AN EFFICIENT METHOD TO DESIGN AND PRINTED MICROSTRIP PATCH ANTENNA FOR 5G USING HFSS

[1]V.Venkateswara Reddy, Assistant Professor, PVKK Engineering College, Anantapuram
[2]Dr. P. M. Hadalgi, Professor in Dept. of Applied Electronics, Gulbarga University, Gulbarga
[3]Karishma ,PG scholar ,PVKK Engineering College, Anantapuram.

***ABSTRACT**: With expanding number of users, the demand for better technology also increases. The fifth Generation 5G technology would be one of the best technologies to meet the need of increased capacity demand, massive connectivity better speed by using the large amount of spectrum in the millimeter wave band, with 5G it is expected to get 80-100 Mbps speed. The need for 5G technology, methodology designing of antenna and various simulations is offered. The micro strip patch antenna is used here in 5G technology is relatively inexpensive to manufacture and design because of its simple physical geometry. Micro strip Patch Antenna shows multi-band characteristics and has a compact structure and hence has emerged as a promising candidate for handheld devices the proposed idea is implemented by using HFSS software which is used for antenna designing.*

1. 1 INTRODUCTION TO ANTENNAS

In the 1890s, there were only a few antennas in the world. These rudimentary devices were primarily a part of experiments that demonstrated the transmission of electromagnetic waves. By World War II, antennas had become so ubiquitous that their use had transformed the lives of the average person via radio and television reception. The number of antennas in the United States was on the order of one per household, representing growth rivaling the auto industry during the same period.

By the early 21st century, thanks in large part to mobile phones, the average person now carries one or more antennas on them wherever they go (cell phones can have multiple antennas, if GPS is used, for instance). This significant rate of growth is not likely to slow, as wireless communication systems become a larger part of everyday life. In addition, the strong growth in RFID devices microstrip patch antennas are referred and presented in this section. Pozar D.M explained microstrip antennas suggests that the number of antennas in use may increase to one antenna per object in the world (product, container, pet, banana, toy, cd, etc.). This number would dwarf the number of antennas in use today. Hence, learning a little (or a large amount)

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about of antennas couldn't hurt, and will contribute to one's overall understanding of the modern world.

2.LITERATURE REVIEW

2.1 INTRODUCTION

Analyzing and designing of microstrip fractal antenna is a challenging task in the design part of communication systems. In this chapter, the literature survey of microstrip patch antennas, rectangular patches, circular patches, patches using slits/slots, meandered antennas, Microstrip fractal antennas, hexagonal patches, stacked patches two layer, multi layer and fractal techniques are reviewed and presented in three major headings.

2.2 MICROSTRIP PATCH ANTENNA

From the literature survey, several journal articles and selected relevant recent reviews pertaining to microstrip patch antennas are referred and presented in this section. Pozar D.M explained microstrip antennas, as innovative topic, and are getting usage in a broad range of new microwave components. Saeed I. Latif et al given the pattern equalization of circular patch antennas using different substrate permittivities and ground plane sizes. V.P.Sarin summarized wideband stacked offset microstrip antenna with improved gain and low cross polarization. M.A.Matin et al investigated broadband microstrip antennas in wireless communication . Tingqiang Wu et al presented a broadband small size microstrip stacked antenna . Babani Suleiman, et al presented a compact microstrip patch antenna with measured gain 3 dB for wireless system .

2.3 MICROSTRIP FRACTAL ANTENNAS

Fractal structures are used on patch antennas for the reduction of the size and area. The literatures related to fractal antennas are given in this section. Gianvittorio, J.P et al discussed miniaturization techniques in fractal antennas. The fractal geometries are used to model objects such as clouds, coastlines. They have space-filling properties to miniaturize antennas [65]. Werner, D.H.et al provided an general idea of fractal antenna research and electromagnetic theory to novel antenna designs [66]. A.Danideh et al presented a semicircular microstrip patch antenna structure. It comprised a rectangular ground. It used a thin substrate fed by microstrip line. It operates for the bandwidth of 5.8–12.9 GHz [67]. M. Kazerooni et al. presented design of wide band multi-ring fractal patch for business applications. The ground plane is only the under part of the feed line. Good performance of S-parameters is obtained. This fractal antenna is suitable for the commercial broadband systems such as, Bluetooth and GSM [68]. Abolfazl designed octagonal geometry structure fractal antenna using Rogers RT duroid substrates and achieved wide band of frequencies.

