

ANALYSIS OF EFFICIENT MICROSTRIP ANTENNA FOR WIRELESS COMMUNICATION

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

by

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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of ROHIT SOM (39130379) and AFTAB ALAM (39130012) who carried out the project entitled "**ANALYSIS OF EFFICIENT MICROSTRIP ANTENNA FOR WIRELESS COMMUNICATION**" under our supervision from Aug 2022 to Oct 2022.

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We, ROHIT SOM (39130379) and AFTAB ALAM (39130012) hereby declare that the Project Report entitled “**ANALYSIS OF EFFICIENT MICROSTRIP ANTENNA FOR WIRELESS COMMUNICATION**” done by us under the guidance of Dr. MATHAN N., M.Tech., Ph.D, Assistant Professor 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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ABSTRACT

Creating a dedicated campus network with unified connectivity, optimized services, and secure communication within a specific area is a challenge for private network operators. To deliver the increased speed, low latency, and other benefits promised by 5G, telecom system integrators, engineers, and consulting companies must have efficient 5G development tools. Altair provides integrated simulation of 5G antennas and 5G networks, that help to understand the use case, define the requirements for the 5G infrastructure, and create a usage plan to apply for the frequency spectrum. Taking a holistic simulation approach, campus network planners avoid interferences upfront and prevent radio wave leakage in surrounding areas. Ensuring the promises of reliable and efficient communications brings new challenges to the design of 5G products. 5G connectivity requires high throughput, low latency, and exceptional coverage at a reasonable cost, all while reducing energy consumption. As networks and applications grow, the precise simulation of antennas in their environment is the key to developing the next generation of broadband products. Altair 5G simulation solutions support and enable the innovation and deployment of wireless connectivity technology improving communication, assuring compatibility, and reducing energy consumption and emission.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Microstrip patch antennas play an increasingly important part in current wireless communication systems. There are many different types of antennas, some of which are folding dipole antennas, slot antennas, patch antennas, and parabolic reflectors. Each variety of antennas has its own set of characteristics as well as a particular application. We may say that antennas are the backbone of practically everything in wireless communication, without which the world could not have reached this age of technology and there are different types of applications in the current age of technology [1]. Radio frequency (RF) and wireless communication technologies are now widely utilized in everyday human activities and various industrial applications. Many wireless communication technologies have arisen in recent years, including wireless local area network, wireless interoperability for microwave access, wireless broadband, and so on. The microstrip patch antenna is a good fit for RF communication system needs, and it has poor gain, a disordered radiation pattern, and limited bandwidth [2]. Researchers and scientists have been engaged in this topic because of the extensive range of wireless applications. Many researchers have published the concept of a microstrip patch antenna, which may be produced on printed circuit boards and is a new technology in electronics [3]. These are extremely important in today's wireless communication systems. The term "antenna" is derived from the Latin word "antenna." The IEEE defines an antenna as "a component of a transmitting or receiving system designed to radiate or receive electromagnetic waves". Microstrip antennae are extremely simple to build using a traditional microstrip fabrication technique. A substrate with a higher dielectric constant must be used to design a compact microstrip patch antenna, resulting in lower efficiency. In the era of modern technology, applications of fifth-generation (5G) are growing fast. It can provide many services, such as medical treatment and remote control of industrial equipment. It also improves the safety of society ensuring security and boosts the development of the economic growth of a country. As we step into the 4th industrial revolution, the demand of people across

the world have increased to a large extent which can be served only by 5G applications.

The 5G wireless communication system has become the most significant part of our life. In our day-to-day life, all most all the devices are dependent on it. 4G systems cannot provide the demand of the people across the world due to its low speed, unstable connections, and loss of streaming capabilities. Whereas 5G is able to provide high speed, stable connections, and higher bandwidth, and most importantly, the transmission delay is much less as compared to 4G. 5G networks will be used by industries and consumers in many purposes, especially in wireless devices. A microstrip patch antenna can be a great deal for the 5G applications [4]. It can provide higher bandwidth, higher efficiency, low power consumption and high gain [5], [6]. To ensure maximum energy, high gain is a must in antenna technology. In this work, Rogers is used as a substrate as it has the capability to work at a higher frequency [7]. This work designs and analyses a microstrip patch antenna for 5G communication, which is designed to resonate at 28 GHz.

In telecommunication, a **microstrip antenna** (also known as a **printed antenna**) usually means an antenna fabricated using photolithographic techniques on a Printed Circuit Board (PCB). It is a kind of internal antenna. They are mostly used at microwave frequencies. An individual microstrip antenna consists of a patch of metal foil of various shapes on the surface of a PCB (printed circuit board), with a metal foil ground plane on the other side of the board. Most microstrip antennas consist of multiple patches in a two-dimensional array. The antenna is usually connected to the transmitter or receiver through foil microstrip transmission lines. The radio frequency current is applied (or in receiving antennas the received signal is produced) between the antenna and ground plane. Microstrip antennas have become very popular in recent decades due to their thin planar profile which can be incorporated into the surfaces of consumer products, aircraft and missiles; their ease of fabrication using printed circuit techniques; the ease of integrating the antenna on the same board with the rest of the circuit, and the possibility of adding active devices such as microwave integrated circuits to the antenna itself to make active antennas patch antenna.

The most common type of microstrip antenna is commonly known as patch antennas. Antennas using patches as constitutive elements in an array are also

possible. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate, such as a printed circuit board, with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. Some patch antennas do not use a dielectric substrate and instead are made of a metal patch mounted above a ground plane using dielectric spacers; the resulting structure is less rugged but has a wider bandwidth. Because such antennas have a very low profile, are mechanically rugged and can be shaped to conform to the curving skin of a vehicle, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices.

Microstrip antennas are relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry. They are usually employed at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength at the resonant frequency. A single patch antenna provides a maximum directive gain of around 6-9 dBi. It is relatively easy to print an array of patches on a single (large) substrate using lithographic techniques. Patch arrays can provide much higher gains than a single patch at little additional cost; matching and phase adjustment can be performed with printed microstrip feed structures, again in the same operations that form the radiating patches. The ability to create high gain arrays in a low-profile antenna is one reason that patch arrays are common on airplanes and in other military applications.

Such an array of patch antennas is an easy way to make a phased array of antennas with dynamic beamforming ability.

An advantage inherent to patch antennas is the ability to have polarization diversity. Patch antennas can easily be designed to have vertical, horizontal, righthand circular (RHCP) or lefthand circular (LHCP) polarizations, using multiple feed points, or a single feed point with asymmetric patch structures. This unique property allows patch antennas to be used in many types of communications links that may have varied requirements.

The most commonly employed microstrip antenna is a rectangular patch which looks like a truncated microstrip transmission line. It is approximately of one-

half wavelength long. When air is used as the dielectric substrate, the length of the rectangular microstrip antenna is approximately one-half of a free-space wavelength. As the antenna is loaded with a dielectric as its substrate, the length of the antenna decreases as the relative dielectric constant of the substrate increases. The resonant length of the antenna is slightly shorter because of the extended electric "fringing fields" which increase the electrical length of the antenna slightly. An early model of the microstrip antenna is a section of microstrip transmission line with equivalent loads on either end to represent the radiation loss.

The dielectric loading of a microstrip antenna affects both its radiation pattern and impedance bandwidth. As the dielectric constant of the substrate increases, the antenna bandwidth decreases which increases the Q factor of the antenna and therefore decreases the impedance bandwidth. This relationship did not immediately follow when using the transmission line model of the antenna, but is apparent when using the cavity model which was introduced in 1973 by Itoh and Mitra. The radiation from a rectangular microstrip antenna may be understood as a pair of equivalent slots. These slots act as an array and have the highest directivity when the antenna has an air dielectric and decreases when it is replaced by a dielectric substrate with increasing relative permittivity.

The half-wave rectangular microstrip antenna has a virtual shorting plane along its centre. This may be replaced with a physical shorting plane to create a quarter-wavelength microstrip antenna. This is sometimes called a half-patch. The antenna only has a single radiation edge (equivalent slot) which lowers the directivity/gain of the antenna. The impedance bandwidth is slightly lower than a half-wavelength full patch as the coupling between radiating edges has been eliminated.

Another type of patch antenna is the planar inverted-F antenna (PIFA). The PIFA is common in cellular phones (mobile phones) as a built-in structure. These antennas are derived from a quarter-wave half-patch antenna. The shorting plane of the half-patch is reduced in length which decreases the resonance frequency. It offers a low profile and also with acceptable SAR properties. This antenna resembles an inverted F, which explains the PIFA name. It is popular as a compact antenna with an omnidirectional pattern.

Often PIFA antennas have multiple branches to resonate at the various cellular bands. On some phones, grounded parasitic elements are used to enhance the radiation bandwidth characteristics. The folded inverted conformal antenna (FICA) has some advantages with respect to the PIFA, because it allows better volume reuse.

Defected Ground Structure (DGS)-integrated microstrip patch has been popular for multiple purposes. This technique introduces a limited number of small-sized slots, termed as 'defects' on the ground plane beneath the patch, and is potentially capable of improving its far-field as well as near-field properties. This was conceived and introduced in 2005 by Guha to control the cross-polarized radiations without involving any extra component, volume, weight, or cost. The technique is advanced enough to reduce cross-polarized radiations even over the diagonal-planes of a microstrip patch. DGS-technique is equally effective in reducing the mutual coupling in large microstrip arrays and hence mitigating the scan blindness issue of the radar beams. The DGS technique is found to be highly attractive in airborne applications.

