MONOPOLE ANTENNA WITH BIO INSPIRED PATCH FOR UWB APPLICATIONS

A Project report submitted in partial fulfillment of the requirements for the award of the degree of

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IN

ELECTRONICS AND COMMUNICATION ENGINEERING

Submitted by

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ANIL NEERUKONDA INSTITUTE OF TECHNOLOGY AND SCIENCES

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CERTIFICATE

This is to certify that the project report entitled **"MONOPOLE ANTENNA WITH BIO INSPIRED PATCH FOR UWB APPLICATIONS"** submitted by in partial fulfillment of the requirements for the award of the degree of **Bachelor of Engineering B.YOGITA SAI SRUTHI(315126512023), I.LAKSHMAN(315126512051), B.MANISH KUMAR(315126512020), K.ANURADHA(315126512065)** in **Electronics & Communication Engineering** of Andhra University, Visakhapatnam is a record of bonafide work carried out under my guidance and supervision.

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ABSTRACT

A printed monopole antenna with bio-inspired leaf structured antenna for UWB applications is proposed in this document. The antenna was designed using FR4 Epoxy as substrate having 4.4 dielectric constant and the thickness of the substrate is 1.6mm. The leaf structure is obtained by combaining an ellipse with a triangular structure created using polylines. Later this leaf is scaled, moved and duplicated to obtain two petal and 3-petal leaf structure. A comparision was made among single petal, two petal and three petal antenna based on the performance parameters like bandwidth VSWR and Gain. The bandwidth obtained for the proposed antenna is 15.52 dB with VSWR is less than 2 throughout the band range. Also the 2D gain plots for the corresponding three antenna structures are resulting good gain values.

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LIST OF ABBREVATIONS

PIFA : Planar Inverted F Antenna

WLAN :Wireless Local Area Network

WIMAX :World wide Interperobility for Microwave Access

VSWR :Voltage Standing Wave Ratio

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1.ANTENNA FUNDAMENTALS

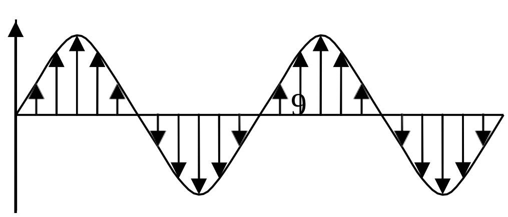
In this chapter, the basic concept of an antenna is provided and its working is explained. Next, some critical performance parameters of antennas are discussed. Finally, some common types of antennas are introduced.

1.1 Introduction

Antennas are metallic structures designed for radiating and receiving electromagnetic energy. An antenna acts as a transitional structure between the guiding device (e.g. waveguide, transmission line) and the free space. The official IEEE definition of an antenna as given by Stutzman and Thiele follows the concept: “That part of a transmitting or receiving system that is designed to radiate or receive electromagnetic waves”.

How an Antenna radiates?

In order to know how an antenna radiates, let us first consider how radiation occurs. A conducting wire radiates mainly because of time-varying current or an acceleration (or deceleration) of charge. If there is no motion of charges in a wire, no radiation takes place, since no flow of current occurs. Radiation will not occur even if charges are moving with uniform velocity along a straight wire. However, charges moving with uniform velocity along a curved or bent wire will produce radiation. The radiation from an antenna can be explained with the help of Figure 1.1 which shows a voltage source connected to a two conductor transmission line. When a sinusoidal voltage is applied across the transmission line, an electric field is created which is sinusoidal in nature and this results in the creation of electric lines of force which are tangential to the electric field. The magnitude of the electric field is indicated by the bunching of the electric lines of force. The free electrons on the conductors are forcibly displaced by the electric lines of force and the movement of these charges causes the flow of current which in turn leads to the creation of a magnetic field.



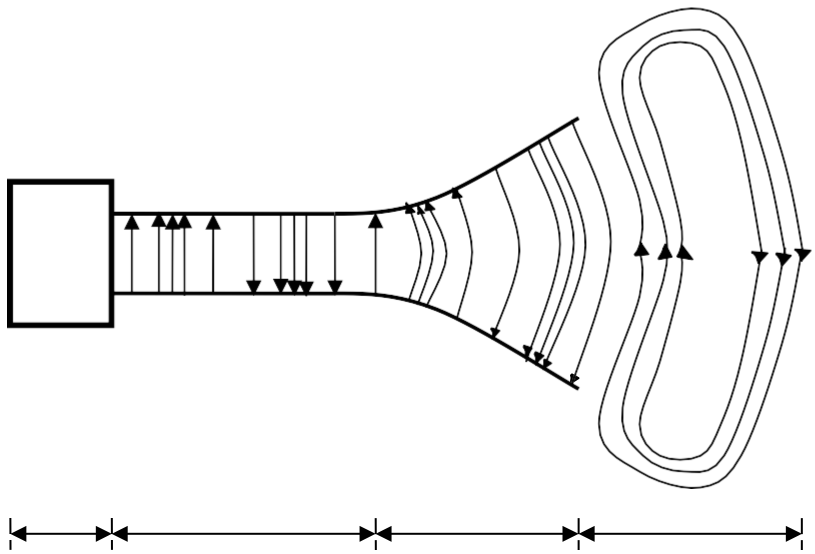


Fig 1.1:Radiation from an antenna

Due to the time varying electric and magnetic fields, electromagnetic waves are created and these travel between the conductors. As these waves approach open space, free space waves are formed by connecting the open ends of the electric lines. Since the sinusoidal source continuously creates the electric disturbance, electromagnetic waves are created continuously and these travel through the transmission line, through the antenna and are radiated into the free space. Inside the transmission line and the antenna, the electromagnetic waves are sustained due to the charges, but as soon as they enter the free space, they form closed loops and are radiated.