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3.PROPOSED METHOD

With expanding number of users, the demand for better technology also increases.

The fifth Generation 5G technology would be one of the best technologies to meet the need of increased capacity demand, massive connectivity better speed by using the large amount of spectrum in the millimeter wave band, with 5G it is expected to get 80-100 Mbps speed. The need for 5G technology, methodology designing of antenna and various simulations is offered. The micro strip patch antenna is used here in 5G technology is relatively inexpensive to manufacture and design because of its simple physical geometry. Micro strip Patch Antenna shows multi-band characteristics and has a compact structure and hence has emerged as a promising candidate for handheld devices the proposed idea is implemented by using HFSS software which is used for
antenna designing.

An innovative massive multi-objective design procedure is proposed for the synthesis of next-generation antennas for 5G base stations. The 5G antenna design problem is formulated by jointly considering several contrasting requirements in terms of bandwidth, directivity, half-power beam width , polarization, and neighbor element isolation. Towards this end, a finite-array model is developed which enables the simulation of a set of adjacent elements during the design process. Thanks to such an approach, the obtained design can be directly included in 5G antenna arrays without further re-optimization to compensate for mutual coupling effects.

The resulting massive multi-objective problem is recast as a multi-objective one by suitably clustering the cost function terms according to their physical features, and ad-hoc global search techniques are customized and applied in order to address with the obtained highly non-linear optimization problem. Preliminary numerical results concerning a Pareto-optimal tradeoff solution are presented to validate the proposed approach.

Microstrip antennas have several advantages compared to other bulky type of antennas. Some of the main advantages of micro strip antennas are that it has low fabrication cost, its lightweight, low volume, and low profile configurations that it can be made conformal, it can be easily be mounted on rockets, missiles and satellites without major modifications and arrays of these antennas can simply be produced .

However, micro strip antennas have some drawbacks including narrow bandwidth, low power handling capability and low gain. But with technology advancement and extensive research into this area these problems are being gradually overcome.

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In many practical designs, the advantages of microstrip antennas far outweigh their disadvantages. With continuing research and development it is expected that micro strip antennas will replace conventional antennas for most applications. Some of the notable applications for microstrip antennas.

Satellite (DBS) system and Global Positioning System (GPS). Microstrip antennas also found useful in non-satellite based application such as remote sensing and medical hyperthermia application.

3.1 General Description

In its simplest form, micro strip antenna is a dielectric substrate panel sandwiched in between two conductors. The lower conductor is called ground plane and the upper conductor is known as patch. Microstrip antenna is commonly used at frequencies from to 100 GHz and at frequencies below ultra high frequency, UHF micro strip patch become exceptionally large. The radiating patch can be design in various shapes according to the desired characteristics. Illustrated in Figure 1.1 is the simplest structure of a rectangular microstrip patch antenna.

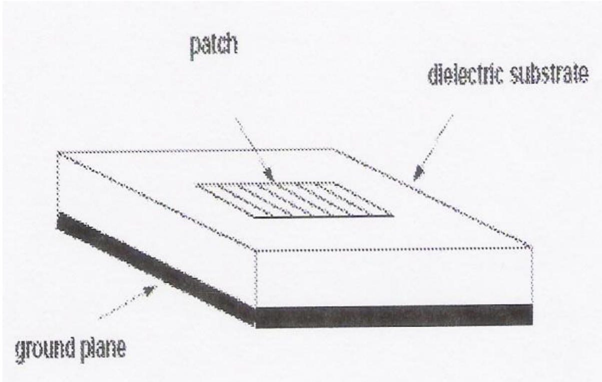

Fig 3.1 Rectangular microstrip patch antenna

3.2Conducting Layers

The common materials used for conducting surfaces are copper foil or copper foil plated with corrosion resistant metals like gold, tin and nickel.

These metals are the 3 main choice because of their low resistivity, resistant to oxidation, solderable, and adhere well to substrate.

