Slot Loaded Compact Microstrip Patch Antenna for Dual Band Operation

Submitted in partial fulfilment of the requirements for the award of Bachelor of

Engineering Degree in Electronics and communication Engineering

By

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **ASISH.B(Reg.No.38130018)** and **SRIDHARAN.T (Reg.No.38130214)** who carried out the project entitled "**SLOT LOADED COMPACT MICROSTRIP PATCH ANTENNA FOR DUAL BAND OPERATION**" under our supervision from September 2021 to March 2022.

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DECLARATION

ASISH.B(Reg.No.38130018) and**SRIDHARAN.T**(Reg.No.38130214) hereby declare that the Project Report entitled "**SLOT LOADED COMPACT MICROSTRIP PATCH ANTENNA FOR DUAL BAND OPERATION"** done by me under the guidance of **Dr.V.J.K.KISHORESONTI,M.Tech.. Ph.D.,**Is submitted in partial Fulfilment of the requirements for the award of Bachelor of Engineering degree in Electronics And Communication Engineering.

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ABSTRACT

A novel design of a compact microstrip patch antenna using meandering technique is proposed in this paper where the designed antenna seems to behave as a microstrip patch loaded with conducting strips.

A rectangular microstrip patch antenna with addition of conducting strip radiates at much lower frequency than a conventional rectangular microstrip antenna, due to increase of resonant length, but it also causes the increase in total size of the antenna.

In this article, the resonant frequency has been lowered significantly by loading a regular rectangular microstrip patch antenna with rectangular slot in a proper position in such a way that the whole structure looks like a strip loaded radiator.

About 86.5% size reduction has been achieved experimentally with very good agreement of simulated and measured results. The equivalent circuit and approximate resonant frequency calculation have been discussed .

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INTRODUCTION

1.1 INTRODUCTION(SPLIT LONG PARAS)

In contemporary world, where the space technology is booming with very high pace, require the hardware which is of small size and high efficiency. The antenna is the integral part of the wireless communication and it also required to be low profile with high efficiency and improved parameters. Low profile antennas are regularly used in various commercial and public applications such as radio, mobile and wireless communication wherein size of the antenna is matter of concern. For this purpose, Microstrip Antenna (MSA) is unvaryingly used. MSA is well-matched with MMIC design. The microstrip patch antenna is majorly consist of patch, substrate and ground mounted one above other in a layer making three slices, along with this there is feeding part also connected on the suitable place. The dimension of patch and ground of MSA can be exploited to get more affirmative variation in different parameters like resonant frequency, radiation pattern, gain, efficiency and directivity. Moreover, when certain load is inserted, such as pins and varactor diode, between the patch and ground, results in variation of parameters values. Major drawbacks in operation of MSA are low power gain, low efficiency, spurious feed radiation and narrow bandwidth. However, in certain application like security systems narrow frequency bandwidth is considered advantageous. Also, there are certain techniques to enhance the bandwidth and efficiency i.e., increasing the substrate’s height. However, at the same time as the height increase it extracts more power for direct radiation because of introducing of surface wave which is again undesirable. These surface waves in return radiate at discontinuity or bands and result in the degradation of polarization characteristic and antenna pattern. Defected Ground Structure (DGS) is useful in suppressing cross polarization. By introducing cavity or any shape the surface wave can be removed while bandwidth remains as improved. Stack configuration is also use to enhance the bandwidth. DGS technique is used to achieve size reduction and also further bandwidth as well as gain enhancement.

Artificial magnetic conductor has been used for the antenna's miniaturization and reduction of antenna size has achieve but at the cost of lower gain. Introduction of Koch fractal shape on the patch also reduce the size of antenna up to 21% but the gain starts decreasing after few iterations. One more technique of short circuiting the patch to ground of MSA is introduced for miniaturization but again the problem happened with the gain. The main drawback of smaller physical dimensioned antenna is that it has narrow impedance bandwidth. Multiband response is introduced in MSA antenna but yet again the gain is remained problem. Miniaturization has been accomplished by using complementary split ring resonators, wherein the size reduced up to 10%. For the reduction of size of antenna Meta material is used for ground plane along with high permittivity substrate which results in considerable antenna reduction but at the cost of poor efficiency and narrow impedance bandwidth of antenna. This task can also be performed by substrate of pure magnetic property but finding pure magnetic material is demanding to obtain. Defected ground structure is already investigation in microstrip patch antenna for miniaturization purpose and till then the reduction of antenna achieved was 34%. Arrangement of L-Shape and U-Shape slits on the Ground plane are also used for miniaturization of antenna wherein impedance bandwidth is in range of 3.1%-25%. Patch and the ground plane are shorted through a shorting pin and ground plane are disturbed for miniaturization and has acceptable gain for all band which is in the range of 3.5dBi to 6.6dBi. When MSP antennas are used in low frequency band the size of antenna get increased. A particular inset-fed MSA has generated resonant frequency of 3.6 GHz wherein defected ground structure makes the frequency band shifted towards a lower frequency, in doing so miniaturization of the MSA antenna is justified. Defected ground structure is incorporated with defected patch antenna to improve its performances and achieve miniaturization but miniaturization up to 50% was achieved, comparing with conventional microstrip antenna. Electromagnetic band gap (EBG) structure is used like defect ground structure to miniaturize and attain multiband resonant frequencies. Two cells of spiral-shaped defected ground structure (DGS) with each cell composed of spiral with four arms are used in the design. Simulation's outcome showed that 50% reduction in size was accomplished. Without defected ground structure and other slots the antenna resonates at 3.22 GHz but after the DGS and slots introduced in MSA the frequency shift from 3.22 GHz to 1.07 GHz [20]. DGS technique is also used for array microstrip patch antenna size reduction wherein the miniaturization achieved is 37%.

The recent boom in wireless communication industry, has generated the great demand for dual band or multi band antennas in mobile communication and data communication areas. In such communication areas, the problems to be resolved are broad bandwidth and gain, while striving for miniature geometry.Therefore, occurs an urgent requirement for a economical, condensed, extremely reliable, integrated. antenna is a desirable feature of multifunction antennas used in mobile communication equipment.[1]-[4] A MSPA (Microstrip Patch Antenna) has a radiating PEC materialistic sheet called patch on one side of the dielectric substrate which is connected with ground plane on the other side. The patch is made of conducting material such as copper or gold and can take any possible shape.The patch is generally square, rectangular, circular and triangular or any other shape. Microstrip Patch Antennas can be fed by a number of techniques.The most admired feeding means used are microstrip line, coaxial probe, aperture coupling and proximity coupling. The proposed antenna is designed using coaxial probe feed [5]-[8]. The microstrip patch antennas have more advantages when compared with the conventional antennas .They are lighter, low volume, low cost, smaller in dimension and easy to fabricate. Radar demands a low profile, light weight antenna, the microstrip antennas are an ideal choice. Other application areas of microstrip patch antennas are wireless communication, satellite communication, medical and military systems. But these low cost patch antenna designs have quite a few shortcomings. They have narrow bandwidth, low gain and low efficiency.[9]-[12] There are some methods to recover these problems which embrace adding up fashioned slots to the patch, defected ground structure and fractal geometry. In this paper, two U-shaped slots and various parameters are considered to achieve the desired results. The X and Ku-bands are portions of the electromagnetic spectrum in the microwave range of frequencies which covers 8GHz-12 GHz range and 12 GHz -18 GHz respectively.

These bands are primarily used for satellite, radar, space and global communications.[13]-[20]The proposed antenna resonates at dual frequency bands are at 9.1 GHz and 14 GHz which cover X and Ku bands without any interference of any other undesired frequencies.

1.2 MICROSTRIP PATCH ANTENNA

Heinrich Hertz demonstrated the microstrip antenna in 1886. Microstrip antennas are also named as “Printed Antennas.” In recent days, Microstrip antennas find application in different wireless standards. It has prominent features such as small figure, little weight, small volume, inexpensive, uniformity to planar and non-planar surfaces, rigorous and quickly integrated on printed circuit board. The microstrip antenna consists of three layers. The bottom layer is the ground plane, and the top layer is the patch with a dielectric substrate is placed between these layers. The range of dielectric constants of the substrate used in the design is 2.2 << 12. Copper is mostly used as a radiating material for patch and ground plane. The patch antenna has different form and size such as rectangular, square, dipole, circular, triangular, circular ring, elliptical. Excitation to antenna are provided using several types of feeding techniques. The most common are proximity coupled feeding, co-axial feeding, aperture coupled feeding and microstrip line feeding. Microstrip line feeding is the most commonly chosen feeding technique as it is easy to fabricate.

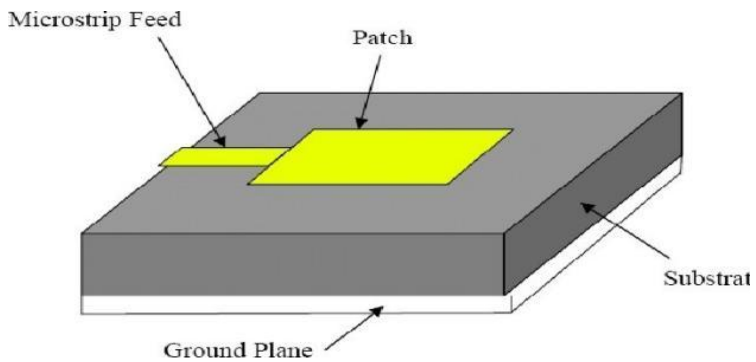


Figure 1.1 Microstrip Patch Antenna

1.3 SHAPES OF MICROSTRIP PATCHANTENNA

The commonly available shapes of patch antenna are square, rectangular, circular,dipole,triangular,circular ring and elliptical with square and rectangular shapes the most commonly used shapes.The various shapes are illustrated in fig 1.2.

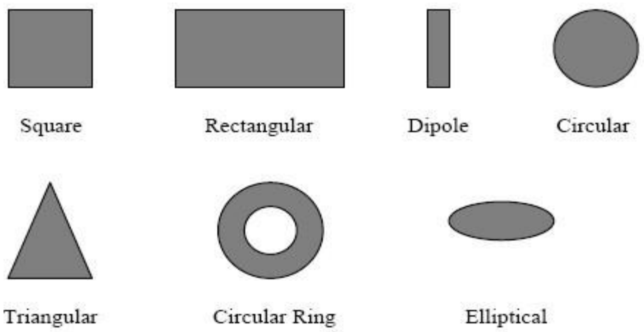


Figure 1.2 Shapes of Microstrip Patch Antenna

1.4 SLOTANTENNA

The slot antenna is popular because they can be cut out of whatever surface they are to be mounted on, and have radiation patterns that are roughly omnidirectional (similar to a linear wire antenna, as we'll see). The polarization of the slot antenna is linear. The slot size, shape and what is behind it (the cavity) offer design variables that can be used to tune performance.