CHAPTER 2

LITERATURE SURVEY AND OBJECTIVES

2.1 LITERATURE SURVEY

Patch antennas have a very important function to fulfil in the world of wireless communication networks that we live in today. The building of a microstrip patch antenna is fairly straightforward and it employs a microstrip fabrication method that is more commonly used. The patch can be configured in any way imaginable; however, the rectangular and circular configurations are the ones that are used the most frequently. These patch antennas are put to use in the simplest way possible for the broadest range of applications that are also the most demanding [1]. This section discusses the technical work of different papers of microstrip patch antennas. A broadband elliptical-shaped slot antenna that can be used for future wireless applications of the 5G is proposed in this article [8]. The suggested antenna for 5G communication achieves a broadband impedance bandwidth of greater than 67 percent (from 20 GHz to beyond 40 GHz) at S11 values of less than -10 db. The bandwidth that was accomplished is sufficient to span both of the forthcoming 5G bands (28/38 GHz). The suggested antenna possesses almost omnidirectional patterns, relatively flat gain, and good radiation efficiency across the frequency band, with the exception of the band that would be rejected. In this study, [9] different designs for rectangular microstrip antennas are presented. One of the typical frequencies for 5G communications is 28 GHz and these antennas all operate at that frequency. In order to achieve more accurate impedance matching, an array arrangement makes use of a corporate feeding network. It enhances performance factors such as returns loss characteristics, impedance bandwidth, gain, and radiation pattern. Other performance metrics that benefit from this are gain and directivity. In conclusion, this eight-element microstrip patch array that has been proposed along with its modified corporate feeding is an excellent option for potential future 5G applications.

This article presents a dual-band printed slot antenna as a potential solution for 5G mobile network infrastructure in the future. The suggested antenna offers almost omnidirectional patterns, relatively flat gain, and good radiation efficiency across the entire frequency band, with the exception of the band that would be

rejected. The suggested dual-band antenna has been shown to have a dual-band response for the 5G system at both 28 and 38 GHz, as shown by the results of simulations. An L-shaped slot is etched out in the feed line to form a notched band in the frequency range of 30-35 GHz. This is done to limit the amount of interference that occurs between the 5G system and other applications. The dual-band antennas that are being considered have a gain of up to 7 dBi, although there is a significant decrease in the notched-frequency band near 31 GHz. The investigations conducted in this study focused on utilizing a wide variety of microstrip antenna configurations. Antenna performance can be evaluated based on several critical characteristics, including return loss, voltage standing wave ratio (VSWR), bandwidth, resonant frequency, and gain. A return loss of less than -10 dB is considered to be an outstanding value. The value range of VSWR that is taken into consideration is 1-2. CST microwave studio is a cutting-edge software application that enables users to create and evaluate a wide variety of antennas, filters, and other types of devices. For use in 5G communication applications, the study describes a high-gain linear 1.4 antenna array that is constructed utilizing a circular slotted patch. The suggested antenna has been developed for a frequency of 28 GHz and is capable of supporting TM₁₁ as a fundamental mode when it is tuned to resonance. The concept of the proposed antenna has been validated through the use of a vector network analysers (VNA) and an anechoic chamber to characterize the prototype of the antenna. The suggested array antenna has a central frequency of 28 GHz, a return loss of 16 dB, and an impedance bandwidth of 10 dB that spans 10 percent of the mili meter-wave band between 24.6 and 27.24 GHz. Research by Al-Gburi et al. 3.5 GHz hexagonal microstrip patch antennas are designed and simulated. Four types of antennas, from single elements to 1×8 arrays, were simulated using CST software. The proposed 1×8 array antenna has a microstrip feed line. Its directional radiation helps the base station provide high-quality, high-capacity network connectivity. This antenna is for long-distance point-to-point connections. The final antenna had a 6.938 dB gain at 3.5 GHz and a -10 dB return loss.

According to the research paper, the antenna operates at 27.97 GHz and has a directivity of 7.6 dB, a bandwidth of 1.06 GHz, 7.5 dB, and a reflection coefficient of -20.95 dB. Additionally, its efficiency is 99.98%. An investigation into the design of patch antennas for use in 5G wireless communication systems is provided here.

In this study, a microstrip patch antenna serves as a communication device that is examined for one-band and dual-band communication at higher frequencies. This research was carried out in the United States (mm-waves). This is a dual-band version of the U-shaped slotted microstrip patch antenna with working bands of 28 GHz and 38 GHz. The Rogers RT 5880 material, which has a dielectric constant of 2.2, was utilized across the entirety of the antenna substrate during the design process. At a frequency of 28 GHz, the antenna had a return loss of -32 dB, while at a frequency of 38 GHz, it was -40 dB. Simulations showed that the proposed dual band would have a gain of 7.92 dB at 38 GHz and 6.7 dB at 28 GHz. For the purpose of mm Wave wireless communication, a square-slotted microstrip patch antenna with a resonance frequency of 37 GHz is presented in this study [16]. The radiating patch is loaded atop the antenna, which comprises of an H-slot and an inverted T-slot. Using the electromagnetic simulation software CST microwave studio, the suggested antenna has been built and investigated on the Rogers RT5880 substrate, which has a relative permittivity of 2.2 and a loss tangent of 0.0009, respectively. A minimal return loss of -43.05 dB, a gain of 8.18 dB, and an impedance bandwidth of 16.22 percent were found to exist at the resonant frequency of 37 GHz in this paper's findings. In this paper [17], a 1×2 array microstrip rectangular patch antenna consisting of two elements is designed. The patch on the antenna is 19.5 mm by 26.5 mm, and it has a frequency of 3.5 GHz and array size of 1×2. The design of the antenna is created in a simulation that operates at a frequency of 3.5 GHz; the substrate material is made of flame retardant (FR) 4, which has a constant of 4.3, and the patch materials are built of copper. The frequency at which the simulation operates is 3.5 GHz. This article presents [18] the design and analysis of a microstrip patch antenna for use in 5G applications that operate in the frequency range of 24.5 to 50 GHz for 5G waves. using high frequency structure simulator (HFSS) software, a simulation and analysis of this design have been performed. The proposed antenna was successful in resonating at three different frequencies: 31 GHz, 34.2 GHz, and 38.4 GHz by employing slotting techniques with favourable return loss, favourable gain, and VSWR less than This concept is beneficial for establishing wireless communications and gaining access to the internet at a fast speed

Lilin Wang, Fangfang Fan, Kai Qin(2020) determines that a broadband miniaturized dual-polarized base station antenna for 5G application is proposed in

this paper. The working frequency completely covers the 5G Sub-6 GHz frequency band (3300-3600 MHz). The antenna achieves $\pm 45^\circ$ dual-polarization by two coaxial lines for feeding and a pair of T-coupled feeding structures placed vertically. The radiation patch is composed of two bent dipoles placed orthogonally, which reduces the size of the antenna radiator effectively. In addition, the antenna uses the double-layer PCB structure and the rectangular patch on the top layer makes the antenna better matched. The relative impedance bandwidth is 53% (2.41 GHz-4.14 GHz) when the return loss is less than -10dB. The antenna gain reaches 10.1dBi at 3.45 GHz and the port isolation is greater than 23dB. Meanwhile, the cross polarization level is below -23dBi. The antenna has the advantages of miniaturization, wide bandwidth, high gain and high polarization purity. A miniaturized wideband dual-polarized base station antenna is presented in this paper. From the results of the simulation, we can see that the antenna's $|S_{11}|$ is less than -10dB and the port isolation is greater than 23dB in the band of 2.41GHz-4.14GHz. The working frequency range of this antenna completely covers the 5G band from 3.3GHz to 3.6GHz. Compared with other base station antenna units, this antenna has a better performance in the operating frequency band, such as miniaturization, wide frequency band, high gain, high isolation and high polarization purity. Therefore, the antenna can be applied as a dual-polarized base station antenna in 5G system.

Ding-Liang Wen, Dong-Ze Zheng, and Qing-Xin Chu(2016) determines that a $\pm 45^\circ$ dual-polarized base station antenna with a planar structure is proposed for 2G/3G bands. The $+45^\circ$ antenna and the -45° antenna share the same radiator, which is composed of four folded dipoles and four coplanar striplines. The coplanar striplines work as $\lambda/4$ impedance transformers. Two Y-shaped feeding lines is designed to obtain a good impedance matching and a planar reflector is employed to achieve a stable radiation pattern. The antenna element has a wide impedance bandwidth of 27.8% with $SWR < 1.5$ (1.7-2.25 GHz), and a stable radiation pattern and a high cross polarization discrimination (XPD) are also obtained across its operating frequency band. Also, an antenna array that consists of ten elements is developed for base station applications. The array is proposed for electrical downtilt and the downtilt angle is designed from 0° to 8° . The measured results show that a wide bandwidth of 30% (1.7-2.3 GHz), a great port-to-port isolation (>30 dB), a stable radiation pattern with 3-dB beamwidth $65^\circ \pm 5^\circ$ in the horizontal plane, a high XPD and a high front-to-back ratio were achieved. A broadband $\pm 45^\circ$ dual-polarized

planar antenna element using four folded dipoles and its ten-element antenna array with electrical downtilt of the antenna beam covering 2G/3G bands have been designed, fabricated, and measured. The measurement shows that both of them have a good antenna performance over their operating frequency bands, i.e., good impedance matching, high port-to-port isolation, stable 3-dB beamwidth, stable antenna gain, high XPD, and high FTBR. Moreover, when the degree of electrical downtilt of the antenna array is increased, its radiation patterns in the horizontal plane still keep stable. Because of all these good antenna performances, the proposed antennas should find many applications in modern cellular mobile communications.