An alternative to metal for conducting surface is to use conductive ink. It is easier to fabricate but have three disadvantages. First, is that conductive inks cannot be soldered in the usual way, to overcome this solder pastes are used. Secondly is oxidation, but the effect is negligible since the oxide is also conductive. The third is the problem of silver ion migration. Silver ions tend to migrate under humid conditions and this will cause a short across the conductive ink lines.

3.3 Dielectric Substrate

The first step in designing micro strip antenna is to choose the suitable substrate. There are various types of substrate available in market that provides considerable flexibility in the choice of a substrate for particular applications.

In most cases, considerations in substrate characteristics involved the dielectric constant and loss tangent and their variation with temperature and frequency, dimensional stability with processing, homogeneity and isotropicity. In order to provide support and protection for the patch elements, the dielectric substrate must be strong and able to endure high temperature during soldering process and has high resistant towards chemicals that are used in fabrication process.

The surface of the substrate has to be smooth to reduce losses and adhere well to the metal used. Substrate thickness and permittivity determine the electrical characteristics of the antenna. Thicker substrate will increase the bandwidth but it will cause the surface waves to propagate and spurious coupling will happen. This problem however, can be reduced or avoided by using a suitably low permittivity substrate. Below are six categories of dielectric material that are used for substrates.

(1)Ceramic - Alumina (r = 9.5, tan (δ) = 0.0003)

This type of dielectric has low loss but brittle. It has high frequency applications and also has excellent resistance against chemicals. The temperature range for alumina is up to 1600oC.

(2) Synthetic materials - Teflon (r = 2.08, tan (δ) = 0.0004)

These materials possess good electric properties but have a low melting point and have poor adhesion. The dimensional stability for this substrate is relatively poor but reinforcement with glass or ceramic will improve the dimensional stability to fairly good.

(3) Composite materials – Duroid (r = 2.2 /6.0/ 10.8, tan (δ) = 0.0017)

Composite materials are a mixture of fiberglass and the synthetic materials cited above. These materials have good electrical and physical properties and excellent dimensional stability.

(4) Ferromagnetic - Ferrite (r = 9 - 16, tan (δ) =0.001)

This type of dielectric is biased by an electrical field. The resonant ftequency of the antenna depends upon the biasing; hence magnetically tuneable antennas are possible.

(5) Semiconductor - Silicon (r = 11.9, tan (δ) =0.0004)

This type of dielectric can be integrated into circuit, but only small areas are available so it is not suitable for antenna applications.

(6) Fiberglass - Woven fiberglass (r = 4.882, tan () = 0.002)

This material is relatively low in cost for such low loss tangent. However, woven fibers tend to be anisotropic and this is undesirable in many designs .

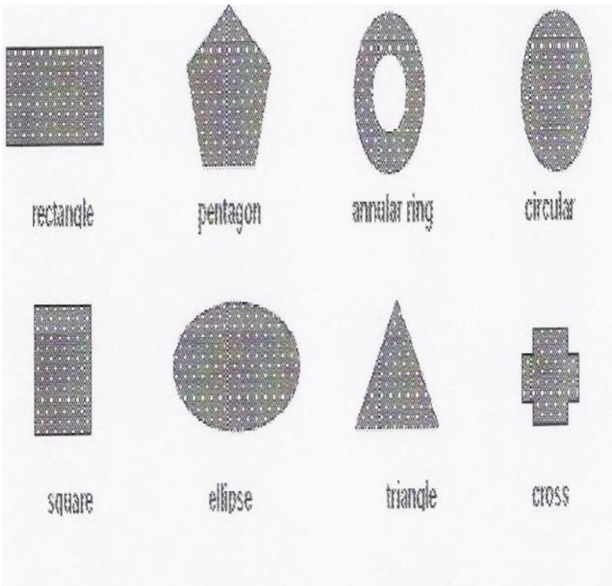

Fig 3.2 Different types of Antennas

3.4. Microstrip Feeds

Matching is usually required between the antenna and the feed line, because antenna input impedances differ from customary 50ohm line impedance. An appropriately 6 selected port location will provide matching between the antenna and its feed line. And the location of the feed line also affects the radiation characteristics. There are three common techniques for exciting a particular microstrip antenna. These are coaxial probe, microstrip line and aperture coupling. In most cases, considerations in substrate characteristics involved the dielectric constant and loss tangent and their variation with temperature and frequency, dimensional stability with processing, homogeneity and isotropicity. In order to provide support and protection for the patch elements, the dielectric substrate must be strong and able to endure high temperature.