1.5 DESIGN TECHNIQUE

In this project, we propose a Square - Slot Microstrip patch Antenna with increased Bandwidth for 5G Wireless Communication. The proposed antenna can operate from 6.5 to 44 GHz and the proposed antenna can displays a good omnidirectional radiation pattern even at high frequencies. Simulated and measured results are presented to validate the usefulness of the proposed antenna structure for Ultra Wide band applications. Good return loss and radiation pattern characteristics are obtained in the frequency band of interest. Simulated and experimental results are presented to demonstrate the performance of a suggested antenna.

1.6 Overview of MicrostripAntenna

A microstrip antenna consists of conducting patch on a ground plane separated by dielectric substrate. This concept was undeveloped until the revolution in electronic circuit miniaturization and large-scale integration in 1970. After that many authors have described the radiation from the ground plane by a dielectric substrate for different configurations. The early work of Munson on micro strip antennas for use as a low profile 2 flush mounted antennas on rockets and missiles showed that this was a practical concept for use in many antenna system problems. Variousmathematical models were developed for this antenna and its applications were extended to many other fields. The number of papers, articles published in the journals for the last ten years, on these antennas shows the importance gained by them. The micro strip antennas are the present day antenna designer's choice. Low dielectric constant substrates are generally preferred for maximum radiation. The conducting patch can take any shape but rectangular and square configurations are the most commonly used configuration. Other configurations are complex to analyze and require heavy numerical computations. A microstrip antenna is characterized by its Length, Width, Input impedance, and Gain and radiation patterns. Various parameters of the microstrip antenna and its design considerations were discussed in the subsequent chapters. The length of the antenna is nearly half wavelength in the dielectric; it is a very critical parameter, which governs the resonant frequency of the antenna. There are no hard and fast rules to find the width of the patch

1.7 OBJECTIVE

The main objective of our project is to design a Miniaturized Microstrip patch antenna that can be used for 5GHz application and to observe the effect of various antenna parameters like Return loss(dB), Gain(dBi), Directivity (dBi) and Bandwidth and validate the overall performance of the antenna. Microstrip line feed have been used to excite the Miniaturized Microstrip patch antenna.

Microstrip patch antennas that are compact and have high gain, narrowband operating frequencies are very much in demand for wireless communication systems. There are many merits of microstrip patch antenna such as low profile, light weight, simple realization process and low manufacturing cost. Though these antennas have so many advantages, they also have some disadvantages like narrow bandwidth. Enhancement of the performance to cover thedemanding bandwidth is necessary [1]. There are numerous well- known methods to increase the bandwidth of antennas, including increase of the substrate thickness, the use of a low dielectric substrate, the use of various impedance matching and feeding techniques, and the use of multiple resonators .In this paper, a wide-band antenna fed by a microstrip line is presented.

Microstrip patch antenna consists of a radiating patch, dielectric substrate and a ground plane. The thickness of the ground plane or of the microstrip is not very important. The height h is much smaller than the wavelength of operation, but it should not be much smaller than 0.025 of a wavelength otherwise, the antenna efficiency will be degraded. There are several types of patches like rectangular, square, circular, pentagon, hexagon, etc [2]. The proposed antenna is designed using a square patch. The main reason for choosing square patch over the most commonly used rectangular patch is that it works well at higher frequencies and also provides better efficiency. The electric field is zero at the center of the patch, maximum at one side, and minimum on the other side. It can be seen that the minimum and maximum continuously change sides according to the instantaneous phase of the applied signal. The following Fig.1. shows the structure of Microstrip Patch Antenna The proposed antenna is designed using Advanced Design System (ADS) software. ADS has powerful and easy-to-use interface .It provides complete schematic capture and it also provides complete layout environment. The antenna design consists of RT duroid 5880 as substrate with dielectric constant 2.2 and thickness of 1.6. It has relative permittivity tan value as low as 0.0009. When compared to other substrates, the efficiency, gain, return loss are higher for RT duroid [3]. A substrate of low dielectric constant provides compact radiating structure to meets the required bandwidth. Low dielectric constant of the substrate produces larger bandwidth and the high dielectric constant of the substrate results in smaller size of antenna. Therefore, trade-off relationship exists between antenna size and bandwidth.

Compact microstrip antennas have received much attention due to increasing application of small antennas for personal communication equipments [1–5]. Shorted patch antennas have been reported to overcome the size constraints for a variety of communication link. Recently it has been demonstrated that loading the microstrip antenna with shorting pin and shorted wall can reduce the patch size for a fixed operating frequency [6–9]. Various kind of microstrip antennas have been proposed to achieve dual band operation such as redial slot [10], microstrip patch antenna with π shaped slot [11]. One of the most popular techniques to obtain the dual band frequency is reactive loading by introducing the slots parallel to radiating edge of the patch [12] and cutting square slot in the patch [13, 14]. Another type of reactive loading can be introduced to get higher frequency by cutting a notch parallel to the rediating edge of the patch [15]. In this paper, two antenna geometries are analysed for dual band operation using the circuit theory concept. In first geometry, a notch with dimension (Ln × Wn) is introduced along one of the radiating edge and another radiating edge is shorted with shorting wall, while in second geometry, a slot with dimension (Ls × Ws) is loaded in rectangular microstrip patch antenna with shorted wall. Various antenna parameters are calculated as a fun

1.8 ORGANISATION OFREPORT

CHAPTER 2-Deals with Literature review of papers.

CHAPTER 3-Deals with Basic Antenna parameters.

CHAPTER 4-Deals with CST design studio software tool

CHAPTER 5-Deals with proposed antenna design

CHAPTER 6-Deals with Results and discussion for the proposed system.

CHAPTER 7-Deals with Conclusion and Future enhancements.

1.9 CONCLUSION

Microstrip Patch Antenna offers several advantages such as low profile , light weight, low cost and easy to Integrate with other Circuits. These make them find Application in diverse areas such as Commercial and Military Applications, Radar Applications and Wide band applications like WIMAX, WILAN. Thus an overview of the Microstrip Patch antenna is observed and studied. The different shapes of Microstrip patch antennas like square, rectangular, circular, triangular is mentioned and design techniques are studied

CHAPTER- 2

LITERATURE REVIEW

Mudasar Rashid, Mehre E Munir, Khalid Mahmood and Jehanzeb Khan, "Design of Miniaturized Multiband Microstrip Patch Antenna using Defected Ground Structure" International Journal of Advanced Computer Science and Applications (IJACSA), 9(6), 2018

The recent developments in communication and antenna engineering demands compact and multiband antennas. Microstrip antenna is one of the most useful antennas for wireless communication because of its inherent features like low profile, light weight and easy fabrication. This design is aimed at miniaturized Microstrip Patch Antenna (MSA), without deteriorating its other parameters, such as gain, bandwidth, directivity and return loss. A significant amount of 89% miniaturization has been made possible by careful and meticulous investigation of slots insertion in patch and ground of MSA antenna. Dielectric substrate used in this design is polyester which has shown better result. As the focus of this design is to miniaturize the MSA, the technique used here is Defected Ground Structure (DGS), along with Defected Patch Structure (DPS) which actually shifted the resonant frequencies to the lower range without increasing its physical dimensions. Besides this shorting pin is also introduced between patch and ground, which also contributed in the enhancement of parameters like gain and return loss. The position of pin played an important role in the acquirement of better performance and radiation at desirable frequency band. Different shapes have been designed on Ground and Patch to obtain enhanced results. With the use of DGS, the designed antenna started radiation at multiple frequency bands. The frequency bands generated by this designed antenna are in the range of L band and S band of IEEE standard which made it apposite to use in variety of applications

Yon-Jeong Jang and Jong-Myung Woo, "The Miniaturized Microstrip Antenna with `L' type Plates," 2005 18th International Conference on Applied Electromagnetics and Communications, 2005, pp. 1-4, doi: 10.1109/ICECOM.2005.204943.

In this paper, the miniaturized linear and circular polarization microstrip antennas are designed and fabricated at the resonant frequency of 1.575GHz. To miniaturize the microstrip patch antenna (MPA), the `L' type plates are attached under the rectangular microstrip patch. In case of the linear polarization, the size of the microstrip antenna attached the 14 plates is reduced to 67.9% (47mm × 47mm) compared with general MPA (83mm × 83mm). The return loss, -10dB bandwidth and gain are -34.4dB, 49MHz (3.1%) and 1.19dBd. And the radiation pattern is broad through the size reduction of the patch. Also in case of the circular polarization, the size of the microstrip antenna with 13 plates is reduced to 54.6% (53mm × 54mm) compared with the general MPA (76mm × 83mm). The gain and axial ratio are 1.36dBd and 1.37dB at 1.575GHz, the 2dB axial ratio bandwidth is 14MHz (0.8%).

HanaeElftouh, Naima Amar Touhami, Mohamed Aghoutane, Safae El Amrani, Antonio Tazón, and Mohamed Boussouis, "Miniaturized Microstrip Patch Antenna with Defected Ground Structure," Progress In Electromagnetics Research C, Vol. 55, 25-33, 2014.

The aim of this work is to miniaturize a microstrip patch antenna resonating at 3 GHz. For this purpose, defected ground structure (DGS) has been employed to shift the resonance frequency of an initial microstrip antenna from 5.7 GHz to 3 GHz by disturbing the antenna's current distribution. The proposed DGS is incorporated in the ground plane under the patch antenna to improve its performances. Finally, a miniaturization up to 50%, with respect to the conventional microstrip antenna, is successfully accomplished. A prototype of the antenna was fabricated with the FR4 substrate and tested. The measurements results were in good agreement with simulation results.

Jingxian Liu, Wen-Yan Yin, and Sailing He, "A New Defected Ground Structure and its Application for Miniaturized Switchable Antenna," Progress In Electromagnetics Research, Vol. 107, 115-128, 2010.

