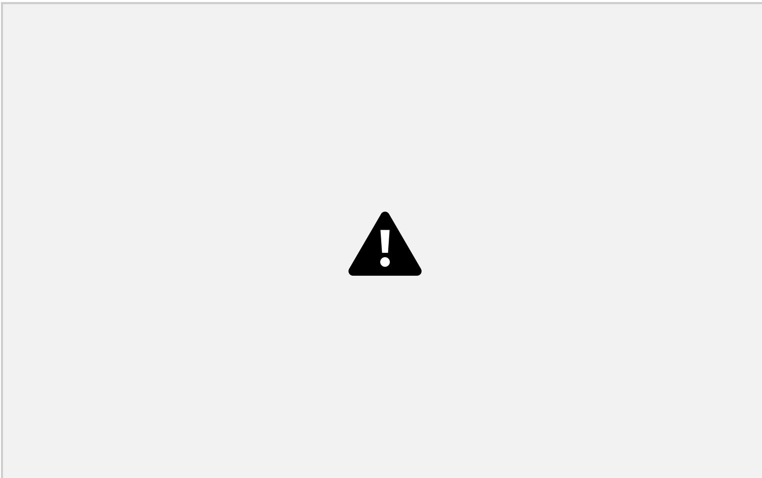


FIGURE 2.2: Microstrip Line Feeding. Here the feed radiation generally leads to spurious radiations

2.2.2. CO-AXIAL PROBE

Here, the feed is given via a coaxial cable. The inner conductor extends to the radiating patch through the dielectric and is soldered there. The outer conductor is connected to the ground plane. The most important advantage of this method is that the probe can be placed at any location inside the patch to suit the impedance matching. It is easy to fabricate and has lower spurious radiation. Modelling it is difficult and

its narrow bandwidth is generally not desired. Again, the input impedance becomes

more

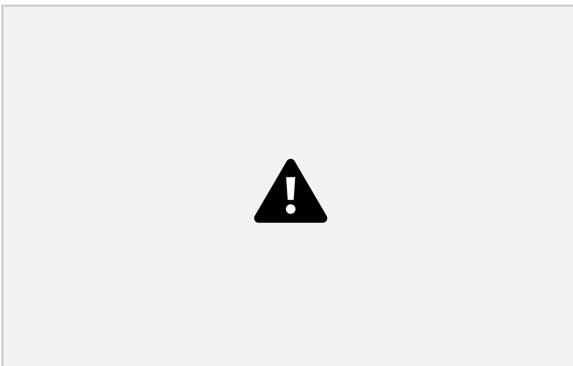


FIGURE 2.3: Microstrip Line Feeding. Here the feed radiation generally leads to spurious radiations

2.2.3. APERTURE COUPLING

Here in aperture coupling, the radiating patch and the feed-line are separated by the ground plane as depicted in the figure. The coupling is made possible through an aperture or slot in the ground plane. This slot is centered around the patch. This leads to lower cross polarization due to configuration symmetry. The shape, size and location of the slot decides the amount of coupling

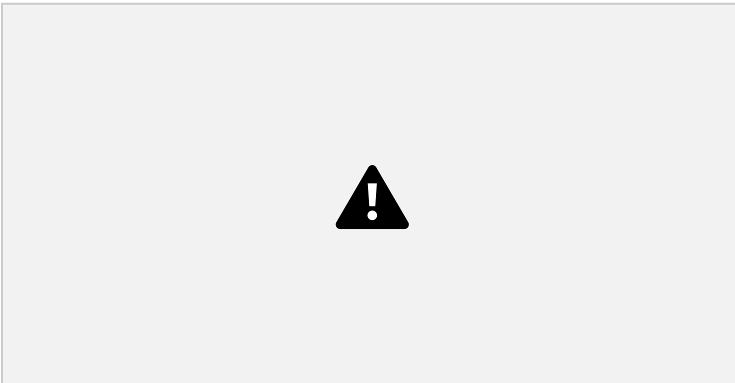


FIGURE 2.4: Aperture Coupling

2.2.4. PROXIMITY COUPLING

Proximity Coupling has two dielectric substrates. The feed-line is in between these substrates and the radiating patch is on top of the upper substrate. This technique drastically reduces any kind of spurious radiation feed thereby increasing the bandwidth as there is an overall increase the substrate thickness. We can also individually choose the different dielectric media for better performance.