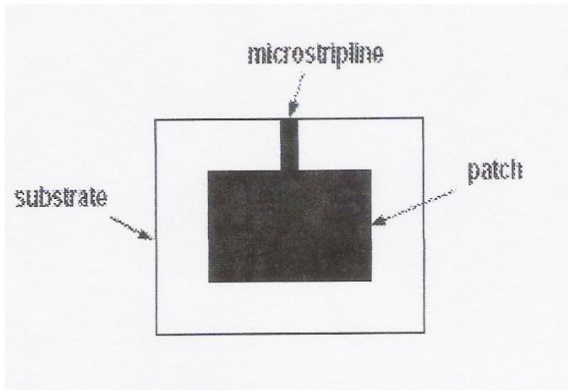

Fig 3.3.Microstrip feed

3.5 Microstrip Line Feed

In the aperture coupling the feed line and the patch are on different sides of the ground plane .

A slot is cut in the ground plane to couple the electromagnetic to the radiating patch, thus no via connectors needed. This technique is to avoid spurious radiation escapes from the feed line and corrupt the sidelobes or polarization of the antenna.

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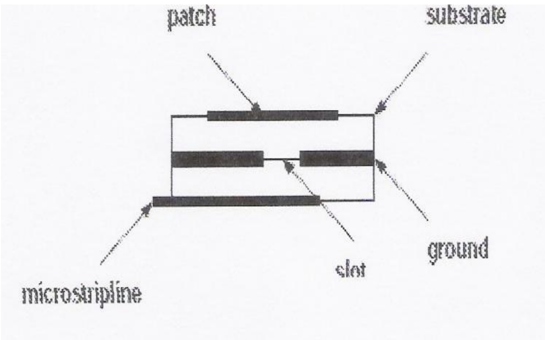

Fig.3.4 Aperture coupling feed

3.6 Rectangular Microstrip Patch Antenna

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.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.

Microstrip patch antennas are being widely used in various fields of communication, like ground to air communication in case of spacecrafts and aircrafts for the past few decades [1]. Because of their ease of installation, low cost and light weight they are preferred mainly over other antennas. Very small size wide band antennas are of great demand in future technologies with the rapid growth of wireless communication technology [2]. In spite of inherent limitation like narrow bandwidth and low gain, microstrip patch antennas have numerous advantages [2]. But various techniques have been investigated for the enhancement of both bandwidth and gain. This paper proposes an antenna that works at 8.5 GHz with parasitic patch placed next to the main patch with an intension to increase the bandwidth. The parasitic patch is sometimes known as electro magnetically coupled patch [3]. Along with the parasitic patch various slots are used on both parasitic patch and the main patch. These slots on both the patches not only enhance the bandwidth but also shift the resonant frequency and tune the frequency bands [4]. Apart from parasitic patch there are various techniques to enhance the bandwidth, they are increasing the substrate thickness, using the defected ground structure and etching slots on the radiating element [5]. In this paper both parasitic patch and slots are used for bandwidth enhancement.

However on increasing the substrate thickness for better bandwidth, it exists the practical limit. If the thickness is increased