A new defected ground structure (DGS) is firstly proposed in this paper, which has better slow-wave effect than that of cross or dumbbell one. Using the model of transmission line, its equivalent parameters are extracted. With good omni-directional properties, the proposed DGS is then used in the design of a proximity coupled antenna for its miniaturization. The size of the developed antenna is about 68% smaller than that of the conventional one. Further, two artificial cells are added on the feed line to reduce the protrudent stub length from 26.9mm to 18.94 mm. With the utility of the DGS and artificial cells, the size of proximity coupled antenna is reduced significantly. By introducing a PIN diode at the end of feed line, the antenna is switchable in both x- and y-direction linear polarizations. Such miniaturization in antenna size has little negative effect on its cross polarization, with both simulated and experimental results presented for comparison.

Devesh Tiwari, Jamshed Aslam Ansari, Abhishek Kr. Saroj, Mukesh Kumar, Analysis of a Miniaturized Hexagonal Sierpinski Gasket fractal microstrip antenna for modern wireless communications, AEU - International Journal of Electronics and Communications, Volume 123, 2020, 153288.

A multi-band, high gain, miniaturized fractal microstrip antenna is described in this article for modern communication systems. Space-utilizing and structure-similarity are the two main characteristics of fractal miniaturization technique. In the proposed design, a hexagonal Sierpinski gasket structure is loaded on a square microstrip antenna. Using fractal miniaturization techniques, the patch area is reduced by 68.4% along with 168.8% increase in the perimeter by loading several triangular slots of different dimensions in various iterations. The simulation and optimization of various iterations are analysed using Ansoft HFSS simulation tool and verified with fabricated antenna results. The proposed design presents the hexa-band, dual-polarization performance at 3.46, 8.28, 12.26, 17.21, 23.40, 26.01 frequencies (GHz) with Peak

Gain (dB) of 6, 8.37, 9.65, 9, 7.84 and 9.34 respectively. The designed miniaturized hexagonal fractal antenna exhibits high gain, high directivity, omnidirectional radiation pattern entire multi-resonant frequency and useful for modern wireless communications like 5G and IoT application, satellite and Radar applications etc.

Adewale Ayomikun Elijah, MastanehMokayef, Miniature microstrip antenna for IoT application, Materials Today: Proceedings, Volume 29, Part 1, 2020, Pages 43-47.

Wireless technology is greatly influenced by the advanced technological development of the antenna. With the rapid expansion of Internet of Things (IoT) application in the modern communication system, the demand for micro antennas is increasing. Microstrip patch antennas are generally used in IoT applications due to its compatibility. The key benefit of the microstrip antenna is that it allows easy integration into IoT devices. Thus, in this work, rectangular microstrip patch antenna is designed and the performance was analysed. In this work, the antenna resonant frequency range was 100 MHz and 5.8 GHz, which is appropriate for IoT application was used. The antenna was designed with FR-4 substrate material. For this work, CST software (version 2014) was used as simulation software. In this work, two types of antenna were designed, which was conventional microstrip antenna and optimized microstrip antenna containing U-shaped structure. The performance of these two antennas was compared in terms of bandwidth, gain and return of loss. The key results of this work showed that the optimized U-shaped antenna improved the bandwidth from 134.1 MHz to 167.6 MHz, gain from 1.83 dB to 2.54 dB and return of loss -20.32 dB to −26.56 dB compared to the conventional antenna. In addition, the optimized antenna achieved operating frequency of 5.755 GHz, which is suitable for IoT applications.

CHAPTER- 3

ANTENNA THEORY

3.1 INTRODUCTION

As an emerging technology, Ultra-Wide Band (UWB) provides a different approach compared to the conventional narrow band systems. One of the promising application area is in medicine. Formally before 2001 UWB was mainly used in military applications, but from 2002 the UWB the Federal Communication Commission (FCC) gradually allowed the commercial usage of these bandwidths. The regulated frequency for UWB technique by FCC is from 3.1GHz to 10.6GHz.

Applying Ultra-Wide Band (UWB) technology in medical applications is an emerging research trend in recent years. First attempt of using UWB radar in medical applications is in human body monitoring and imaging in 1993. On August 9, 1994, the first US Patent application was filed for medical UWB radar. One year later, MIT began an educational project for the Radar Stethoscope. In 1996, the biomedical use of UWB radars is better described with photo and sample tracings, and in the same year, the US Patent was awarded. Since then, UWB is often deemed as a possible alternative to remote sensing and imaging. Compared with X-ray imaging, UWB radar probes use non-ionizing electromagnetic waves which proved to be harmless to human body. Moreover, the UWB radar has very low average power level and is very power efficient. Thus is suitable to be a potentially cost effective way of human body imaging, especially in real time imaging. By 1999, many works have begun for UWB medical applications in cardiology, obstetrics, breath pathways and arteries.

3.2 ANTENNA BASICS

An antenna is an electrical device which converts electrical power into radio waves and vice versa. It acts like an interface between the radio waves propagating through space and electric currents moving in metal conductors, used with a transmitter or receiver. In transmission side, electric current is supplied by a radio transmitter to the antenna terminals, and the antenna radiates the energy from the current as electromagnetic waves. In reception, an antenna intercepts some of the power of a radio wave in order to produce an electric current at its terminals that is applied to a receiver to be amplified.

By definition, an antenna is a device used to transform an RF signal, traveling on a conductor, into an electromagnetic wave in free space. Antennas demonstrate a property known as reciprocity, which means that an antenna will maintain the same characteristics regardless if it is transmitting or receiving. Most antennas are resonant devices, which operate efficiently over a relatively narrow frequency band. An antenna must be tuned to the same frequency band of the radio system to which it is connected, otherwise the reception and the transmission will be impaired. When a signal is fed into an antenna, the antenna will emit radiation distributed in space in a certain way.

3.2.1 ANTENNA FIELD REGIONS

The radiation moves away from the antenna at a distance R. These changes can be split into three distinct groups as shown in Fig 3.1

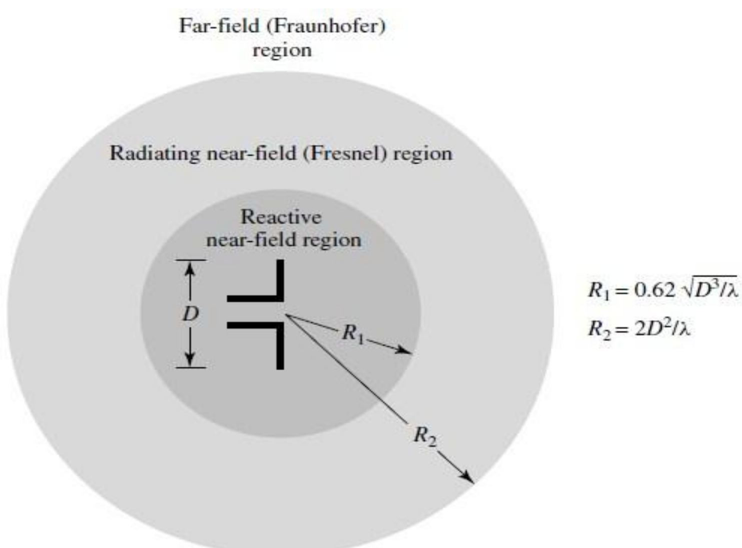


Figure 3.1 Antenna Field Regions

3.2.2 REACTIVE

In the immediate vicinity of the antenna, we have the reactive near field. In this region the fields are predominantly reactive, which means the E-field and the H-field are out of phase by 90 degrees to each other. The boundary of this region is commonly given as:

$$1. R < 0.62\sqrt{\frac{D^3}{\lambda}}$$

3.2.3 RADIATING NEAR FIELD (FRESNEL) REGION

The region between the near and far field is known as radiating near field or Fresnel region. In this region, the reactive fields are not dominate and the radiating fields begin to emerge. However, unlike the Far field region, here the shape of the radiation pattern may vary appreciably with distance. This region is commonly given by:

$$2.\ 0.62\sqrt{\frac{D^3}{\lambda}} < R < \frac{2D^2}{\lambda}$$

3.2.4 RADIATING FAR-FIELD OR FRAUNHOFER REGION

In the radiating far-field or Fraunhofer region the field components are transverse to the radial direction from the antenna and all the power flow is directed outwards in a radial fashion. In this region the shape of the field pattern is Independent of the distance R, from the antenna. The inner boundary is taken to be the distance. This region is given by:

$$3. R > \frac{2D^2}{\lambda}$$

Where, D is the largest dimension of the antenna.

3.3 ANTENNA PARAMETERS

The choice of a particular antenna depends on factors such as gain, radiation pattern, polarization, bandwidth, resonant frequency and impedance. The antenna parameters such as gain, resonant frequency, impedance etc., define the performance of the antenna.

3.3.1 RETURN LOSS

The return loss is another way of expressing mismatch. It is a logarithmic ratio measured in dB that compares the power reflected by the antenna to the power that is fed into the antenna from the transmission line. The relationship between SWR and return loss is the following:

4. $$Return\,Loss(in\ dB) = 20\log 10\ (\frac{SWR}{SWR-1})$$

3.3.2 GAIN

The gain of an antenna is usually given with reference to an isotropic radiator and expressed in units of dBi (decibels over isotropic). In practice, the gain is compared with the radiation from a single half-wave dipole fed with an equal amount of power since a perfect isotropic reference is impossible to build. In this case, units of measurement are dBd (decibels over dipole). High gain antennas are of first priority because they are able to receive even weaker signals. The relationship between dBi and dBd is given by:

5.dBi = dBd+ 2.15 dB

Where, dBi– decibel referenced to an isotropic antenna.

dBd – decibel referenced to a half wavelength dipole.

3.3.3 DIRECTIVITY

Directivity is the ability of an antenna to focus energy in a particular direction when transmitting, or to receive energy better from a particular direction when receiving. In a static situation, it is possible to use the antenna directivity to concentrate the radiation beam in the wanted direction. However in a dynamic system where the transceiver is not fixed, the antenna should radiate equally in all directions, and this is known as an Omni-directional antenna. Mathematically, the formula for directivity is given as:

$$6.\ D = \frac{1}{\frac{1}{4\pi}\iint |F(\theta,\varphi)|^2 \sin\theta d\theta d\varphi}$$

3.3.4 RESONANT FREQUENCY

Signals of different frequencies reach the antenna simultaneously and for it to be of any importance, it should be able to select only one frequency of interest at a time. That frequency is called the resonant frequency and it is achieved by the use of a tuned circuit at the receiver or transmitter. Antennas are only effective for a range of frequencies over which they can operate and this is determined by their physical length.