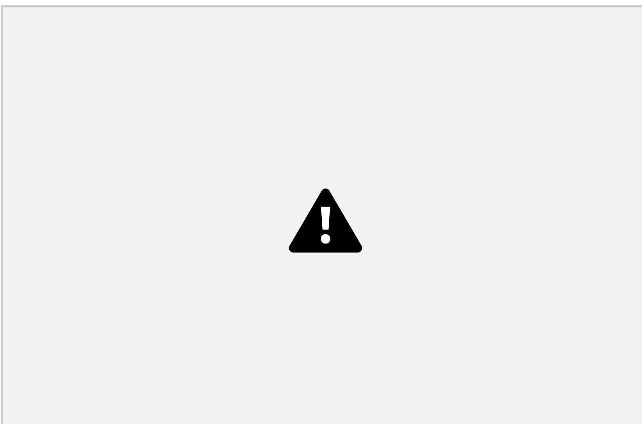


FIGURE 2.5: Proximity Coupling

2.3. Analysis Methods

The two major models used in the study of microstrip patch antennas are the transmission line model and cavity model. Transmission model is the simplest of all. Even though it is a bit less accurate, it gives an approximate physical insight. On the other hand, the Cavity Model is complex in nature. But it gives a very good physical insight and is more accurate. Another model called the Full Wave model which even though gives less insight compared to the above two models and is far more complex gives extremely accurate, versatile and can easily treat single elements, finite and infinite arrays.

2.3.1. Transmission Line Model

The transmission line model represents the microstrip antenna by two slots each of width (W) and height (h), separated by the transmission line of length (L). Microstrip is generally a non homogenous line of two dielectrics, generally the substrate and the air as seen in figure 2.6.

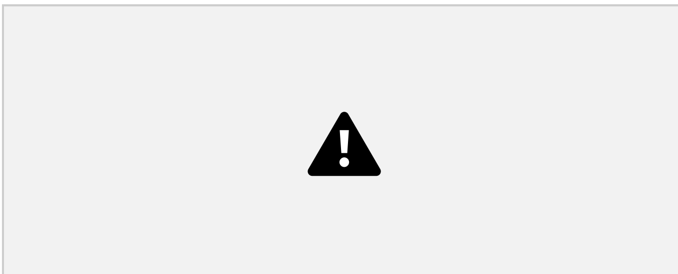


FIGURE 2.6: Microstrip Line

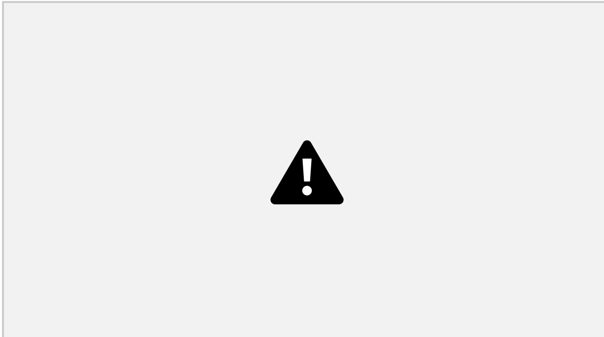


FIGURE 2.7: Electric Field Lines

We can see in figure 2.7 that most of the electric field lines lie inside the substrate and very few of them lie outside in air. Thus, pure TEM mode cannot be supported, and instead of that the quasi-TEM mode would be the dominant mode of propagation. So, to account for the fringing effects and wave propagation an effective dielectric constant (εreff) must be obtained. This value will be slightly smaller than the relative permittivity (εr) since the fringing fields around the perimeter of the patch are not confined in the substrate but are also spread.

CHAPTER-III

DESIGN AND SIMULATION OF MICROSTRIP PATCH ANTENNAS FOR 5G APPLICATION

Ansys HFSS is a high-frequency structure simulator that can be used to design and simulate high frequency electronic items. This includes: antennas, antenna arrays, RF or microwave components, highspeed 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.

Ansys HFSS Capabilities

Its dependable automated adaptive mesh refinement allows engineers to concentrate on the design, rather than spending hours figuring out the correct model mesh.

In addition, Ansys HFSS stands out from all other EM simulators due to its automation and guaranteed accuracy.

In comparison, competing EM simulators require manual user control, and numerous solutions to ensure that the generated mesh is suitable and accurate.