Mingjian Li and Kwai-Man Luk (2015) determines that a new +45° dual-polarized magnetoelectric dipole antenna is proposed. The antenna is excited by two T-shaped probes placed at a convenient location. The measured overlapped impedance bandwidth is 48% with standing-wave ratio (SWR) <1.5 from 1.69 to 2.76 GHz. The measured gains vary from 7.6 to 9.3 dBi and from 7.6 to 9.4 dBi for port 1 and port 2, respectively. The isolation between the two ports is larger than 30 dB. The proposed antenna achieves a low cross-polarization level of less than -21 dB and a low back radiation level of less than -29 dB over the operating frequency range. With a broadband 90 degree phase shifter and a power divider, the proposed antenna can radiate circularly-polarized (CP) wave and exhibit a wide impedance bandwidth (SWR < 2) of 90% from 1.23 to 3.23 GHz, which covers the whole 3-dB axial-ratio (AR) bandwidth of 82% from 1.28 to 3.05 GHz. In this operation frequency band, the proposed CP antenna has a broadside gain of larger than 5 dBi above 1.45 GHz. Considering the common overlapped bandwidth limited by the impedance, AR, and gain, the proposed antenna exhibits an effective bandwidth of 71%. A novel broadband -45° dual-polarized antenna composed of four square metallic plates, four rectangular metallic posts, two orthogonal -shaped probes, and a box-shaped reflector has been designed. Measured results revealed that the proposed antenna exhibited an overlapped impedance bandwidth of 48% with SWR < 1.5 from 1.69 to 2.76 GHz and broadside gains of 7.6-9.3 dBi and 7.6-9.4 dBi for port 1 and port 2, respectively. The isolation between the two ports was more than 30 dB. Measured radiation patterns with FBRs of over 29 dB and cross-polarization level of less than -21 dB were achieved. By simply adding a feed circuitry, the proposed antenna was excited with a wideband CP radiation. The

antenna operating bandwidth with $SWR \leq 2$, $AR \leq 3$ dB and gain 9.5 dBi was 71% from 1.45 to 3.05 GHz. The dual-polarized and CP antennas find applications in various mobile and wireless communications.

Qing-Xin Chu and Yu Luo (2013) determines that A broadband multi-dipole antenna with stable beamwidth is presented. Through a rational design of position of dipoles and a reflector, an antenna with a wide impedance bandwidth, stable radiation pattern and nearly identical E- and H-planes is achieved. A laboratory model has been characterized experimentally. Experimental results agree well with simulations. Results show that an impedance bandwidth of 59.7% for $SWR < 2$ from 1.55 to 2.87 GHz was achieved. Stable radiation pattern with 3 dB beamwidth 63.3 ± 2.9 degree at H-plane and 63.4 ± 2 degree at E-plane and an antenna gain of 9 ± 0.6 dBi was found over the operating frequencies. A wideband multi-dipole antenna composed of two long dipoles, two short dipoles and a reflector with a pair of sidewalls has been investigated. A prototype with center frequency of 2.2 GHz was designed, fabricated, and measured. More than 59.7% impedance bandwidth for , a gain of 9 ± 0.6 dBi and very stable radiation patterns has been achieved. The beamwidth is around 63.3 degree at E-plane and 63.4 degree at H-plane. Because of these excellent features, the antenna should find wide applications in the modern wireless communication systems.

Guihong Li, Huiqing Zhai, Member, IEEE, Long Li, Senior Member, IEEE, Changhong Liang, Senior Member, IEEE, Rongdao Yu, and Sheng Liu (2014) determines that Wideband indoor base station antenna (operating at 5.8 GHz WLAN and 5.5 GHz WiMAX), loaded with artificial magnetic conductor (AMC), is proposed for multiple-input multiple-output (MIMO) system. The MIMO system has sixteen elements, and each element has a pair of folded dipoles, fed by a coupling E-shape microstrip feedline. Periodical AMC surfaces are introduced underneath the dipole elements to achieve unidirectional radiation and low profile. They also contribute to antenna miniaturization and bandwidth enhancement. The MIMO system has the advantages of wide bandwidth, good isolation, enhanced radiation, and low correlation, all within a compact volume. The MIMO array was fabricated and tested, and the results are in good agreement with those of the simulations. A compact two-/sixteen-element MIMO antenna array is proposed in this presentation for indoor base station applications. The MIMO array element employs a pair of

inside folded dipoles for antenna miniaturization. A coupling E-shape microstrip feedline was utilized in the element to provide good matching. Enhanced front radiation pattern and restrained back lobe were obtained by introducing AMC surface underneath the elements. The AMC surface also plays a key role in antenna miniaturization, bandwidth enhancement and low profile. The simulation and measurement results of the MIMO arrays indicate that good isolation and low correlation can be achieved to the satisfaction of WLAN/WiMAX standards.

YueHui Cui, RongLin Li, *Senior Member, IEEE*, and Peng Wang determines that A novel dual-broadband planar antenna is proposed for 2G/3G/LTE (4G) mobile communications. The proposed dual-broadband antenna consists of one element for the lower band and two elements for the upper band, making it possible to be arrayed without appearance of grating lobes in the upperband. The lower-band element comprises a pair of printed dipoles with a pair of parasitic elements for bandwidth enhancement. Two upper-band elements composed of two pairs of folded dipoles are nested inside the lower-band element, forming a compact arrayable antenna unit. The dual-broadband antenna achieves a bandwidth of 20% (800-980 MHz) for the lower band and a bandwidth of 60% (1540-2860 MHz) for the upper band. A dual-broadband antenna array that consists of 4 elements for the lower band and 8 elements for the upper band is developed for base station applications. The dual-broadband array achieves a bandwidth of 22% (780-980 MHz) for the lower band and a bandwidth of 68% (1470-3000 MHz) for the upper band, covering all the frequency bands for 2G/3G/LTE (4G) systems. Measured antenna gains for the array are dBi for the lower band and dBi for the upper band, suitable for potential applications in mobile communication base stations. A dual-broadband antenna consisting of a lower-band element and two upper-band elements is developed. The upper-band elements are nested inside the lower-band element, forming a compact arrayable antenna unit. The dual-broadband antenna unit is arrayable and can operate as a base station antenna element over the frequency ranges 800-980 MHz and 1540-2860 MHz. A 4-element array operating over 780-980 MHz and an 8-element array operating over 1470-3000 MHz were built and measured to demonstrate their potentials as base station antennas for 2G/3G/LTE (4G) mobile communications. The dual-broadband antenna array has a planar configuration, suitable for low-cost manufacturing.

Yu_±Luo, Qing-Xin Chu, and Ding-Liang Wen (2016) determines that A novel method of enhancing cross-polarization discrimination (XPD) of a $+45^\circ$ dual-polarized base-station antenna, by addition of four parasitic elements placed in a square contour, is presented. First, it was established that high XPD at the broadside can be obtained by addition of four parasitic elements around a simple $+45^\circ$ dual-polarized base-station antenna. Second, we investigated the principle of wide beamwidth high XPD after studying magnitude currents on parasitic element, spacing between parasitic elements and length of parasitic elements. Finally, a 45° dual-polarized base-station antenna was designed, fabricated and measured. Measurement results are in good agreement with the results of simulation in terms of radiation pattern, gain, and Voltage Standing Wave Ratio (VSWR). In particular, the enhanced XPD is more than 20 dB at the boresight and more than 10 dB within 60° of the main lobe at the horizontal plane. A method to improve XPD for 45° dual-polarized base-station antenna, by the addition of four parasitic elements, is proposed followed accordingly by a proposal for broadband 45° dual-polarized base-station antenna. The antenna has high XPD at broadside, broadband impedance matching and stable radiation patterns. It proved to be a good candidate for base-station antennas.

Shi-Gang Zhou, *Member, IEEE*, Peng-Khiang Tan, and Tan-Huat Chio (2012) determines that A wideband dual-polarized antenna with high isolation and low cross polarization is presented. A pair of orthogonal planar printed dipoles, with a reflector ground plane, are used to obtain the two linear polarizations. Slots cut at the dipole's corners and shorted connections between the orthogonal dipoles are used to improve the isolation and cross polarization. Measured results show that the antenna achieves a from 575-722 MHz (22.7% bandwidth). The isolation between the two polarizations is better than 35 dB, and the cross-pol level is 30 dB below the co-pol level over the entire band. The overall height of the antenna is 80 mm, which is about 0.15λ at 575 MHz. A wideband dual-polarized antenna with good isolation and cross polarization has been designed, fabricated, and tested. Parameters of the antenna are also studied. The proposed antenna achieves 22.7% bandwidth for despite the overall height being only at the lowest operating frequency. The isolation between the two ports is better than 32 dB, and the cross polarization is better than 30 dB over the whole frequency band.

It has a relatively flat measured gain of about 8.0dB over the frequency band mentioned above.