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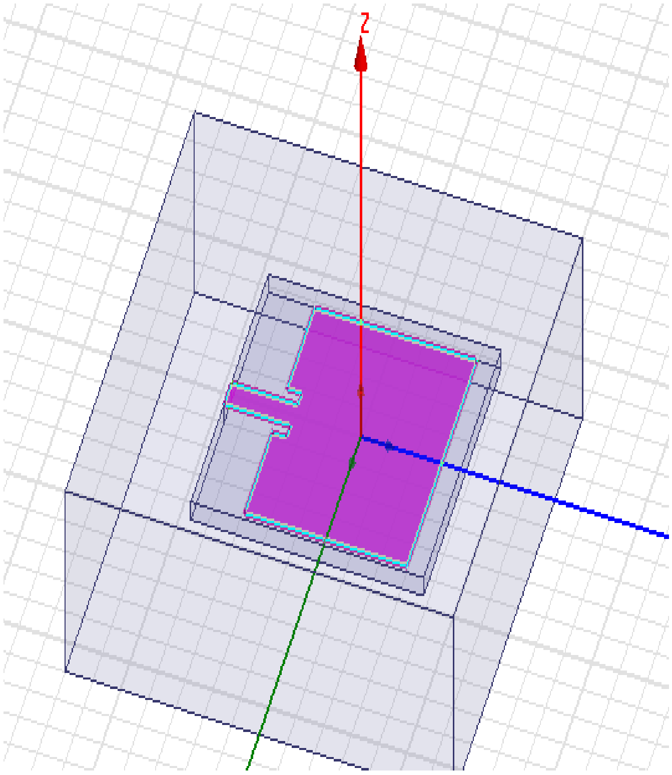
beyond 0.1λ, there occurs degradation of antenna performance due to surface wave propagation and it causes large mismatch between the feed line and the antenna [6]. So, compared to increase in thickness of substrate, parasitic patch is the popular technique for bandwidth extension without degrading the performance of low profile antenna. Excitation to the parasitic patch is provided through coupling with the fringing fields of the main patch [6]. This parasitic patch provides an additional resonance with a good performance of bandwidth enhancement [7]. It can also suppress the surface waves for the improved radiation efficiency in a specific frequency band. Resonant frequency is determined by the length of the parasitic patch and bandwidth is determined by its width [8]. The microstrip patch antenna proposed for satellite applications is designed at 15 GHz with multiple slots on the rectangular patch. These slots on the patch shift the resonant frequency to the lower side and also affect various antenna parameters [9].

3.7 Parasitic Antenna Design

Figure shows the proposed antenna design with both main patch and the parasitic patch including slots on them. The dimensions of the proposed design are mentioned in the table 1. The type of feed used in the design is line feed with an input impedance of 50 ohms. The substrate material that is used here is FR4 epoxy which has relative permittivity 4.4 and loss tangent 0.02. The thickness given to the substrate is 1.6 mm and using the defected ground structure and etching slots on the radiating.