3.1. INTRODUCTION TO 5G

The advent of the Fifth Generation (5G) in wireless communication marks a revolutionary leap forward in the capabilities of mobile networks, promising to redefine the way we connect, communicate, and interact with technology. At its core, 5G represents a paradigm shift from its predecessors, introducing unprecedented data speeds, ultra-low latency, and the ability to accommodate a massive number of connected devices. The quest for higher data rates is a cornerstone of 5G, aiming to deliver multi-gigabit-per-second speeds that will empower users to seamlessly engage with bandwidth-intensive applications such as high-definition video streaming, augmented and virtual reality experiences, and immersive gaming. However, the transformative potential of 5G extends beyond speed alone; its ultra-low latency is a game changer, enabling real-time communication critical for applications like autonomous vehicles, remote medical procedures, and augmented reality systems.

Furthermore, 5G is not solely about individual user experiences but embraces the vision of a hyper-connected world through the Internet of Things (IoT). With its capacity for massive device connectivity, 5G forms the backbone of an intricate web where billions of devices communicate seamlessly. This connectivity goes beyond smartphones and tablets, extending to a diverse array of devices in smart homes, cities, industries, and healthcare.

In addition to speed and connectivity, 5G introduces the concept of network slicing, allowing the customization of the network to cater to different use cases. This capability ensures that the network can be tailored to meet the specific requirements of various applications, from delivering enhanced mobile broadband services to supporting massive machine-type communications and ultra-reliable low-latency communications.

As the 5G rollout progresses globally, this technology is poised to drive innovation across industries, unlocking possibilities that were once considered futuristic. Whether it's unlocking the full potential of smart cities, enabling breakthroughs in healthcare, or powering the next generation of industrial automation, 5G stands as a transformative force that will shape the future of connectivity and communication.

3.2. DESIGNING OF MICROSTRIP PATCH ANTENNA

Software part of our project involves the designing of microstrip patch antenna and analysis of various parameters of microstrip patch antenna. The software part of our project revolved around determination of the radiation pattern and return loss curve (s11 vs frequency) of several simple rectangular patch antennas. From the transmission line model of rectangular patch antennas, it is clear that the three essential parameters for the design of a rectangular Microstrip Patch Antenna are:

1) Frequency of operation (fo): The resonant frequency of the antenna must be selected appropriately.

2) Dielectric constant of the substrate (εr): A substrate with a high dielectric constant reduces the dimensions of the antenna.

3) Height of dielectric substrate (h): For the microstrip patch antenna to be used in certain applications (such as cell phones) it is essential that it is not bulky and to ensure this

the height of the dielectric substrate can't be more than a few mm.The effect of all the above 3 factors and the position of feed point on antenna performance was studied by simulating several rectangular patch antennas.

This patch is intended for cell phone applications and hence its frequency of operation was chosen to be 3.5 GHz. Its parameters are

fo=3.5 GHz

εr=4.4

h=1.6 mm

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. It has been shown that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around the periphery. Hence, for this design, the patch dimensions would be given as:

Lp= 19.987974567339

Wp= 26.082026547865

Structure of microstrip patch antenna

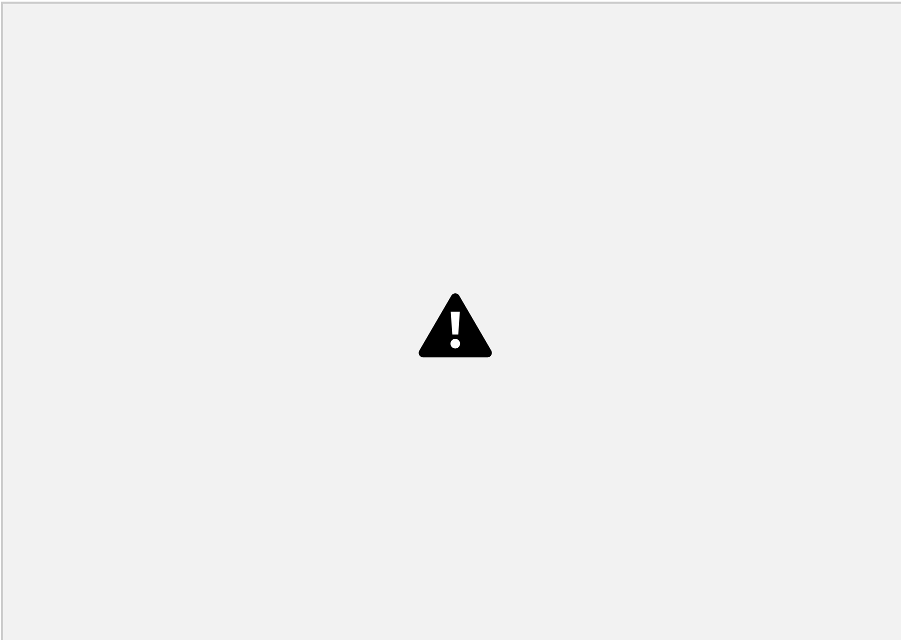


Figure 3.1: Structure of microstrip patch antenna

3.3. RESULTS

3.3.1. S11 RETURN LOSS

Figure 3.2: S11 Return Loss

3.3.2. GAIN

Figure 3.3: Gain

3.3.3. BANDWIDTH

Figure 3.4: Bandwidth

3.3.4. DIRECTIVITY