Qing-Xin Chu, *Senior Member, IEEE*, Ding-Liang Wen, and Yu Luo, *Student Member, IEEE* (2015) determines that a broadband dual-polarized base station antenna is proposed for 2G/3G/LTE bands. The proposed antenna has Y-shaped feeding lines to impart a wide impedance bandwidth to it, and a rectangular box-shaped reflector to enhance its stability in radiation patterns over the operating frequencies. A prototype of the proposed antenna is designed, fabricated, and tested. The measured results show achievement of impedance bandwidth of 45% for SWR at both ports, port-to-port isolation 25 dB, astable radiation pattern with 3-dB beamwidth at H-plane and V-plane, and a stable antenna gain of 8.2 to 0.6 dBi from 1.7 to GHz. A broadband dual-polarized antenna array with five elements for the band is developed for base station application. beamwidth at H-plane at port 1 and at port 2 with SWR over the operating frequency band. Simulation results have a good agreement with measurement ones. A broadband dual-polarized antenna element with Y-shaped feeding lines and its five-element antenna array with electrical down tilt of the antenna beam covering 2G/3G/LTE bands have been designed, fabricated, and measured. The antenna element has a wide impedance bandwidth of 45% with SWR, stable 3-dB beamwidths at both H-plane and V-plane, a stable antenna gain, and a high port-to-port isolation from 1.7 to 2.7 GHz. The array has a good impedance matching with SWR, a stable antenna gain of 14.8 to 14.4 dBi at port 1 and 14.5 to 14.1 dBi at port 2 and very stable radiation patterns with 3-dB beamwidth at H-plane of at port 1 and at port 2 from 1.7 to 2.7 GHz. When the degree of electrical down tilt of the antenna beam is increased, the radiation patterns at H-plane are still keep stable. Furthermore, the antenna has a simple and compact structure and is easy to be manufactured on a large scale. Because of these advantages, the proposed antenna will find many applications in modern wireless communications.

Fuyun Li, Yuehui Cui, and RongLin Li (2015) determines that A novel broadband artificial magnetic conductor (AMC) surface is proposed for lowering the height of planar antennas. By replacing the conventional perfect electric conductor (PEC) ground plane with the AMC surface, the height of planar antenna can be significantly reduced. Three planar antennas for

LTE700/GSM900 base stations are investigated. The antenna height is lowered from $0.263\lambda_{0.83\text{GHz}}$ to $0.083\lambda_{0.83\text{GHz}}$, (where $\lambda_{0.83\text{GHz}}$ is the wavelength in free space at the frequency 0.83 GHz). The height-lowered planar antennas maintain a wide bandwidth of, e.g., 38% for a linearly polarized antenna, 35% for a dual-polarized antenna, and 46% for a circularly polarized antenna. All these planar antennas above the AMC surface have a gain of higher than 7 dBi. A broadband circularly polarized (CP) antenna with AMC is depicted in Fig. 6. The total height of the antenna is also 30 mm. The measured return loss ($-|S_{11}|$) compared with the simulated results is shown in Fig. 7. The measured bandwidth for $S_{11} < -15$ dB is 46.3% and the bandwidth for axial ratio is 37.8%.

Zengdi Bao , Zaiping Nie , Xianzheng Zong(2012) determines that A broadband dual-polarization base station antenna element for DCS/PCS/3G and 4G (certain standards) bands is presented in this paper. Simulations and measurements have shown that it has an impedance bandwidth of $\text{VSWR} < 1.4$ over 1.71GHz-2.69GHz, within which the ports isolation (PI) is better than 32dB and the cross polarization isolation (CPI)(within $\pm 60^\circ$ of the mainlobe) is low than 30dB. It has a simple and compact structure and is easy to be manufactured in large scale. For the advantages mentioned above, it could be used to form an antenna array used in wireless communication base station. As an important aspect, some key parameters those have great influences on antenna performance, including the pattern of the reflector, are discussed in this paper. The dual-polarization base station antenna element presented in this paper operates in 1.71GHz-2.69GHz frequency range which can cover the DCS/PCS/3G/4G bands. Simulated and measured results have proven that its main technique specifications can meet industrial standards very well.

Xing-Xin Guo and Qing-Xin Chu, *Senior Member, IEEE* (2013) determines that a wideband dual-polarized antenna for LTE (Long Term Evolution) communication system is presented. The antenna is excited by inverted L-shaped strip feed line. A wide impedance bandwidth operating from the frequency 1.71GHz to 2.69 GHz with Voltage Standing Wave Ratio(VSWR) less than 1.5 is achieved. The isolation of the antenna between the two input ports is over 40dB. Stable radiation patterns with low cross-polarized, low backlobe radiation and gain of 9dBi have been obtained across the entire operating frequency bands. A new wideband

dual-polarized with high isolation and low cross polarization is proposed. The isolation of the antenna is more than 40dB over the whole 1.7-2.69GHz impedance bandwidth. The gain is range from 8.5dBi to 9.8dBi over the operating bandwidth. The antenna achieves low cross polarization under -40dB and is a good candidate for LTE mobile communication system.

Daoyi Su, Jason J. Qian, *Senior Member, IEEE*, Hua Yang and Demin Fu(2005) determines that A f45 polarization diversity antenna with widebandwidth is presented in this paper. The antenna has a half-power beam width of 65 in the horizontal plane for use in wireless telecommunication base stations. Especially, a folded dipole antenna with a protruding part is used as a +45° polarization element and the another folded dipole with a concave part is used as a -45° polarization element. The protruding part and the concave part of dipoles make the two folded dipoles with the same height but not touching each other. With such a cross-pair of folded dipoles, a small polarization diversity antenna is constructed. The antenna was analyzed and optimized by the High Frequency Structure Simulation software, and a good agreement was achieved between computation and experiments on the half-power beam width in the horizontal plane.

2.2 LITERATURE SUMMARY

Creating a dedicated campus network with unified connectivity, optimized services, and secure communication within a specific area is a challenge for private network operators. To deliver the increased speed, low latency, and other benefits promised by 5G, telecom system integrators, engineers, and consulting companies must have efficient 5G development tools.

Altair provides integrated simulation of 5G antennas and 5G networks, that help to understand the use case, define the requirements for the 5G infrastructure, and create a usage plan to apply for the frequency spectrum. Taking a holistic simulation approach, campus network planners avoid interferences upfront and prevent radio wave leakage in surrounding areas.

Ensuring the promises of reliable and efficient communications brings new challenges to the design of 5G products. 5G connectivity requires high throughput, low latency, and exceptional coverage at a reasonable cost, all while reducing energy consumption. As networks and applications grow, the precise simulation of antennas in their environment is the key to developing the next generation of broadband products. Altair 5G simulation solutions support and enable the innovation and deployment of wireless connectivity technology improving communication, assuring compatibility, and reducing energy consumption and emission.

CHAPTER 3

ANTENNA DESIGN

3.1 DESIGN OF THE ANTENNA

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. Microstrip patch antennas are utilized in various application including automotive, logistics tracking, global positioning system (GPS), and microwave communication. Figure 1 shows a microstrip antenna with W as the width, L as the length, and ϵ_{eff} as the effective dielectric constant of the rectangular patch [3]. This section discusses the design and development of a patch antenna for wireless communication because it is well known that it can be mounted on a printed circuit board (PCB) for various communication devices. As a result, researchers devised different patch antenna designs for wireless applications with this in mind. IE3D, HFSS, CST, MATLAB, and other simulation software are available for designing, simulating, and analyzing microstrip antennas. Figure 2 shows the dimensions of the antenna, including the length, and width of the ground, patch, substrate, and feed line. To design, develop, and simulate the micro strip patch antenna, CST microwave studio was used. This paper used RT/Duroid5880 as the substrate material in this proposed prototype patch antenna design, which dielectric of the substrate is 2.2 and thickness is 0.3451 mm.

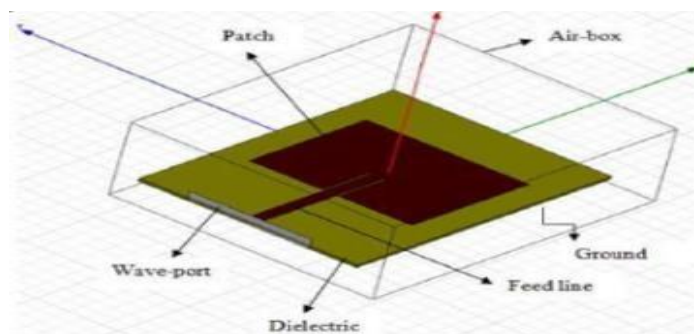


Fig 3.1 Microstrip Patch Antenna

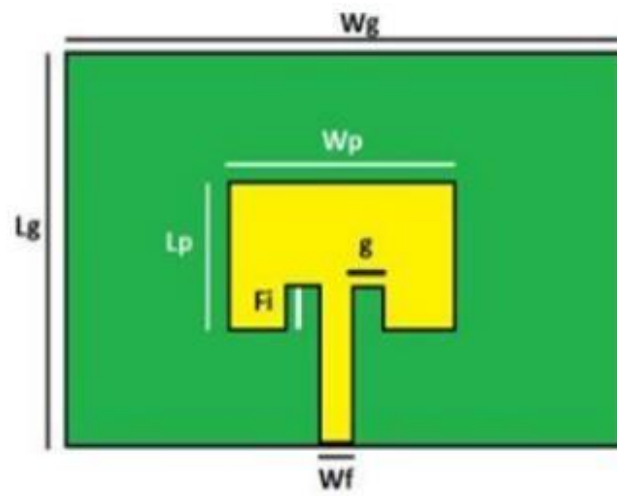


Fig 3.2 IEEE 33-Bus Radial System

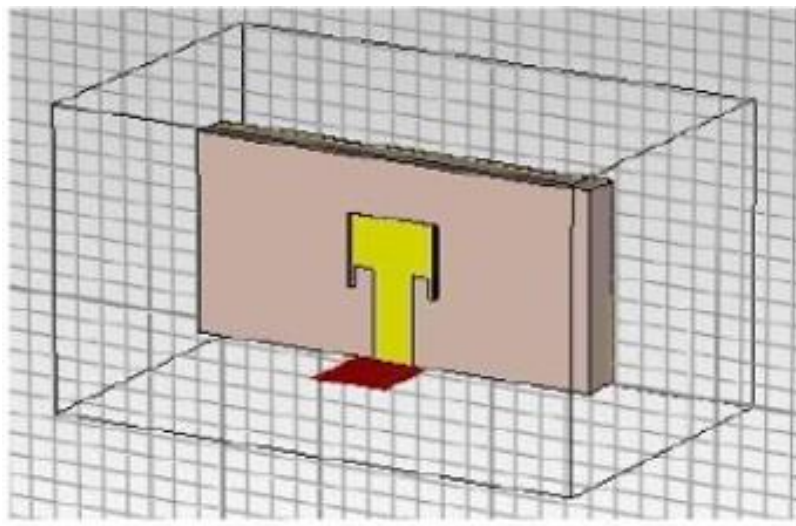


Fig 3.3 Simulation of the Microstrip Patch Antenna in CST

The following equations are used in this work to calculate the parameters [19], [20].