3.3.5 IMPEDANCE

The input impedance of an antenna determines the amount of energy it can receive or transmit. Maximum power transfer will occur when the antenna is matched to the receiver or transmitter as in accordance with the maximum power transfer theorem. Most of all, an antenna is connected to the load by a feeder (usually a coaxial cable) which is unbalanced. In consequence, the cable radiates and this affects the efficiency of energy transfer to or from the antenna.

3.3.6 BANDWIDTH

The bandwidth of an antenna describes the range of frequencies over which an antenna can radiate properly. One of the ascertaining parameter used to choose an antenna is its desired bandwidth. Many types of antenna have very narrow bandwidths and cannot be used for wideband applications. The bandwidth range can vary widely from one antenna to another antenna. Patch (Microstrip) antennas have a very low bandwidth, while spiral antennas have a very large bandwidth. Several techniques can be used to improve the bandwidth of an antenna, Tapering the elements of antennas is one of the techniques used to improve the antenna bandwidth.

3.3.7 RADIATION PATTERN

The radiation pattern of an antenna is the most important requirement since it determines the direction in which the signal is transmitted or received. It is specified by the beam width and side lobe level in the plane (vertical or horizontal) it is being measured. In most cases, the radiation pattern is determined in the far-field region as given in fig 3.2 and is represented as a function of the directional coordinates. Radiation properties include power flux density, radiation intensity, field strength, directivity phase or polarization.

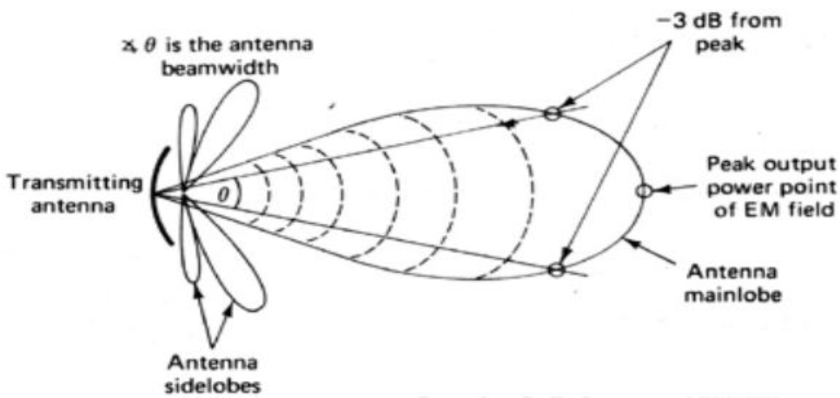


Figure 3.2 Radiation Pattern of an Antenna

3.3.8 VSWR

Standing wave ratio (SWR) is the ratio of the amplitude of a partial standing wave at antinodes (maximum) to the amplitude at an adjacent node (minimum), in an electrical transmission line. The SWR is usually defined as a voltage ratio called the VSWR, for Voltage standing wave ratio. For example, the VSWR value 1.2:1 denotes Maximum standing wave amplitude that is 1.2 times greater than the minimum Standing wave value. The voltage standing wave ratio is:

$$7. \qquad VSWR = \frac{Vmax}{Vmin} = \frac{1+r}{1-r}$$

Where,r – Reflection co-efficient

V min, V max – Minimum voltage ,Maximum voltage

3.3.9 POLARIZATION

Polarization is the orientation of the electric field of the radio wave with respect to the earth's surface. The transmitting and receiving antennas should have the same polarization for efficient radiation. Polarization classifications are shown in fig 3.3.

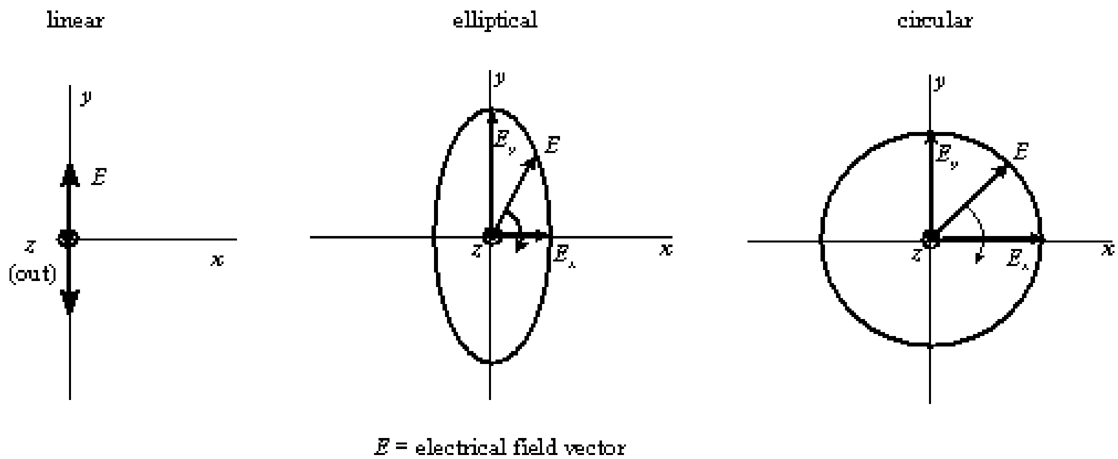


Figure 3.3 Types of Polarization

3.4 ANTENNA DESIGN EQUATIONS

The essential parameters for the design of a rectangular Microstrip Patch Antenna are:

3.4.1 Calculation of width (W)

8. $$Wp = \frac{Co}{2fr}\sqrt{\frac{2}{1+\varepsilon}}$$

Where,

W - Width of the patch

C_o - Speed of light (3×108m/s)

ε - Value of the dielectric substrate

3.4.2 Calculation of effective Dielectric constant ( )

9. $\varepsilon_{ref} = \frac{\varepsilon+1}{2} + \frac{\varepsilon-1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}}$

Where,

W - Width of the patch

3.4.3 Calculation extension Length

It is used for calculating resonant frequency of Microstrip antenna.

10. $\Delta L = 0.412\,\frac{(\varepsilon+0.3)\left(\frac{W_p}{h}-0.264\right)}{(\varepsilon-0.258)\left(\frac{W_p}{h}-0.8\right)}$

Where,

W_p - Width of the patch

3.4.4 Calculation of Length (L)

Effective Length (Leff):

11. $L_{eff} = \frac{V_f}{2f*\sqrt{\varepsilon}}$

Actual Length (L):

12. $L = L_{eff} - 2\Delta L$

Where,

ε_{ref} - Effective dielectric constant

3.5 ADVANTAGES AND DISADVANTAGES

3.5.1 ADVANTAGES

- They operate at microwave frequencies where traditional antennas are not feasible to be designed.
- This antenna type has smaller size and hence will provide small size end devices.
- The microstrip based antennas are easily etched on any PCB and will also provide easy access for troubleshooting during design and development. This is due to the fact that microstrip pattern is visible and accessible from top. Hence, they are easy to fabricate and comfortable on curved parts of the device. Hence it is easy to integrate them with MICs or MMICs.
- As the patch antennas are fed along centre line to symmetry, it minimizes excitation of other undesired modes.
- The microstrip patches of various shapes e.g., rectangular, square, triangular etc. are easily etched.
- They have lower fabrication cost and hence they can be mass manufactured.
- They are capable of supporting multiple frequency bands (dual, triple).
- They support dual polarization types viz. linear and circular both.
- They are light in weight.
- They are robust when mounted on rigid surfaces of the devices.

3.5.2 DISADVANTAGES

- The spurious radiation exists in various microstrip based antennas such as microstrip patch antenna, microstrip slot antenna and printed dipole antenna.
- It offers low efficiency due to dielectric losses and conductor losses.
- It offers lower gain and It has higher level of cross polarization radiation.
- It has lower power handling capability.

- It has inherently lower impedance bandwidth.
- The microstrip antenna structure radiates from feeds and other junction points.

3.6 APPLICATIONS OF MICROSTRIP ANTENNA

The Microstrip patch antennas are well known for their performance and their robust design, fabrication and their extent usage. The advantages of this Microstrip patch antenna are to overcome their de-merits such as easy to design, light weight etc., the applications are in the various fields such as in the medical applications, satellites and of course even in the military systems just like in the rockets, aircrafts missiles etc. the usage of the Microstrip antennas are spreading widely in all the fields and areas and now they are booming in the commercial aspects due to their low cost of the substrate material and the fabrication. It is also expected that due to the increasing usage of the patch antennas in the wide range this could take over the usage of the conventional antennas for the maximum applications. Microstrip patch antenna has several applications. Some of these applications are discussed as below:

3.6.1MOBILE AND SATELLITE COMMUNICATION APPLICATION

Mobile communication requires small, low-cost, low-profile antennas. Microstrip patch antenna meets all requirements and various types of microstrip antennas have been designed for use in mobile communication systems. In case of satellite communication circularly polarized radiation patterns are required and can be realized using either square or circular patch with one or two feed points.

3.6.2GLOBAL POSITIONING SYSTEM APPLICATIONS

Nowadays microstrip patch antennas with substrate having high permittivity sintered material are used for global positioning system. These antennas are circularly polarized, very compact and quite expensive due to its positioning. It is expected that millions of GPS receivers will be used by the general population for land vehicles, aircraft and maritime vessels to find there position accurately.

3.6.3RADIO FREQUENCY IDENTIFICATION (RFID)

RFID uses in different areas like mobile communication, logistics, manufacturing, transportation and health care . RFID system generally uses frequencies between 30 Hz and 5.8 GHz depending on its applications. Basically RFID system is a tag or transponder and a transceiver or reader.

3.6.4WORLDWIDE INTEROPERABILITY FOR MICROWAVE ACCESS (WIMAX)

The IEEE 802.16 standard is known as WiMax. It can reach up to 30 mile radius theoretically and data rate 70 Mbps. MPA generates three resonant modes at 2.7, 3.3 and 5.3 GHz and can, therefore, be used in WiMax compliant communication equipment.

3.6.5RADAR APPLICATION

Radar can be used for detecting moving targets such as people and vehicles. It demands a low profile, light weight antenna subsystem, the microstrip antennas are an ideal choice. The fabrication technology based on photolithography enables the bulk production of microstrip antenna with repeatable performance at a lower cost in a lesser time frame as compared to the conventional antennas.

3.6.6TELEMEDICINE APPLICATION

In telemedicine application antenna is operating at 2.45 GHz. Wearable microstrip antenna is suitable for Wireless Body Area Network (WBAN). The proposed antenna achieved a higher gain and front to back ratio compared to the other antennas, in addition to the semi directional radiation pattern which is preferred over the omni-directional pattern to overcome unnecessary radiation to the user's body and satisfies the requirement for on-body and off-body applications. A antenna having gain of 6.7 dB and a F/B ratio of 11.7 dB and resonates at 2.45GHz is suitable for telemedicine applications.