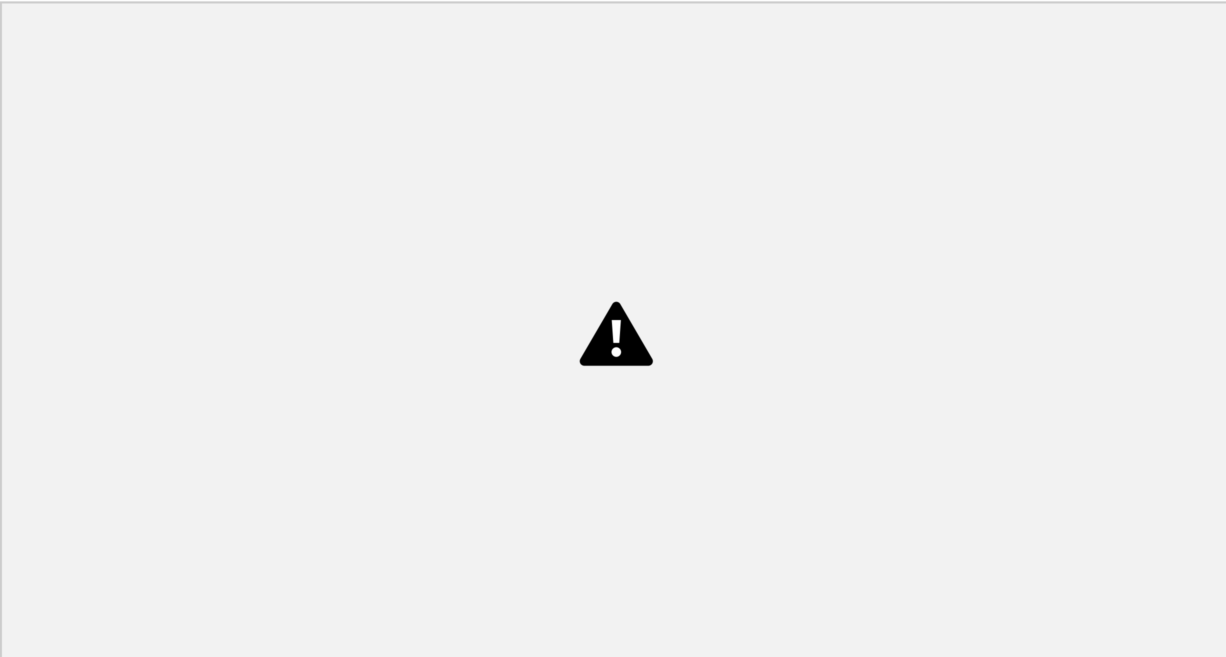


Figure 3.5: Directivity

3.3.5 RADIATION EFFICIENCY DUE TO ELECTRIC FIELD

Figure 3.6: Radiation Efficiency Due To Electric Field

3.3.5 RADIATION EFFICIENCY DUE TO MAGNETIC FIELD

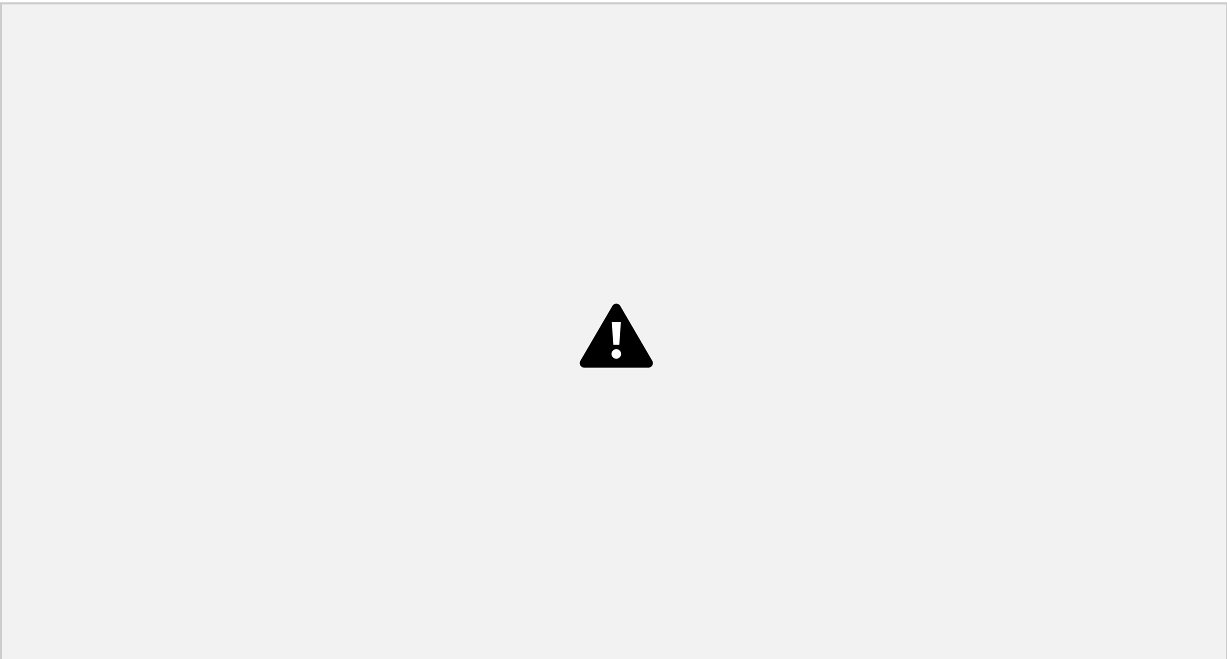


Figure 3.7: Radiation Efficiency Due To Magnetic Field

3.3.6. VSWR