a. Microstrip patch antenna width

$$Wp = \frac{c_0}{2f_r \sqrt{\frac{\epsilon_r + 1}{2}}} \quad eq --- (1)$$

b. The effective dielectric constant

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left(1 + 12 * \frac{h}{w} \right)^{-1.5} \quad eq --- (2)$$

c. Extended length

$$L_{ext} = \frac{c_0}{2f_r \sqrt{\epsilon_{reff}}}$$

The following equation is used to get rid of the fringing effect, and thus actual length of the patch antenna is obtained.

$$\Delta L = 0.412 \frac{\left(\frac{w}{h} + 2.64 \right) (\epsilon_{reff} + 3)}{(\epsilon_{reff} - 2.58) \left(\frac{w}{h} + 8.13 \right)}$$

$$L = L_{ext} - 2\Delta L \quad eq --- (3)$$

A 50 ohm inset feed transmission feed line was used to connect to the patch of the antenna.

d. Feed line width

$$W_f = \frac{7.48h}{e^{\left(\frac{z_0 \sqrt{\epsilon_r + 1.41}}{87} \right)}} - 1.25t \quad eq -- (4)$$

The measurements of the antenna are included in Table 1. Both the width and the length of the ground are denoted by the notation Wg and Lg, respectively. Besides, antenna patch width , length along with height of substrate and thickness are given. The values of the various components are represented by some other parameters.

3.2 OBJECTIVES OF THE PROJECT

Due to lower latency, greater transmission speed, wider bandwidth, and the possibility to connect with greater multiple devices, fifth-generation (5G) networks are far better than 4G. In this study, a microstrip patch antenna operating at 28 GHz is investigated and modeled for future 5G communication technologies. The substrate used in this work for the antenna is Rogers RT/Duroid5880. Dielectric of the substrate is 2.2 and thickness is 0.3451 mm. HFSS software is used to simulate the antenna as it is convenient to use. From the simulation, the return loss, gain, radiation efficiency, sidelobe level was found to be -38.348 dB, 8.198dB, 77%, and -18.3 dB respectively. The result found from this simulation is better than the works took place in the past. As a result, it can be utilized as a capable candidate for 5G wireless technology. The results of this proposed antenna are superior to those of existing antennas published in recent scientific journals. As a result, it's likely that this antenna will meet the needs of 5G wireless communication systems.

CHAPTER 4

PROPOSED SYSTEM

4.1 About the Design: -

The antenna is a microstrip antenna array with a single-layer feeding structure for wireless local area network applications and WiMAX band or wireless broadband communication, and mid-band spectrum for 5G communications (4.3-4.9 GHz).

- The U-shaped and M-shaped microstrip feedlines on the same layer are employed above the ground structure, which has two rectangular slots.
- Two ports are provided along the feeding lines, which are perpendicular to each other. Port 1 and Port 2 are the input ports of the M- shaped and U-shaped microstrip feedlines, respectively.

Dimensions: -

- Substrate/antenna size- 30x40 mm
- The thickness of antenna- 2 mm

Material Used: -

- Substrate- FR4 epoxy (Relative permittivity- 4.4)
- Radiation Box- Air

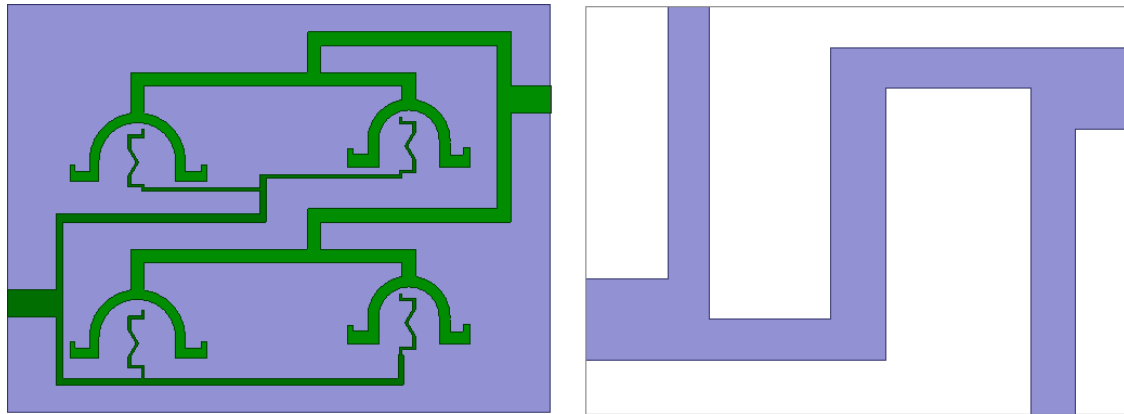


Fig 4.1 Antenna Design

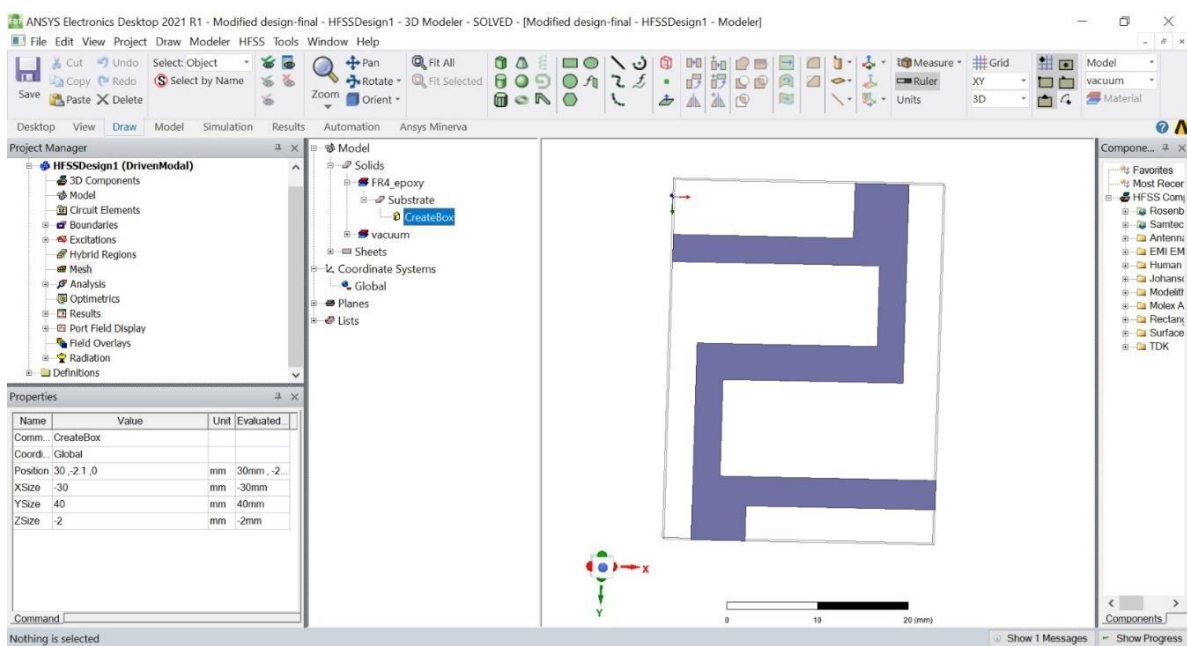


Fig 4.2 HFSS Model of Antenna

4.2 Design Specifications

TABULATION

S NO	Description	Symbol	Unit
1	Patch length	Lp	G
2	Patch width	Wp	G
3	Ground length	Lg	G
4	Ground width	Wg	G
5	Feed line length	Wf	
6	Feed line width	Wf	G
7	Substrate height	H	G
8	Substrate length	L	G
9	Substrate width	W	G
10	Substrate material	FR4 epoxy	
11	Resonant Frequency	2.3Ghz	
12	Relative permittivity	Er	4.4

4.3 Existing Methodology

- In existing methodology there is no line model MIMO is available.

4.3.1 Drawbacks of existing Methodology

- In existing methodology lot of MIMO is available, but the MIMO are strictly designed in the form of some structural basic alone not in the line basic.
- It less efficiency and takes up more power in reliable case.

4.4 Proposed Methodology

- This is impedance line modal MIMO antenna. one port is in 15ohm impedance and other port is in 75ohm port impedance so both together provide full port impedance effect in the output region.
- This antenna is perfectly matched for 5g mobile application.
- It has compact design and consume very low power to operate the antenna.