3.6.7MEDICINAL APPLICATIONS OF PATCH

It is found that in the treatment of malignant tumours the microwave energy is said to be the most effective way of inducing hyperthermia. The design of the particular radiator which is to be used for this purpose should posses light weight, easy in handling and to be rugged. Only the patch radiator fulfils these requirements. The initial designs for the Microstrip radiator for inducing hyperthermia was based on the printed dipoles and annular rings which were designed on S-band. And later on the design was based on the circular microstrip disk at L-band. There is a simple operation that goes on with the instrument; two coupled Microstrip lines are separated with a flexible separation which is used to measure the temperature inside the human body. A flexible patch applicator can be seen in the figure below which operates at 430 MHz.

3.7 FEEDING METHODS

The excitation of the radiating element is an essential and important factor, which requires careful consideration in designing a most appropriate antenna for a particular application. A wide variety of feed mechanisms are available, not just for coupling energy to individual elements, but also for the controlled distribution of energy to linear or planner array elements.

The feed element may be either co-planer with the radiating elements, or situated in a separate transmission-line layer. Therefore, a brief over view of only four most popular Microstrip Antenna Feed techniques are given. These are namely:

- Microstrip line
- Co-axial Probe

- Aperture coupling

- Proximity coupling.

3.7.1MICROSTRIP LINE FEED

Microstrip line feed is based on the principle that cutting an inset in the patch does not significantly affect the resonant frequency but that it modifies the input impedance. By properly selecting the depth of the inset, one can match the path to the transmission line without additional matching elements.

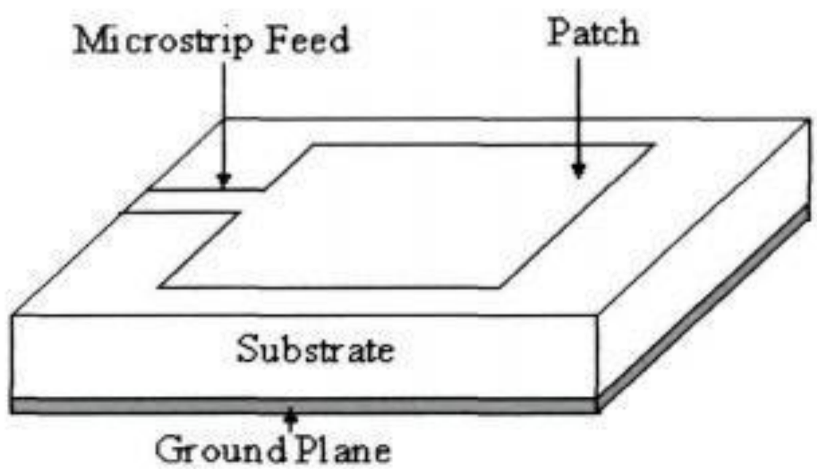


Figure 3.4 Microstrip patch antenna with microstrip line feed.

The feed was the first used for practical applications and is the simplest way to feed a microstrip patch is to connect a microstrip line directly to the edge of the patch, with both elements located on the same substrate. The microstrip line feed though simple in nature but a microstrip structure with the line and patch cannot be optimized simultaneously as an antenna and a transmission line. There must be some compromise between the two so that feed line does not radiate too much at the discontinuities. The spurious radiation and the accumulated reactive power below the patch (cavity effect), degrades the antenna performance and reduces its bandwidth

3.7.2CO-AXIAL LINE FEED

Co-axial line feed was among the first considered and even today one of the most popular in many applications of microstrip patch antenna. In co-axial line feed, the inner conductor of the coax is extending across the dielectric substrate and is connected to the patch while the outer conductor is connected to the ground plane as shown in the figure 3.5

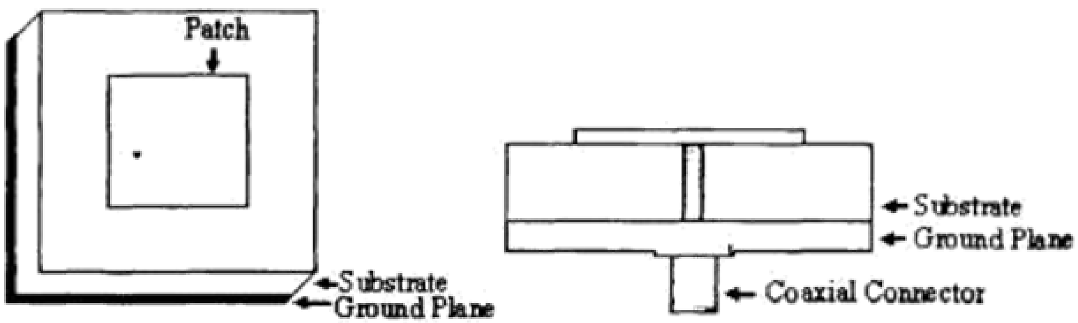
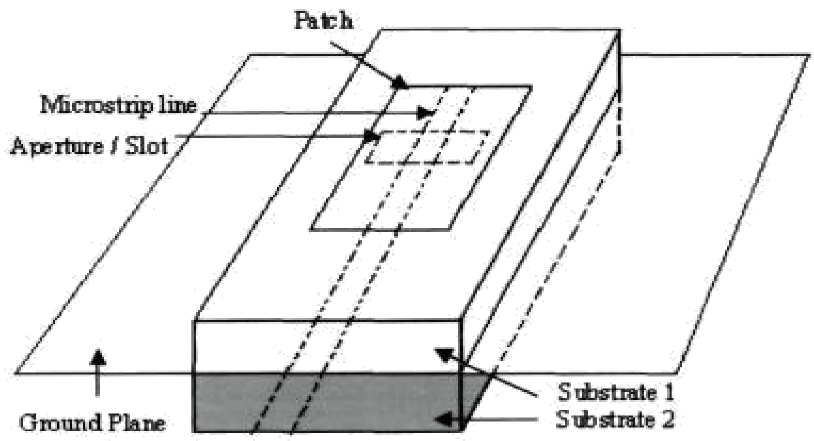


Figure 3.5 Microstrip Patch antenna with coaxial line feed.

In case of coaxial line feed the intrinsic radiation from the feed is small and can be neglected for thin substrates but becomes significant with thicker substrates. Now, most of the theoretical developments consider coaxial feeds and models were developed to characterize the injection of current in to patch accurately. However, coaxial feeds are difficult to realize in practice because drilling or punching holes through the substrate in a particular specific point is critical task, generally this operation would like to avoid. Again introducing the conductor through the holes and soldered to the patch are delicate operations that require careful handling, and mechanical control of the connection is difficult, especially for very high frequencies.

3.7.3APERTURE COUPLING

In a conventional aperture coupling, the microstrip patch antenna consists of



two substrate layers separated by a common ground plane. The radiating microstrip layer on the top of the substrate is fed through an aperture in the ground plane by a microstrip feed line lying on the bottom of the lower substrate. The important requirement is that the common ground plane should contain etched apertures accurately positioned below the microstrip patch and above the feed line. Figure 3.6 shows an Aperture coupled feed microstrip patch antenna.

Figure 3.6 Aperture coupled feed microstrip patch antenna.

The aperture coupled feed technique has many attractive features; one is it provides stronger coupling than a similar triplet or suspended stripline system because of higher concentration of fields above the feed line where the aperture is positioned. Furthermore, a relatively high-permittivity substrate can be used if required for the feed system, without compromising the radiating properties of the lower-permittivity substrate carrying the microstrip patches. In this technique, the slot on the common ground plane is free to radiate bidirectionally. By using multilayer substrate, it can be made unidirectional radiation, but may result in strongly coupled surface wave modes which degraded in the antenna efficiency.

3.7.4PROXIMITY COUPLING

In this feeding technique, the coupling of the patch and the feed line is obtained by placing the patch and the feed at different substrate levels. A thin layer of high dielectric constant substrate is used to reduce the radiation from the feed lines, where as a thick layer of low dielectric constant substrate is used in the upper layer to increase the radiation of the patch. The length of the feeding stub and the width-to-line ratio of the path can be used to control the match. Using the proximity coupling, the frequency band width of a patch resonator could be significantly widened. The special feature is that, the feed line is no longer located to an open surface and there is no need to solder different conductors, unlike co-axial feed. The resulting structure becomes more complex to build, with two dielectric layers instead of one. Again, one cannot easily connect components within the feeding circuit as it is buried inside substrate.

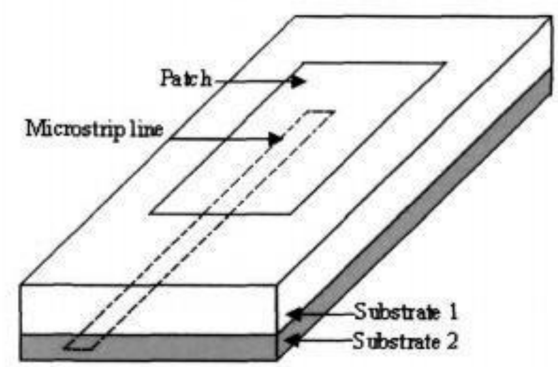


Figure 3.7 Proximity couple feed microstrip patch antenna

Antenna Design Considerations In this paper,a rectangular patch with dimensions 14 mm×16 mm has been designed. Two equal slots are cut from the patch having length 3mm and width 10.5mm. Here FR4 inexpensive substance is used as a substrate with dielectric constant of 4.3 and loss tangent of 0.02. Coaxial feed has been used and feed point is selected in such way that impedance matching takes place.Before designing the antenna structure following three essential parameters are considered

1.Frequency of operation (fr):

The resonantfrequency of the antenna must be selecte appropriately. The resonant frequency for the antenna design is 8 GHz.

2. Dielectric Constant of Substrate(Er):

The substrate considered for the design is FR4 sheet which has a dielectric constant of 4.3.A substrate with a high dielectric constant diminishes size of theantenna.

3. Altitude of dielectric substrate (h):

For the microstrip patch antenna it is indispensable that the transmitter is not massive.Therefore, the height of the dielectric substrate is selected as 1.574mm.