Fig.3.5 3D geometry of Proposed Design



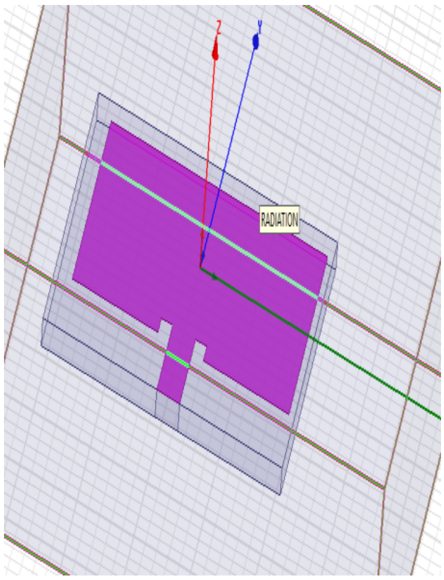


Fig 3.6.Proposed Antenna Design

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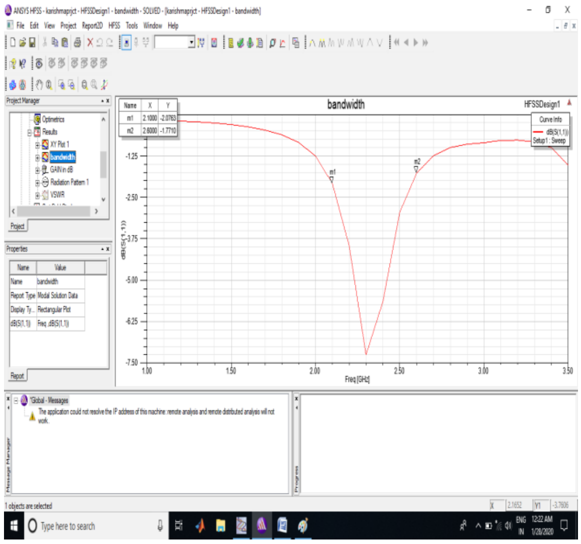
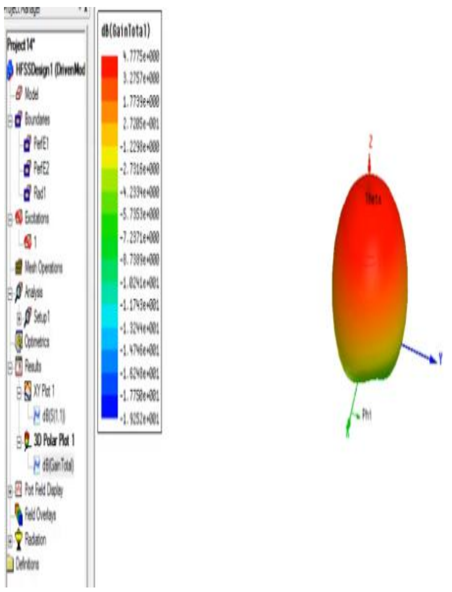
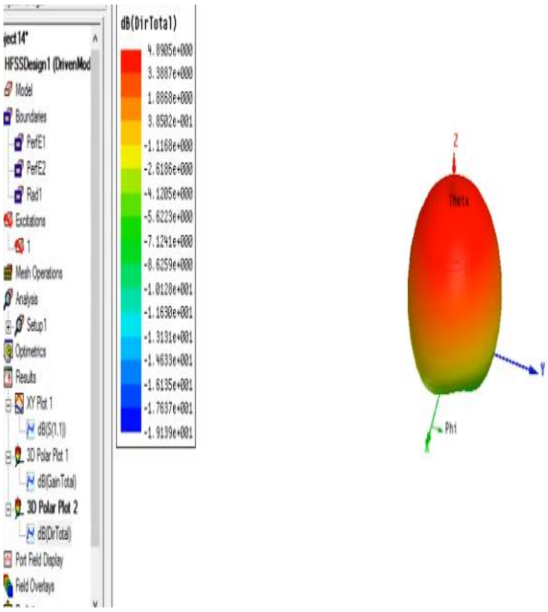
SIMULATION RESULTS



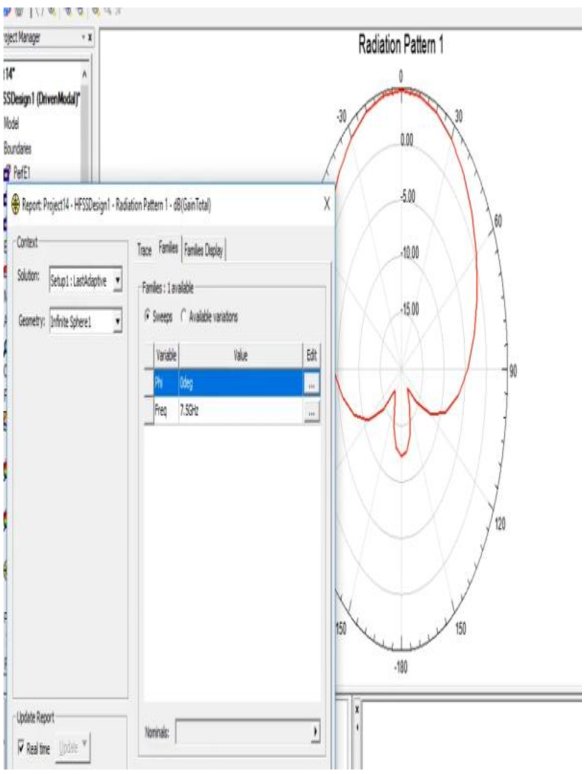
Result 1. The measured results for the proposed design is shown in above and the Return Loss plot of proposed Antenna Design the Resonating Frequency obtained is 2.75 GHz with return loss -2.07 dB comparing the simulation results.



Result 2.Energy radiated per unit solid is the three dimensional radiation pattern of an antenna. The direction capabilities and efficiency of an antenna can be found using the gain. The maximum Gain of proposed Design is observed to be 1.375



Result 3. Energy radiated per unit solid is the three dimensional radiation pattern of an antenna. The direction capabilities and efficiency of an antenna can be found using the directivity. The Directivity of proposed Design is observed to be 4.8905