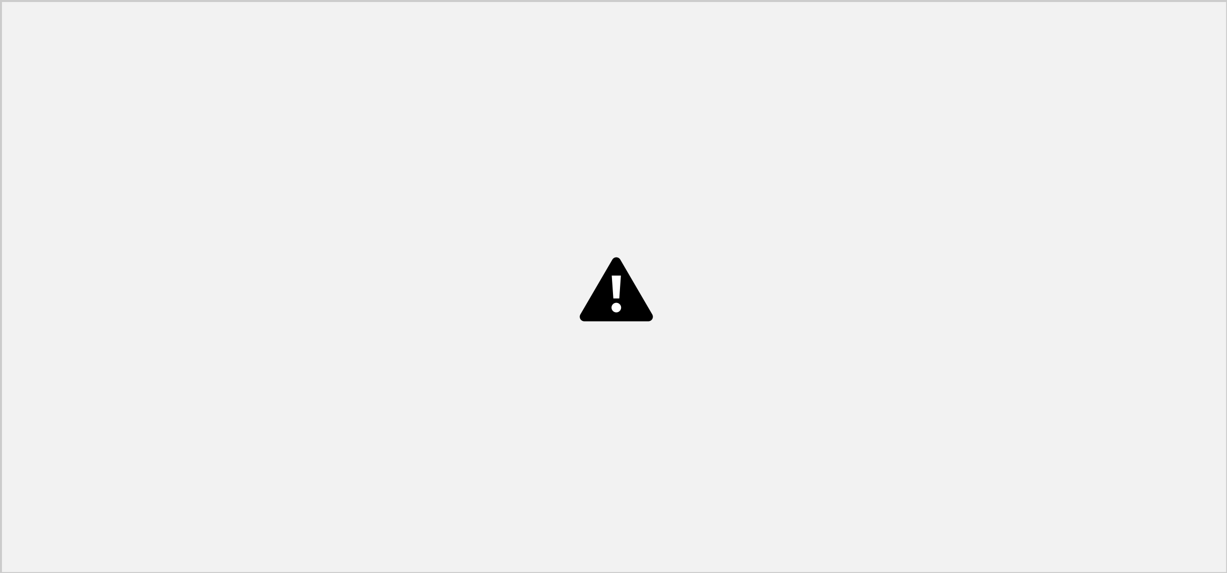
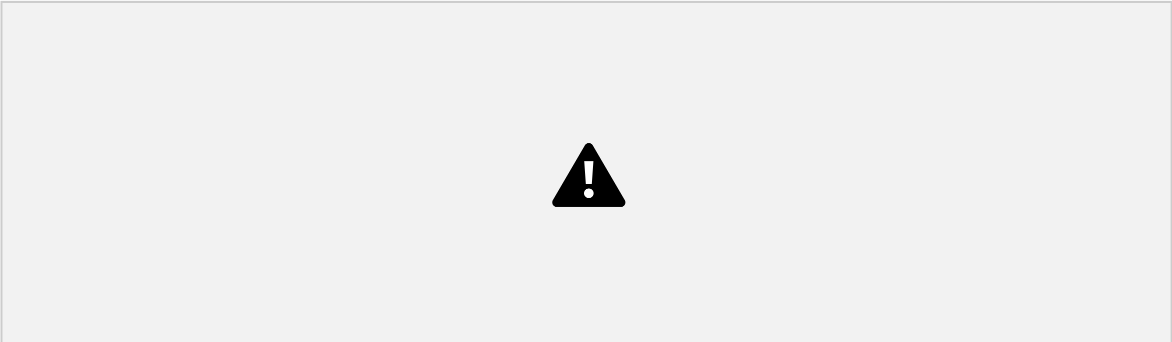


Figure 3.8: VSWR

3.3.7 VECTOR ELECTRIC FIELD



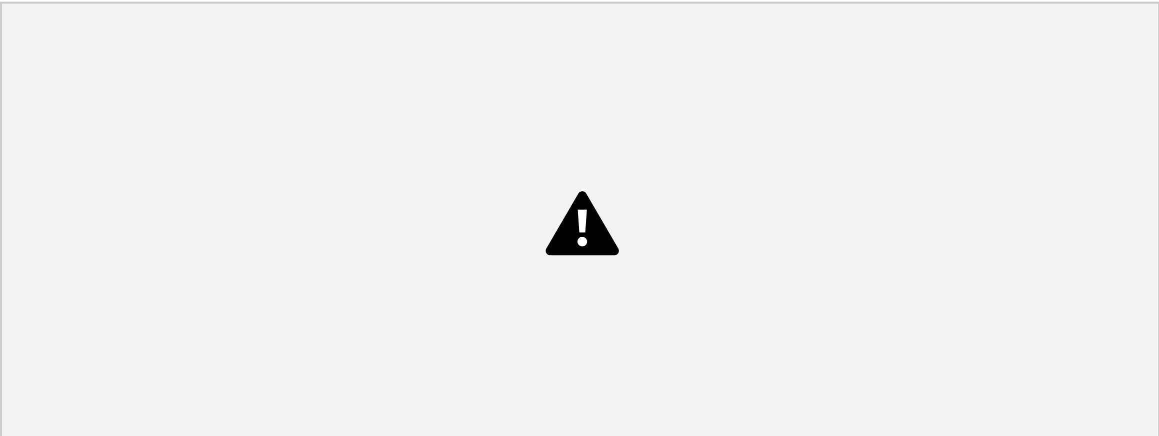


Figure 3.9: Vector electric field

3.3.7. VECTOR MAGNETIC FIELD

In this thesis work, the focus was mostly on study of methods that help in optimization of the antenna designs.