Dual Band Miccrostrip Patch antenna at X and Ku band has been successfully designed. The optimized results shown in this paper depict that designed antenna verifies all the necessary parameters for for faithful operation. The dimesions of substrates affects the frequency response of antenna after doing finite no. of simulation antenna gives approximate -28 dB return loss at 9.1 Ghz frequency band and -24 dB return loss at 14 GHz band.Shape and dimesions of the slots improve the return loss and radiation pattern of the designed antenna. The designed dual band antenna has omnidirectional radiation pattern at X and Ku bands with 4.6 dB and 4.9 gain.From Smith chart and VSWR graphs it is clear that patch antenna is perfectly matched with characteristic impedance.The proposed microstrip patch antenna has 1.2 Ghz and 833 Mhz bandwidth at X and Ku bands respectively.Asku band has lower bandwidth than X band,in future work bandwidth of ku band can be improved further by applying defected ground structure.The designed dual band antenna can be used for satellite and radar applications.

In this proposed work, a novel method of dual-band slotted Microstrip Patch Antenna for satellite communication and Radar application purposes has been staged. The proposed dual-band antenna is designed by introducing radiating patch of the antenna and two U shaped slots in order to attain a dual-band operating frequencies. This dual-band patch antenna operates at two different frequency bands at 9.1 GHz and 14 GHz which are in the range of X (8-12GHz) and Ku (12-18GHz) bands respectively. The antenna is designed from perfect electic conductor (PEC) radiating patch located above substrate of the Flame Retardant 4 (FR4) dielectric material and this substrate is a medium that connects the top radiating patch to the ground plane. The proposed antenna of size 14mm×16 mm is fed by coaxial feed and exhibits excellent bandwidth of 1.2 GHz and 833 MHz at X band and Ku band respectively. This proposed dual band antenna is designed and simulated using user friendly software CST Microwave studio 2010.

Micro strip antennas are low-profile antennas. A metal patch mounted at a ground level with a di-electric material in-between constitutes a **Micro strip** or **Patch Antenna**. These are very low size antennas having low radiation.

3.8 FREQUENCY RANGE

The patch antennas are popular for low profile applications at frequencies above **100MHz**.

3.9 CONSTRUCTION & WORKING OF MICRO STRIP ANTENNAS

Micro strip antenna consists of a very thin metallic strip placed on a ground plane with a di-electric material in-between. The radiating element and feed lines are placed by the process of photo-etching on the di-electric material. Usually, the patch or micro-strip is choosen to be square, circular or rectangular in shape for the ease of analysis and fabrication. The following image shows a micro-strip or patch antenna.

The length of the metal patch is λ/2. When the antenna is excited, the waves generated within the di-electric undergo reflections and the energyis radiated from the edges of the metal patch,which is very low.

3.10 RADIATION PATTERN

The radiation pattern of microstrip or patch antenna is broad. It has low radiation power and narrow frequency bandwidth.

The **radiation pattern** of a microstrip or patch antenna is shown above. It has lesser directivity. To have a greater directivity, an array can be formed by using these patch antennas.

3.11 ADVANTAGES

The following are the advantages of Micro strip antenna −

- Lighteweight
- Low cost
- Ease of installation

3.12 DISADVANTAGES

The following are the disadvantages of Micro strip antenna −

- Inefficient radiation
- Narrow frequency bandwidth

3.13 APPLICATIONS

The following are the applications of Micro strip antenna −

- Used in Space craft applications
- Used in Air craft applications
- Used in Low profile antenna applications

CHAPTER 4

INTRODUCTION TO CSTSTUDIO

4.1 INTRODUCTION

Computer Simulation Software offers accurate, efficient computational solutions for electromagnetic design and analysis. Our user-friendly 3D EM simulation software enables you to choose the most appropriate method for the design and optimization of devices operating in a wide range of frequencies.

The main product of CST is CST STUDIO SUITE, which comprises various modules dedicated to specific application areas. There are modules for

- Microwave and RF applications (CST MICORWAVE STUDIO)
- Low frequency (CST EM STUDIO)
- PCBs and packages (CST PCB STUDIO)
- Cable harnesses (CST CABLE STUDIO)
- Temperature and mechanical stress (CST MPHYSICS STUDIO)
- Interaction of charged particles and electromagnetic fields (CST PARTICLE STUDIO)

Users of CST simulation software work mainly in the areas of microwaves and RF, EMC/EMI, particle acceleration, and various low frequency applications.
Accordingly, the client is widespread and comprises industries such as aerospace, automation, automotive, electronics, power engineering, and medical.

4.2 CST MICROWAVE STUDIO

CST MICROWAVE STUDIO is a full-featured software package for Electromagnetic analysis and design in the high frequency range. It simplifies the process of inputting the structure by providing a powerful solid 3D modeling front end. Strong graphic feedback simplifies the dentition of your device even further. After the component has been modelled, a fully automatic meshing procedure is applied before a simulation engine is started.

CST MICROWAVE STUDIO is part of the CST DESIGN STUDIO suite and offers a number of different solvers for different types of application. Since no method works equally well in all application domains, the software contains four different simulation Techniques (transient solver, frequency domain solver, integral equation solver, Eigen mode solver) to best fit their particular applications. The most flexible tool is the transient solver, which can obtain the entire broadband frequency behavior of the simulated device from only one calculation run (in contrast to the frequency step approach of many other simulators).It is based on the Finite Integration Technique (FIT) introduced in electrodynamics more than three decades ago. This solver is efficient for most kinds of high frequency applications such as connectors, transmission lines, filters, antennas and more.

The CST microwave studio simulation software is used to design and optimize the antenna parameters of dual band operation. The proposed antenna produces wide impedance bandwidth with good radiation pattern. Length (Ls) and Width (Ws) of substrate have great effect on the resonant frequencies of the designed dual band antenna. By optimizing the dimesions of substrate desired dual band frequency response of the antenna can be achieved.U shaped slots improve the return loss of X band and Ku bands and also make antenna to operate at dual frequency bands by eliminating other undesired frequencies.

4.2.1 SIMULATION WORK FLOW

After starting CST DESIGN ENVIRONMENT, choose to create a new CST MICROWAVE STUDIO project. You will be asked to select a template for a structure which is closest to your device of interest, but you can also start from scratch opening an empty project. An interesting feature of the on-line help system is the Quick Start Guide, an electronic assistant that will guide you through your simulation. You can open this assistant by selecting Help quick start guide if it does not show up automatically. If you are unsure of how to access a certain operation, click on the corresponding line .The quick start guide will the neither run an animation showing the location of the related menu entry or open the corresponding help page. As shown in the quick start-dialog box which should now be positioned in the upper right corner of the main view, the following steps have to be accomplished for a successful simulation.

4.2.2 DEFINE THE UNITS

Choose the settings which make defining the dimensions, frequencies and time steps for your problem most comfortable. The defaults for this structure type are geo-metrical lengths in mm and frequencies in GHz.

4.2.3 DEFINE THE BACKGROUND MATERIAL

By default, the modelled structure will be described within a perfectly conducting world. For an antenna problem, these settings have to be modified because the structure typically radiates in an unbounded (open) space or half-space. In order to change these settings, you can make changes in the corresponding dialogue box.

4.2.4 MODEL THE STRUCTURE

Now the actual antenna structure has to be built. For modeling the antenna structure, a number of different geometrical design tools for typical geometries such as plates, cylinders, spheres etc. are provided in the CAD section of CST MICROWAVE STUDIO. These shapes can be added or intersected using Boolean operators to build up more complex shapes. An overview of the different methods available in the tool-set and their properties is included in the on-line help.

4.2.5 DEFINE THE FREQUENCY RANGE

The next setting for the simulation is the frequency range of interest. You can specify the frequency by choosing Solve Frequency from the main menu. Since you have already set the frequency units (to GHz for example), you need to define only the absolute numbers here (i.e. without units). The frequency settings are important because the mesh generator will adjust the mesh refinement (spatial sampling) to the frequency range specified.

4.2.6 DEFINE PORTS

Every antenna structure needs a source of high-frequency energy for excitation of the desired electromagnetic waves. Structures may be excited e.g. using impressed currents or voltages between discrete points or by wave-guide ports. The latter are pre-defined surfaces in which a limited number of Eigen modes are calculated and may be stimulated. The correct definition of ports is very important for obtaining accurate S-parameters.

4.2.7 DEFINE BOUNDARY AND SYMMETRY CONDITIONS

The simulation of this structure will only be performed within the bounding box of the structure. You may, however, specify certain boundary conditions for each plane (xmin; xmax; ymin etc.) of the bounding box taking advantage of the symmetry in your specific problem. The boundary conditions are specified in a dialogue box that opens by choosing Solve Boundary Conditions from the main menu.

4.2.8 SET FIELD MONITORS

In addition to the port impedance and S-parameters which are calculated automatically for each port, field quantities such as electric or magnetic currents, power flow, equivalent currents density or radiated far field may be calculated. To invoke the calculation of these output data, use the command Solve Field Monitors. Start the Simulation after defining all necessary parameters. Start the simulation from the transient solver control dialogue box: Solve Transient Solver. In this dialogue box, you can specify which column of the S-matrix should be calculated. Therefore, select the Source type port for which the couplings to all other ports will then be calculated during a single simulation run.

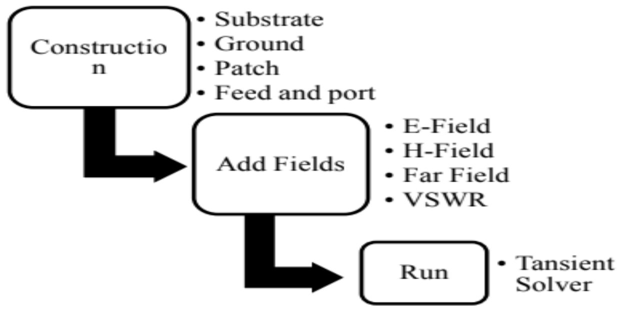


Figure 4.1 Design flow

4.3 CONCLUSION

In this chapter the overview of Ultra wideband antenna and antenna basics is discussed. Various fields and regions of radiating antenna from which the properties are studied. Antenna measuring techniques refers to the testing of antennas to make sure that the antenna meets specifications and characteristics to realize the specified result. Some such parameters of antennas are return loss, gain, directivity, resonant frequency, impedance, bandwidth, radiation pattern, VSWR and polarization which were discussed in detail. The calculation of antenna dimensions is done through the standard predefined equations and these equations are employed to obtain the required measurements. Merits and demerits of the UWB antenna are explored. In this chapter the software tool used for simulation is briefed. CST STUDIO SUITE and its various products are employed for the design and optimization purposes of devices operating in wide range of frequencies. It is used in several applications such as Microwave and RF applications, low frequency applications, PCBs and packages, cable harnesses and for calculation of temperature and mechanical stress. An overview of this tool is given and its method of proceedings are shown. The above steps have to be accomplished for a successful simulation.Microstrip antennas find growing applications in numerous fields due to their reduced interference and cost effectiveness. The four most popular feed techniques used are the microstrip line, coaxial probe, aperture coupling and proximity coupling were reviewed.