RESULTS AND DISCUSIONS



Fig 5.1 Directivity plot 1



Fig 5.2 Gain Plot 1

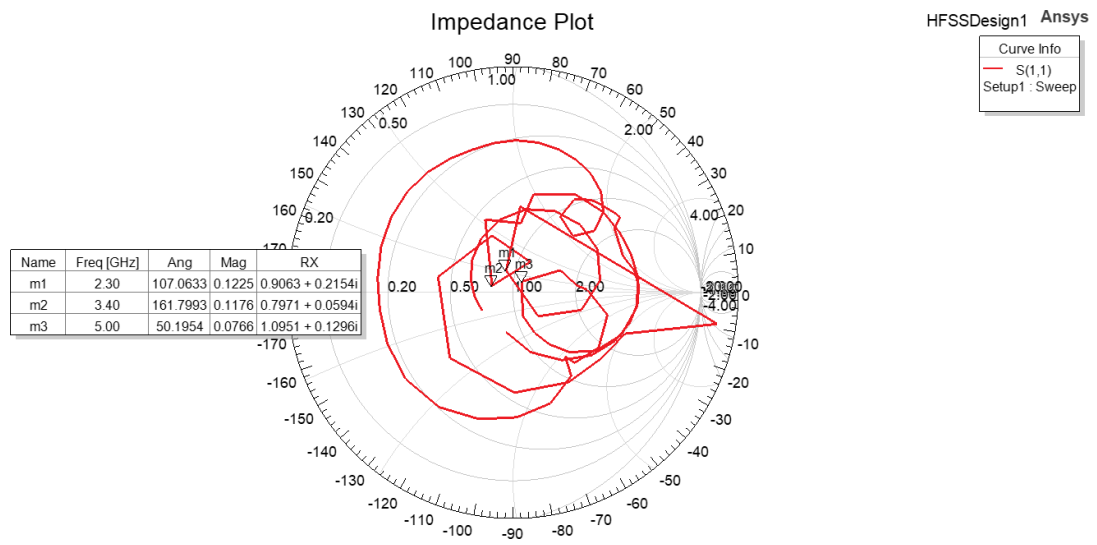


Fig 5.3 Impedance Loss Plot

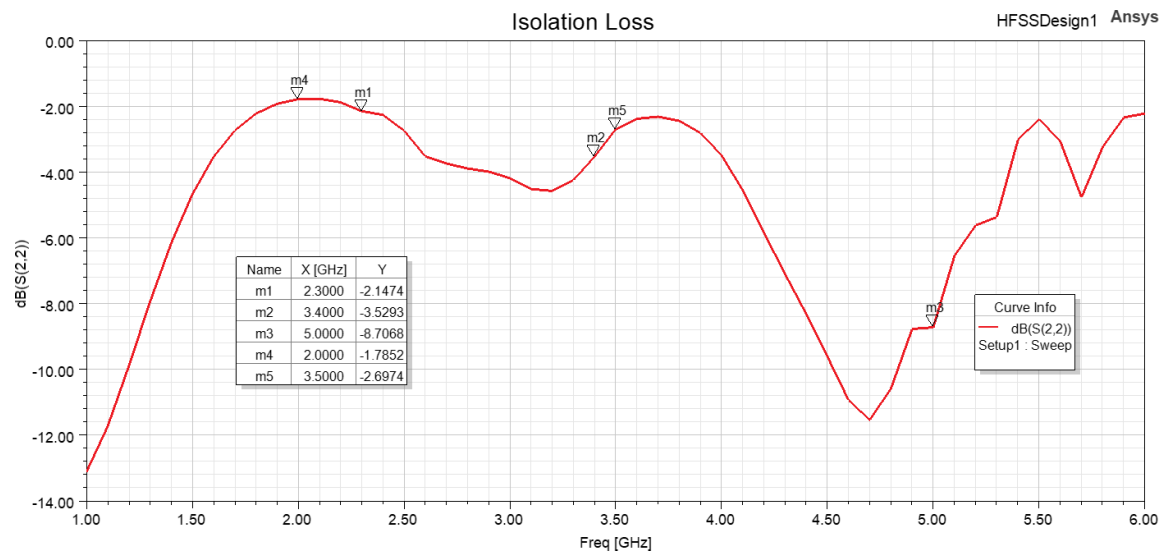


Fig 5.4 Isolation Loss Plot



Fig 5.5 S11 Return Loss Graph

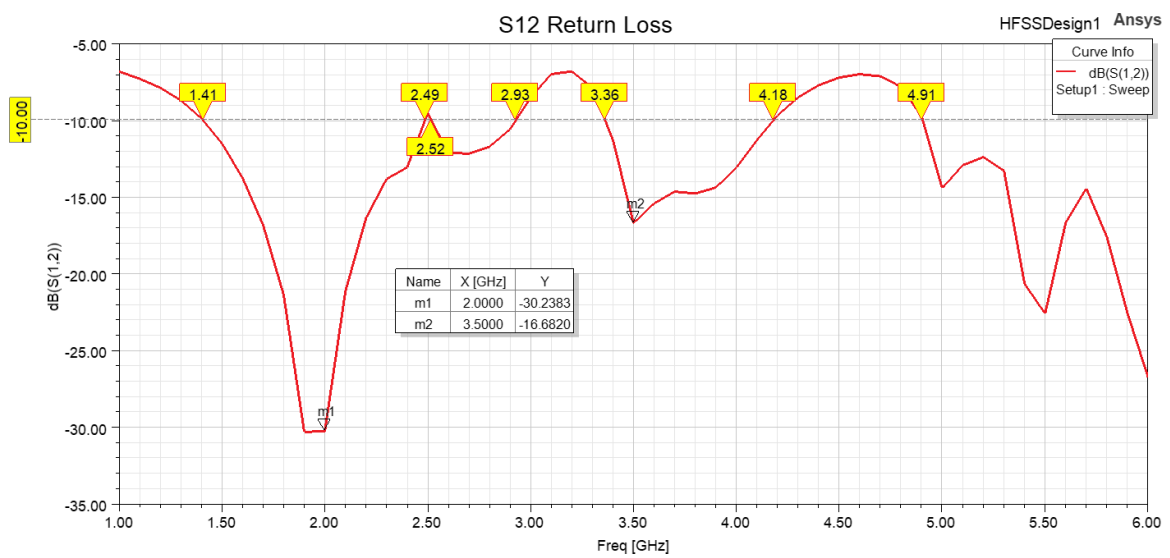


Fig 5.6 S12 Return Loss Graph

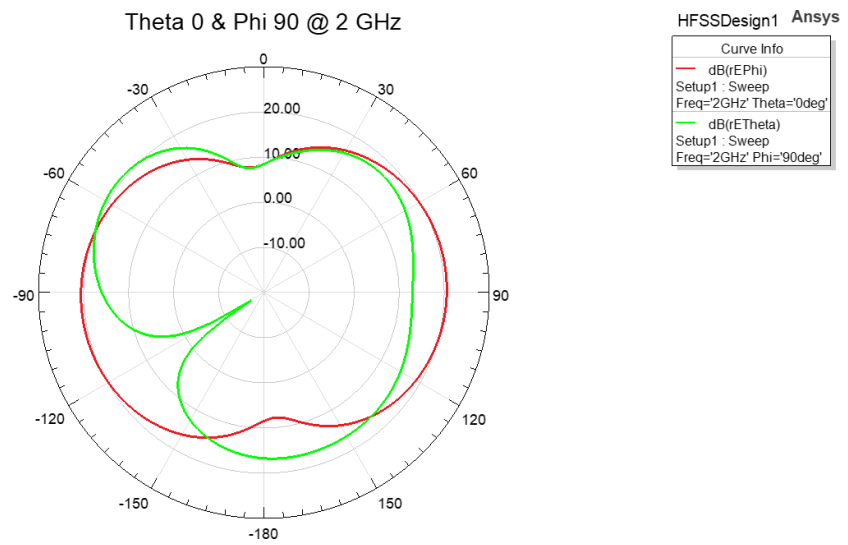


Fig 5.7 Theta 0 & Phi 90 @ 2 GHz

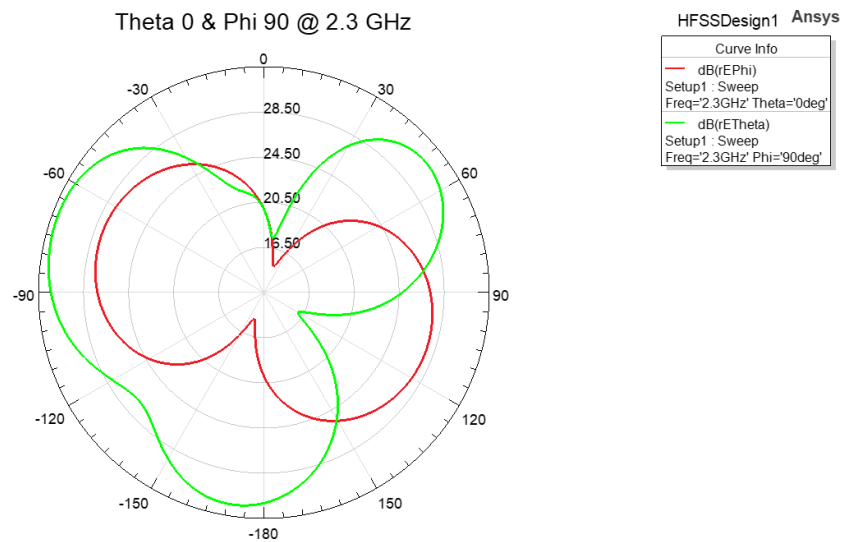


Fig 5.8 Theta 0 & Phi 90 @ 2.3 GHz

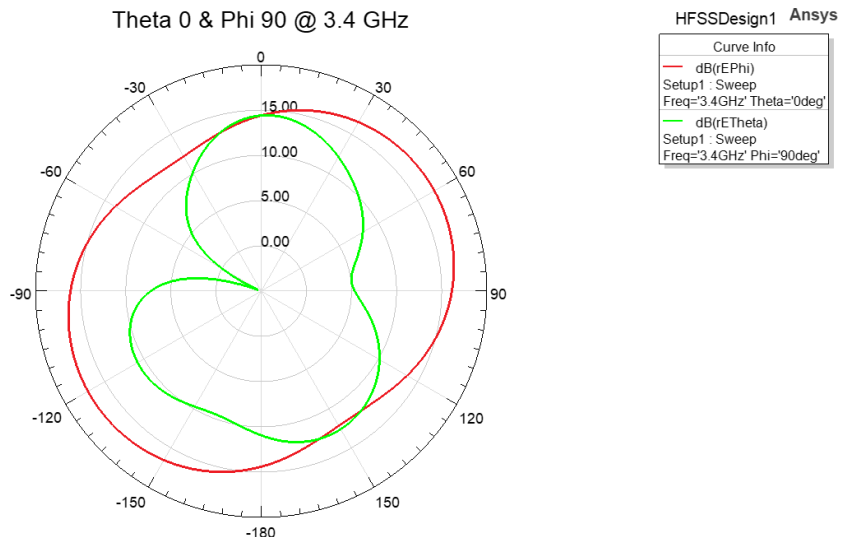


Fig 5.9 Theta 0 & Phi 90 @ 3.4 GHz

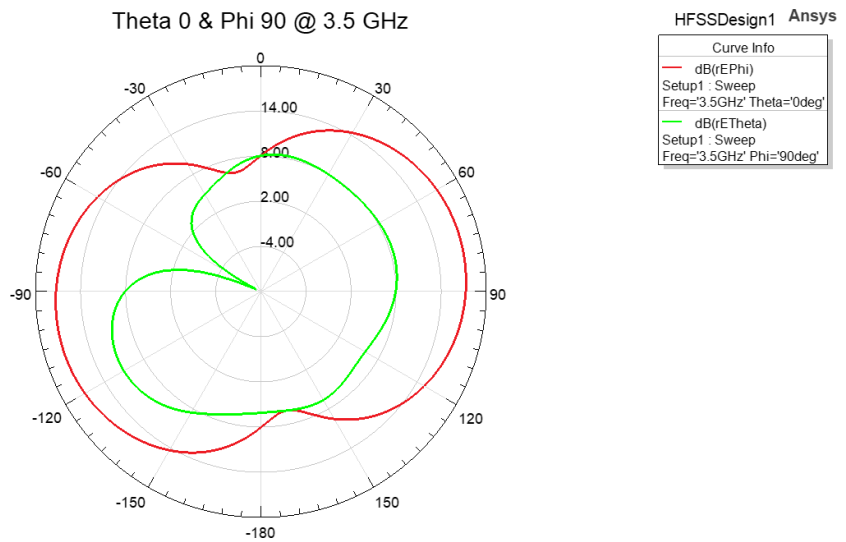


Fig 5.10 Theta 0 & Phi 90 @ 3.5 GHz

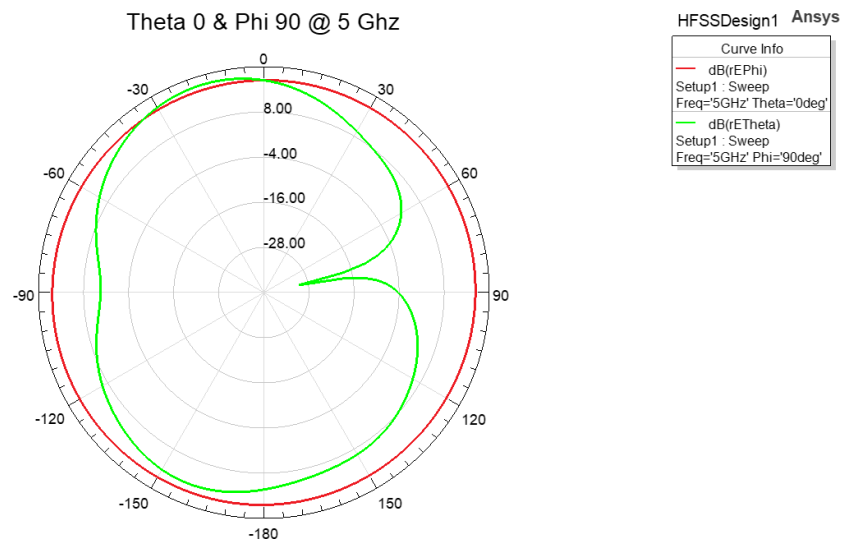


Fig 5.11 Theta 0 & Phi 90 @ 5 GHz

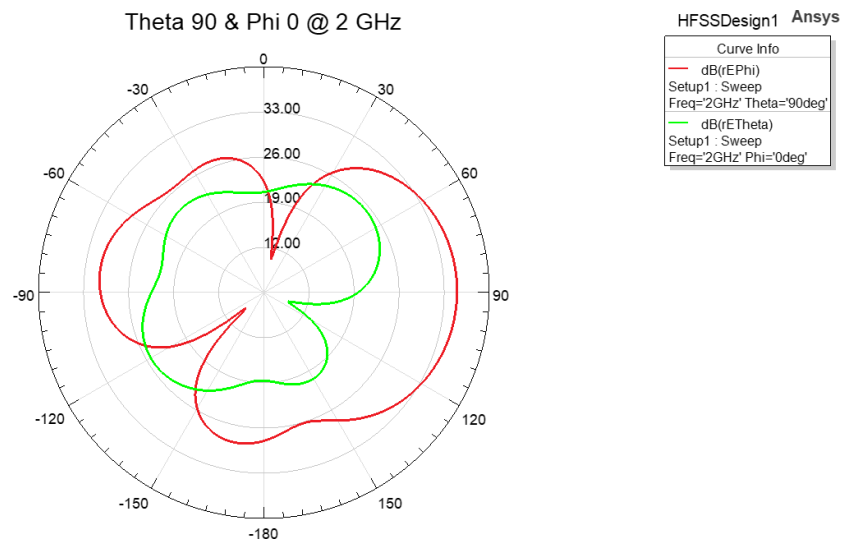


Fig 5.12 Theta 90 & Phi 0 @ 2 GHz

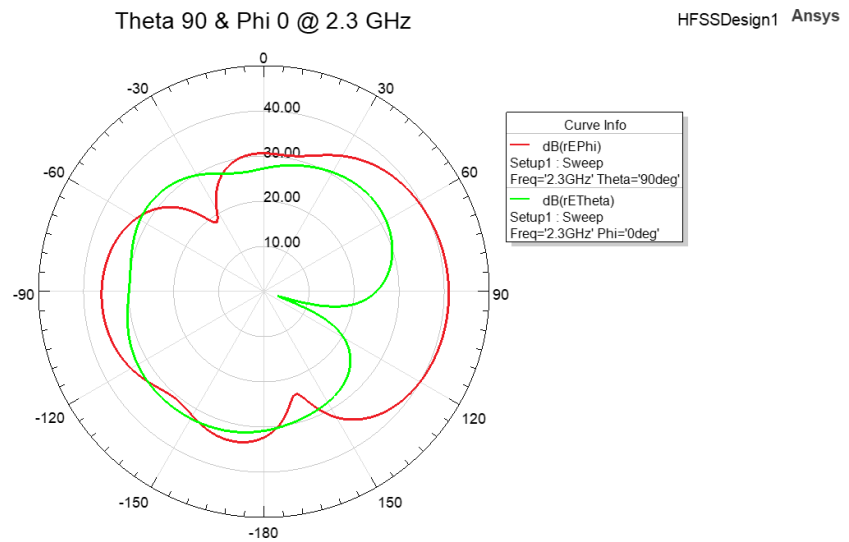


Fig 5.13 Theta 90 & Phi 0 @ 2.3 GHz

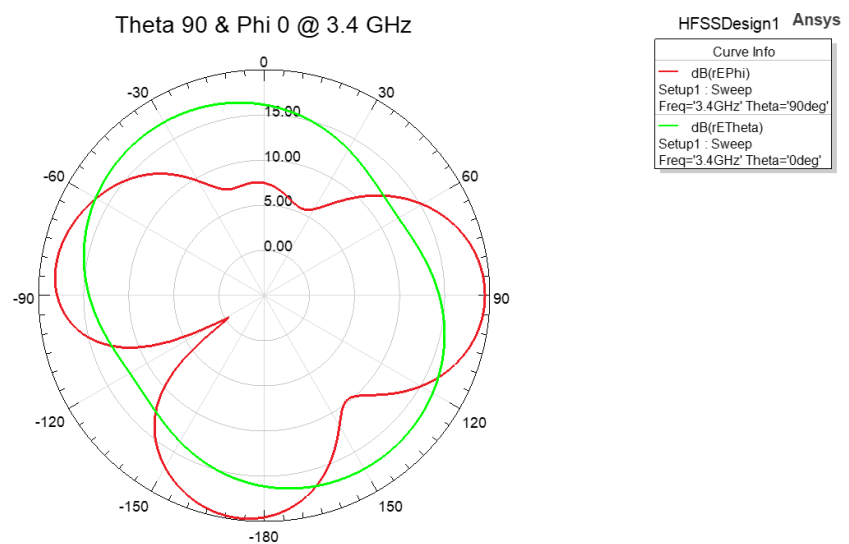