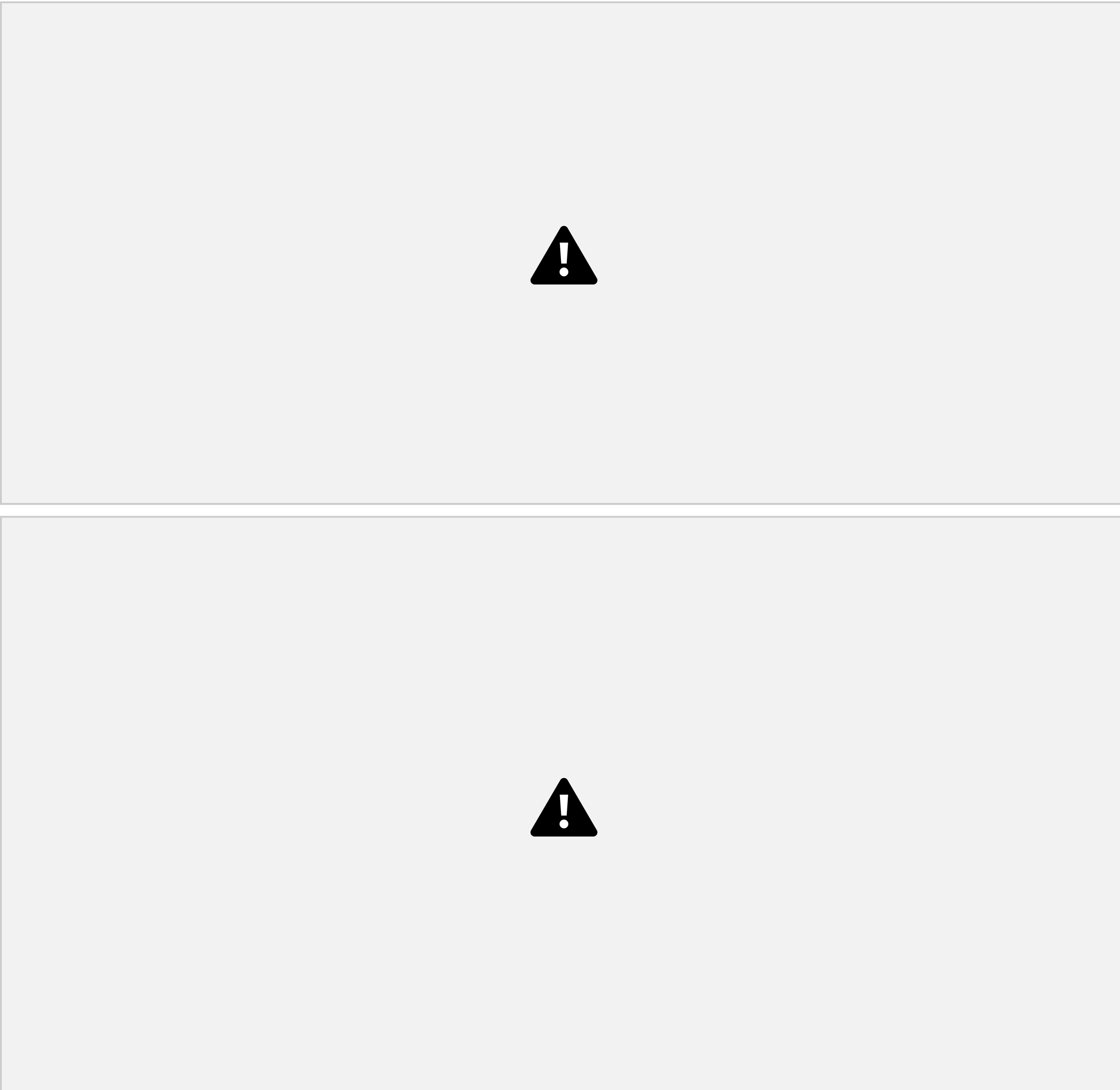


Figure 3.10: Vector magnetic field

CONCLUSION

In this thesis work, the focus was mostly on study of methods that help in optimization of the antenna designs.

The hfss will be a useful tool in visualizing the antenna parameters without involving the complicated equations, since that part will be handled in the backend.

A detailed study was done on the comparisons between conventional and metamaterial-based antenna. In this project we have achieved return loss of -16.779 dB on fr4 substrate with thickness of 1.6 mm.

A microstrip or patch antenna is a low-profile antenna that has a number of advantages over other antennas it is lightweight, inexpensive, and easy to integrate with accompanying electronics.

A detailed knowledge of Gain and Directivity is necessary in order to design a Probe Feed Patch Antenna. Choosing a substrate for antenna design also plays an important role.

In near future, various other substrate materials will be considered and the antenna characteristics will be analyzed with generalized and quantized results

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