CHAPTER-5

ANTENNA DESIGN

5.1 INTRODUCTION

The most critical part of the system is the antenna to be used. The antenna used in the system should act as a transceiver i.e. it should both transmit as well as receive the microwaves. Similar types of antenna are arranged in a pattern to create the array. Many types of antenna are available. And the selection of the antenna to be used in the system is based on the size and the directivity and the bandwidth range and its efficiency. Patch antenna which is also called as the microstrip is used in the system because of its size (very small), comparatively low cost, low profile and ease of fabrication. In general Patch antenna comes in different size and shape according to the application in which it has to be used and the operating frequency of the system. Some of the standard shapes of the patch antenna used are rectangle, square, circular and triangle. Also, the shape of the patch antenna can be decided by the user based on the application.

To Design a microstrip patch antenna, there are various parameters which have to be considered that will affect the antenna bandwidth as well as the resonating frequency.

5.2 FRINGING EFFECT

It is the fringing fields that are responsible for the radiation. The fringing fields near the surface of the patch antenna will be in the y direction. Hence, the fringing E-fields on the microstrip antenna sum up in phase and hence producing the radiation of the microstrip antenna. To describe about the fringing effect, an effective dielectric constant εr is used. The effective dielectric constant is defined as the dielectric constant of the stable dielectric material and is given by

13. $$\epsilon_{reff} = \frac{\epsilon_{reff}+1}{2} + \frac{\epsilon_{reff}-1}{2}[1+12\frac{h}{W}]^{\frac{-1}{2}}$$

5.3 ANTENNA LENGTH AND WIDTH

The Shape of the patch is the main parameter that naturally affects the antenna characteristics. The width of the patch should be selected accordingly in order to get better radiation efficiency. The length of the patch determines the resonant frequency and it is the crucial parameter in the design, however the length of the patch is given by the formula.

$$14. \quad L = L_{eff} - 2\Delta L$$

The effective length of the microstrip patch antenna is

$$15. \quad L_{eff} = \frac{c}{2f\sqrt{\epsilon_{reff}}}$$

The extension of the length is

$$16. \quad \Delta L = 0.5h$$

The following equation is used to calculate the width of the antenna and is given by

$$17. \quad W = \frac{c}{2f}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Where *f* is the resonant frequency, C is the velocity of light in free space (C = $3x10^8$ m/s), εreff is the effective dielectric constant and εr is the dielectric constant of substrate.

5.4 GEOMETRY OF THE PROPOSED ANTENNA

The geometry of the proposed antenna is shown in figure below. The total size of the antenna is 12x13mm. The antenna is made up of 3 layers named ground, substrate and patch. The patch and ground are made of copper and the substrate is made up of FR4 material with a dielectric value of 4.3. The thickness of the substrate is 1.6mm and the thickness of the patch and ground is 0.035mm.

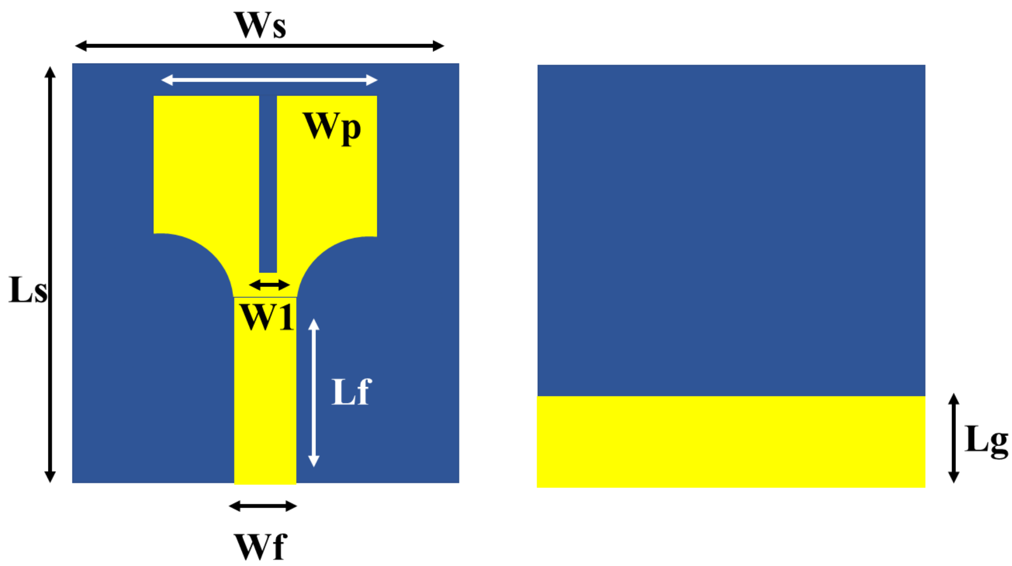


Figure 5.1 Proposed antenna design

Table 5.1 Antenna Dimensions

Sl.No	Parameter	Dimension (mm)
1	Ws	12
2	Ls	13
3	Lg	2.5
4	Wf	3.1
5	Lf	4.5
6	Wp	9
7	W1	0.5

CHAPTER- 6

RESULT & DISCUSSION

6.1 EXPERIMENTAL SET UP

The figure shown below shows the simulation setup where the antenna is designed and a port is connected to the feed to energize the antenna so that the antenna starts radiating. The antenna parameters like reflection coefficient, Bandwidth, VSWR, Gain, Directivity and radiation pattern where analysed.

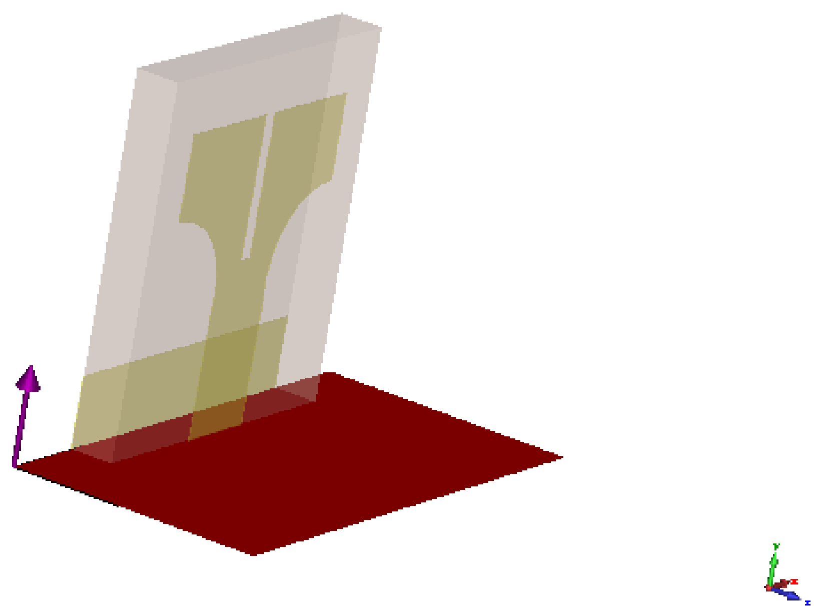


Fig 6.1 Simulation setup in CST Studio

6.2 REFLECTION COEFFICIENT (S11)

The S11 for the proposed antenna is illustrated in fig 6.2. The proposed antenna has a resonant frequency at F= 5.09 GHz. The proposed antenna produces a bandwidth from 4.34 GHz to 6.18 GHz. The return loss obtained for the resonant frequency is around -27.56 dB.

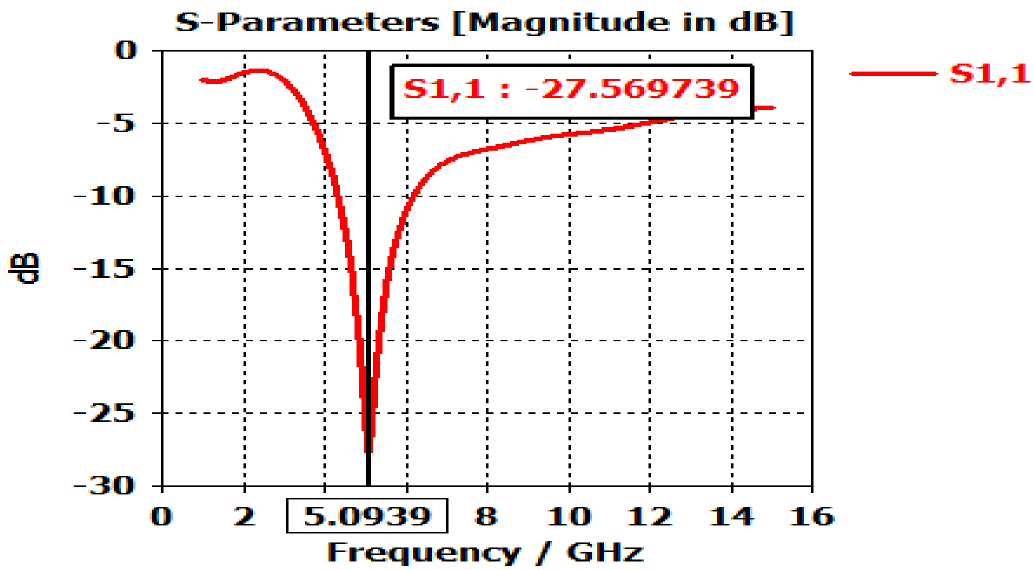


Fig 6.2 S11 for proposed antenna

6.3 VOLTAGE STANDING WAVE RATIO (VSWR)

VSWR (Voltage Standing Wave Ratio), is a measure of how efficiently radio-frequency power is transmitted from a power source, through a transmission line, into a load (for example, from a power amplifier through a transmission line, to an antenna). In an ideal system, 100% of the energy is transmitted. The VSWR is always a real and positive number for antennas. The smaller the VSWR is, the better the antenna is matched to the transmission line and the more power is delivered to the antenna. The minimum VSWR is 1.0. In this case, no power is reflected from the antenna, which is ideal.

Often antennas must satisfy a bandwidth requirement that is given in terms of VSWR. For instance, an antenna might claim to operate from 100-200 MHz with VSWR<3. This implies that the VSWR is less than 3.0 over the specified frequency range. This VSWR specifications also implies that the reflection coefficient is less than 0.5.