Fig 5.14 Theta 90 & Phi 0 @ 3.4 GHz

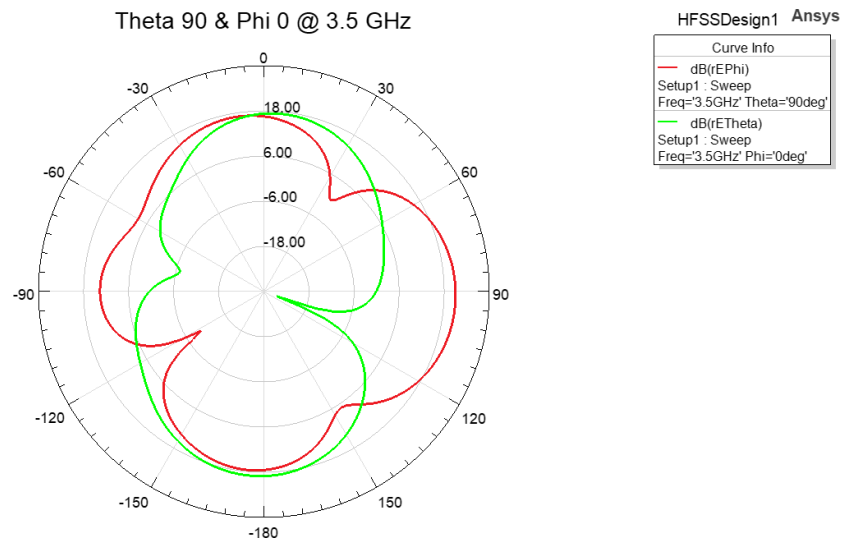


Fig 5.15 Theta 90 & Phi 0 @ 3.5 GHz

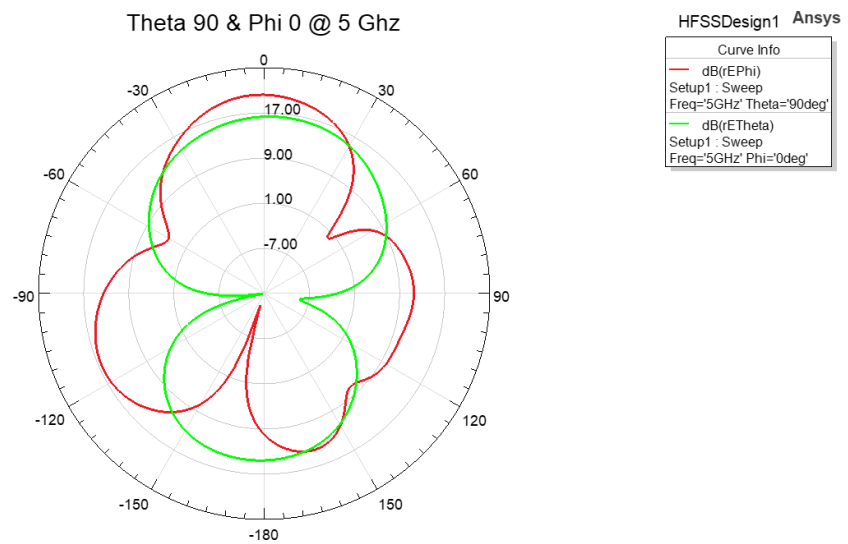


Fig 5.16 Theta 90 & Phi 0 @ 5 GHz

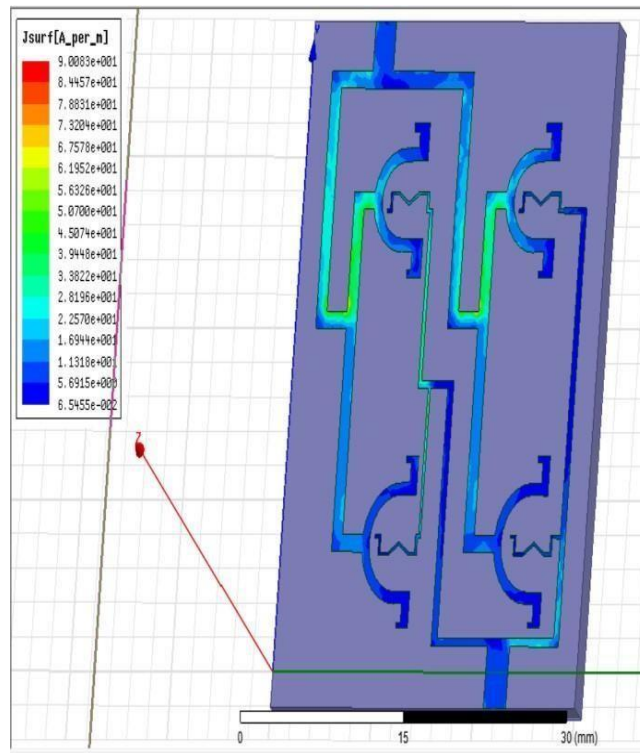


Fig 5.17 The current distribution of the Microstrip Patch Antenna

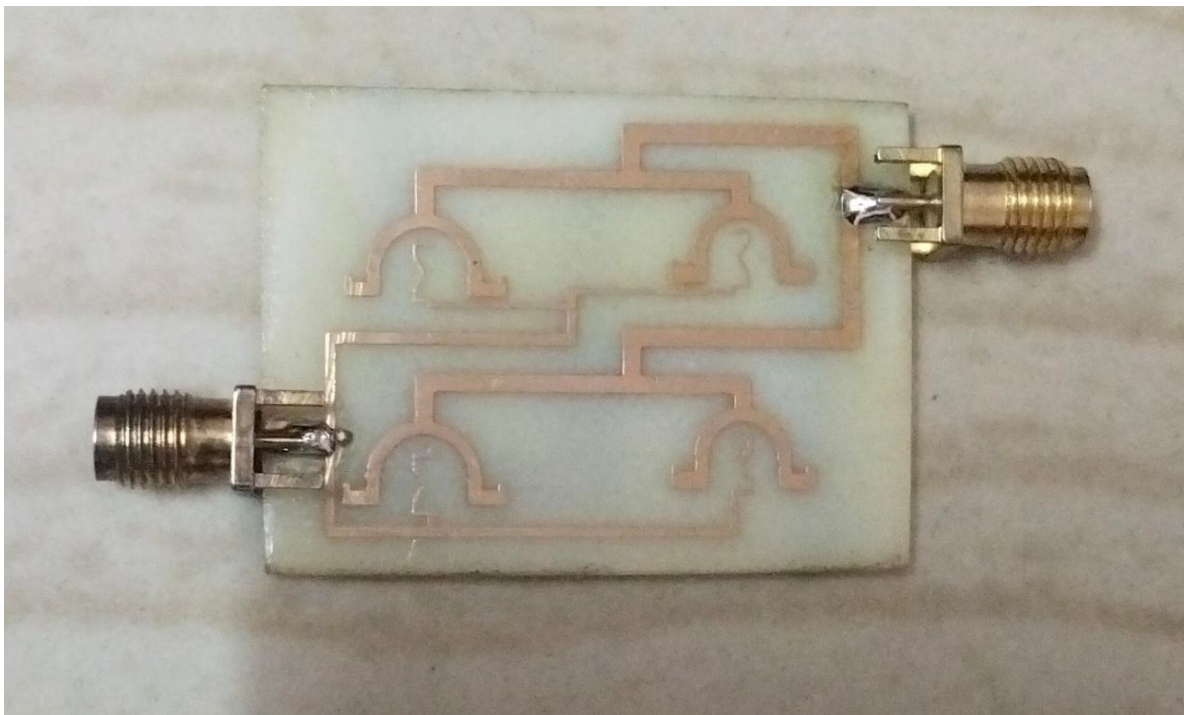


Fig 5.17 Fabricated Model

5.2 Advantages Of Microstrip Patch Antenna

- Simple and inexpensive construction.

- Lightweight and low volume.
- Suitable for array antennas.
- Conformity with planar and non-planar surfaces.

CHAPTER 6

CONCLUSION

In modern times, wireless communication systems are essential components of various wireless communication devices that enable users to communicate even from remote areas. In this study, a microstrip antenna array of 30x40x2 mm was designed, and the simulated and measured results showed good agreement, indicating that the antenna array had stable performance. The -10 dB bandwidth was measured to be 600 MHz (4.3-4.9 GHz), and the central frequency was 4.6 GHz, which is in the mid-bandspectrum used for 5G. Although this frequency band is not commonly allocated for 5G worldwide, some operators in China, Japan, and Russia are planning to use the 4.4 GHz-4.99 GHz range for 5G. For instance, in December 2018, China Mobile was given access to a trial 5G spectrum at 4.8 GHz-4.9 GHz before being awarded a commercial 5G license in June 2019.

Japan's NTT DOCOMO was authorized to use the 4.5 GHz-4.6 GHz band for its 5G network rollout, having trialed 5G 4.5 GHz services in 2017-2018. Additionally, Russian fixed broadband operator ER-Telecom has been permitted to utilize the 4.8 GHz-4.99 GHz spectrum for 5G connectivity tests, intending to provide wholesale services to cellcos.

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