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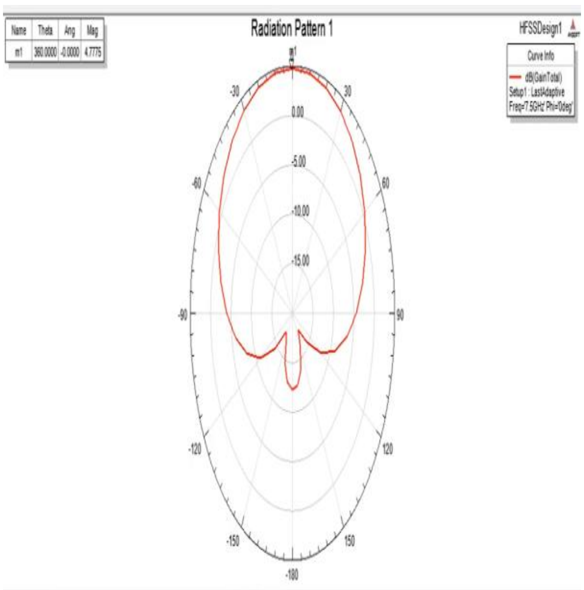
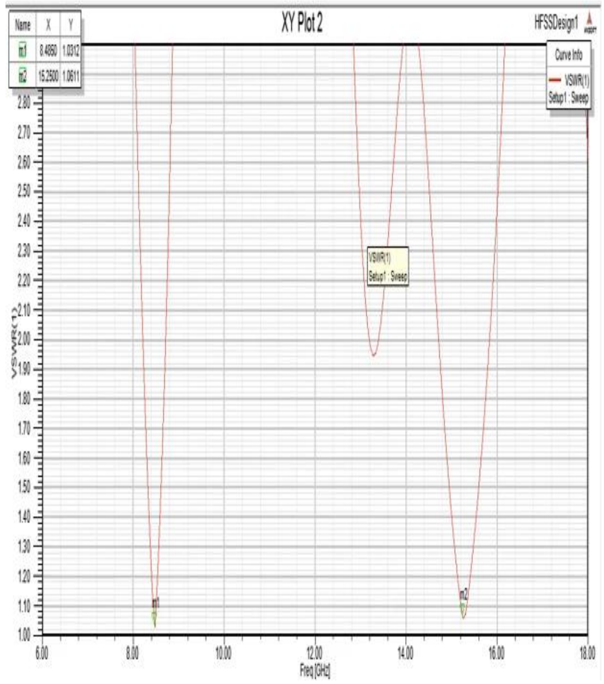
Result 4.Radiation Pattern for Proposed Parasitic Antenna for theta 0 degree at 2.75 GHz



Result 5 . Radiation Pattern for Proposed Parasitic Antenna for theta 360 degree at 2.7GHz

CONCLUSION

This paper explains the micro-strip patch antenna fundamentals and HFSS software. The paper explains in details the steps needed to develop a complete simulation of micro-strip patch antenna using the popular HFSS software. The results are given with parameter values and the comparison between parameters of bases paper and our proposed work.



Result 6.VSWR (Voltage standing wave ratio) is one of the important consideration in microstrip patch antenna. For a better design the VSWR will be equal to 1, which presents that the system is perfectly matched. For the proposed design the VSWR plot is shown in above and from the above the value of VSWR observed is 1.031

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First Author Mr. V.Venkateswara Reddy has completed B.E. Degree in Electronics and Communication Engineering (ECE) from University of Madras and M.Tech from JNTU college of Engineering. He is Pursuing PhD at Gulbarga University, and Kalaburagi in the area of Antennas. He is currently working as Assistant Professor in Department of Electronics & Communication Engineering at P.V.K.K Institute of Technology, Anantapur, and Andhra Pradesh, India. His research areas are Digital systems, Wireless communications-Antennas.

Second Author Dr. P. M. Hadalgi. Received Ph.D.,Degree in Electronics from Karnataka University, Dharwad. He is working as Professor in Dept. of Applied Electronics, Gulbarga University, and Gulbarga. He is an active researcher in the field of Microwave Electronics. His area of interest includes waveguide antenna, microstrip antenna, DRA and instrumentation. He has more than

150 publications in reputed International/National Journals and in conference and symposia.

Third Author Karishma. She received B.Tech degree in Electronics and Communication Engineering from ALTS Engineering College, Anantapur Affiliated to JNTUA Anantapur, A.P . She is pursuing M.Tech degree in Digital Electronics and Communication Systems in PVKK Institute of Technology, Anantapur.