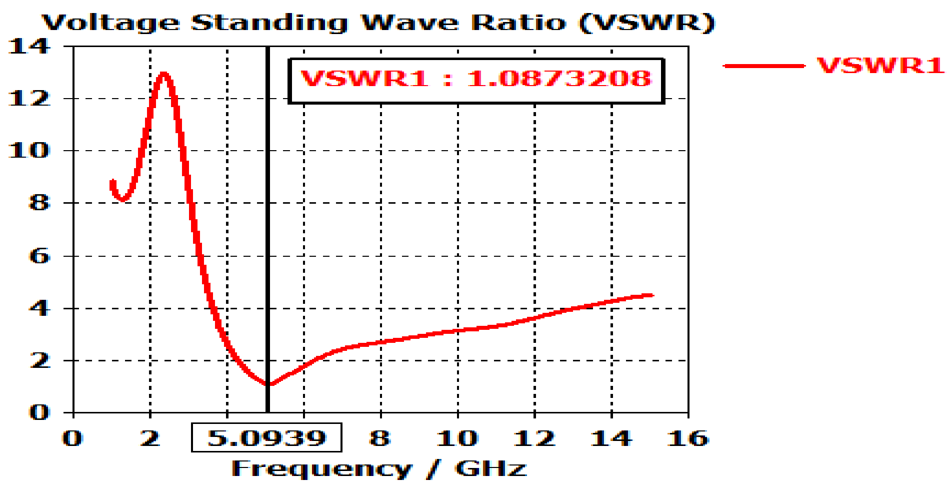


Fig 6.3 VSWR for proposed antenna

6.4 GAIN OF PROPOSED ANTENNA DESIGN

The obtained gain for the proposed antenna design is around 0.86 dBi. The 3d view of the antenna gain is shown in fig. 6.4. The gain is calculated for the resonant frequency f=5.09 GHz.

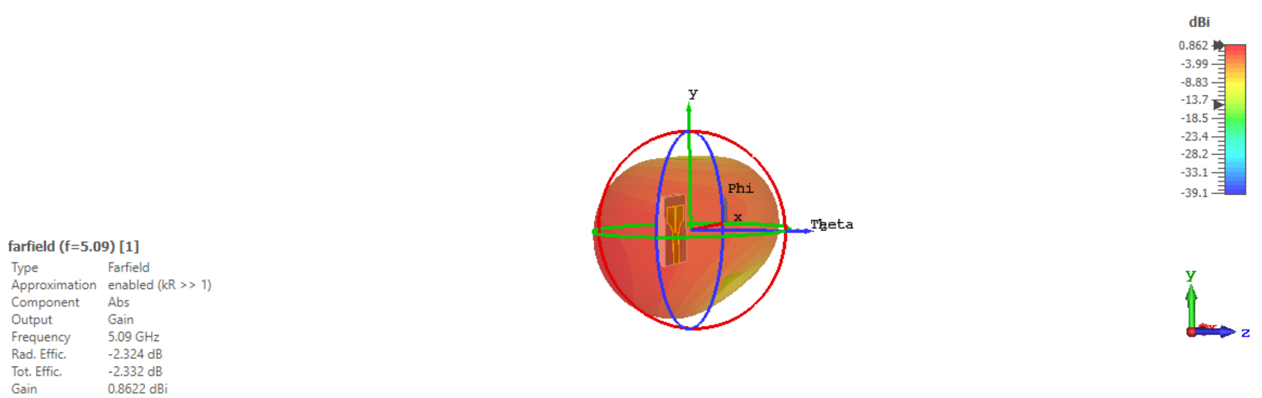


Fig 6.4 Obtained Gain for proposed antenna

6.5 DIRECTIVITY OF PROPOSED ANTENNA DESIGN

The obtained directivity for the proposed antenna design is around 3.186 dBi. The 3d view of the antenna directivity is shown in fig. 6.5. The directivity is calculated for the resonant frequency f=5.09 GHz.

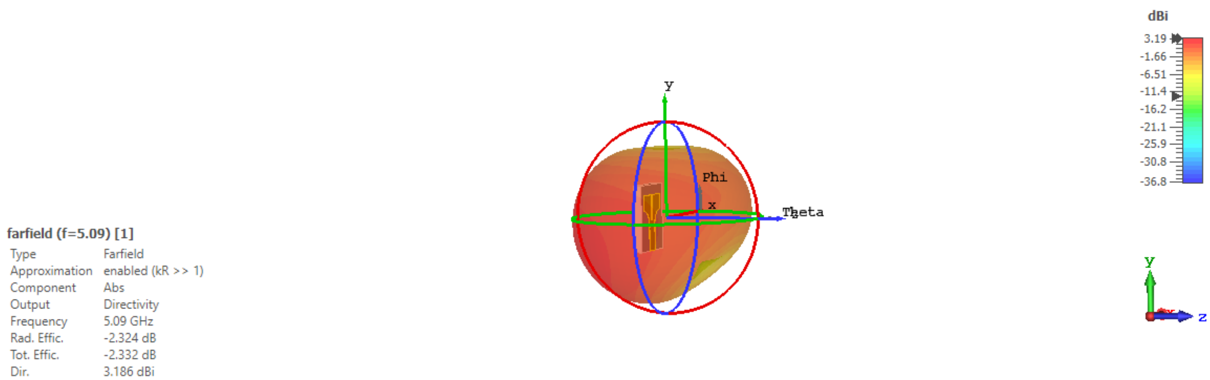


Fig 6.5 Obtained Directivity for proposed antenna

6.6 RADIATION PATTERN OF PROPOSED ANTENNA

The energy radiated by an antenna is represented by the Radiation pattern of the antenna. Radiation Patterns are diagrammatical representations of the distribution of radiated energy into space, as a function of direction. The radiation patterns can be field patterns or power patterns. The field patterns are plotted as a function of electric and magnetic fields. They are plotted on logarithmic scale. The power patterns are plotted as a function of square of the magnitude of electric and magnetic fields. They are plotted on logarithmic or commonly on dB scale.The major part of the radiated field, which covers a larger area, is the main lobe or major lobe. This is the portion where maximum radiated energy exists. The direction of this lobe indicates the directivity of the antenna. The other parts of the pattern where the radiation is distributed side wards are known as side lobes or minor lobes. These are the areas where the power is wasted.

6.6.1 H-PLANE RADIATION PATTERN OF PROPOSED ANTENNA DESIGN

The H-plane radiation pattern is generated by selecting (phi=90) and the corresponding graph is shown in fig 6.6. In this radiation pattern the shape is in donut shape and the main lobe is directed towards 164^0 at frequency f=5.09Ghz.

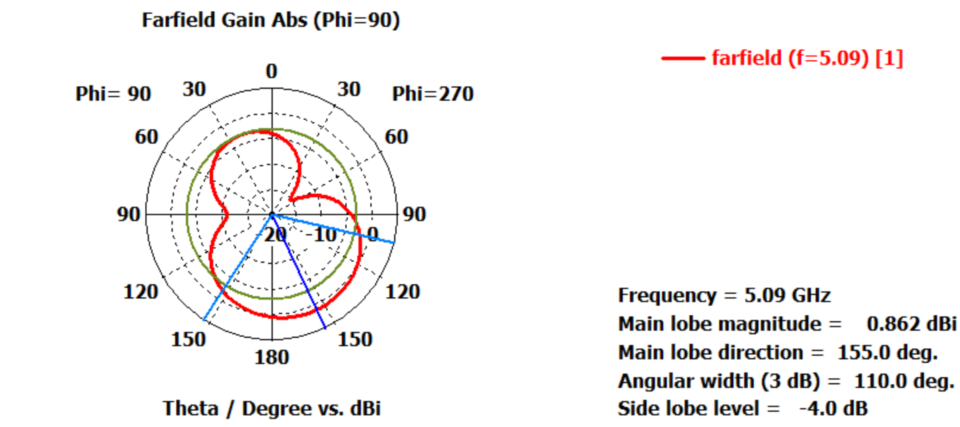


Fig 6.6 H-plane radiation pattern of Proposed Antenna

6.6.2 E-PLANE RADIATION PATTERN OF PROPOSED ANTENNA

The E-plane radiation pattern is generated by selecting (phi=0) and the corresponding graph is shown in fig 6.7. In this radiation pattern the shape is in donut shape and the main lobe is directed towards 180^0 at frequency f=5.09Ghz.

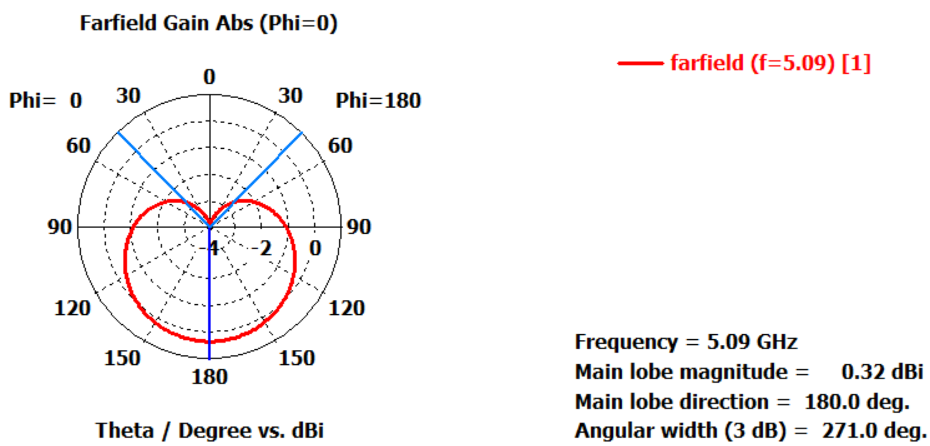


Fig 6.7 E-plane radiation pattern of Proposed Antenna

CHAPTER-7

CONCLUSION AND FUTURESCOPE

A novel miniaturized microstrip patch antenna was designed and simulated in CST studio software tool. The designed antenna is 12x13mm dimension which is very compact in size.

The designed antenna abled to resonate at 5.09 GHz frequency and produce a gain and directivity of 0.86 and 3.18 dBi respectively. The performance of the antenna is obtained by introducing partial ground and slotted patch. Because of the introduction of partial ground the ability to provide better gain is reduced. Since a full ground will act as reflector. The return loss value obtained for the resonant frequency of 5.08GHz is -27.56 dB. The antenna can be used for wireless communication applications like wifietc…

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