1.2 Antenna Performance Parameter

The performance of an antenna can be gauged from a number of parameters. Certain critical parameters are discussed below.

1.2.1 Radiation Pattern

The radiation pattern of an antenna is a plot of the far-field radiation properties of an antenna as a function of the spatial co-ordinates which are specified by the elevation angle ϴ and the azimuth angle Ø . More specifically it is a plot of the power radiated from an antenna per unit

solid angle which is nothing but the radiation intensity [5]. Let us consider the case of an isotropic antenna. An isotropic antenna is one which radiates equally in all directions. The radiation pattern plot of a generic directional antenna is shown in Figure 1.2.

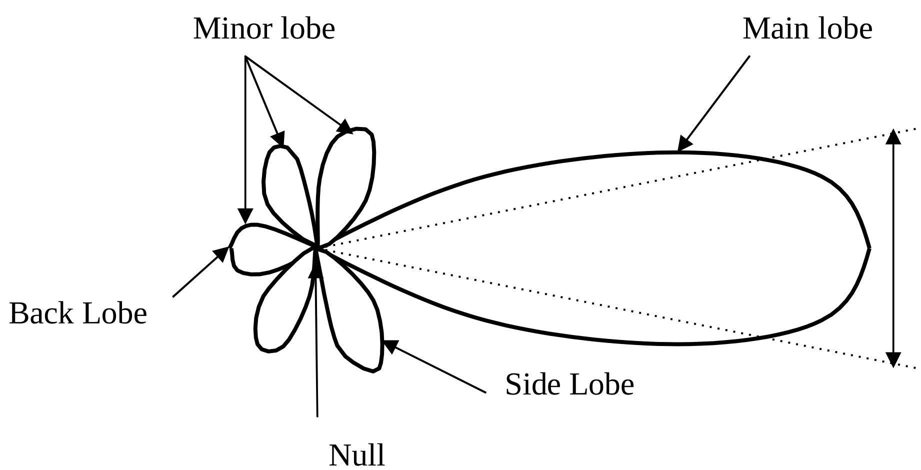


Fig1.2: Radiation pattern of a generic directional antenna

Figure 1.2 shows the following:

HPBW: The half power beamwidth (HPBW) can be defined as the angle subtended by the half power points of the main lobe.

Main Lobe: This is the radiation lobe containing the direction of maximum radiation.
Minor Lobe: All the lobes other then the main lobe are called the minor lobes. These lobes represent the radiation in undesired directions.

1.2.2 Directivity

The directivity of an antenna has been defined by [5] as "the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions". In other words, the directivity of a nonisotropic source is equal to the ratio of its radiation intensity in a given direction, over that of an isotropic source. Sometimes, the direction of the directivity is not specified.
Directivity is a dimensionless quantity, since it is the ratio of two radiation intensities. Hence, it is generally expressed in dBi. The directivity of an antenna can be easily estimated from the radiation pattern of the antenna. An antenna that has a narrow main lobe would have better directivity, then the one which has a broad main lobe, hence it is more directive.

1.2.3 Input Impedance

The input impedance of an antenna is defined by [5] as "the impedance presented by an antenna at its terminals or the ratio of the voltage to the current at the pair of terminals or the ratio of the appropriate components of the electric to magnetic fields at a point". Hence the impedance of the antenna can be written as:

$$Z_{in} = R_{in} + jX_{in}$$

Where, R_{in} is the antenna resistance at the terminals
X_{in} is the antenna reactance at the terminals

The imaginary part, X_{in} of the input impedance represents the power stored in the near field of the antenna. The resistive part, R_{in} of the input impedance consists of two components, the radiation resistance R_r and the loss resistance R_L . The power associated with the radiation resistance is the power actually radiated by the antenna, while the power dissipated in the loss resistance is lost as heat in the antenna itself due to dielectric or conducting losses.

1.2.4 Return Loss (RL)

The Return Loss (RL) is a parameter which indicates the amount of power that is "lost" to the load and does not return as a reflection. As explained in the preceding section, waves are reflected leading to the formation of standing waves, when the transmitter and antenna.

1.2.5 Bandwidth

The bandwidth of an antenna is defined by [5] as "the range of usable frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard." The bandwidth can be the range of frequencies on either side of the center frequency where the antenna characteristics like input impedance, radiation pattern, beamwidth, polarization, side lobe level or gain, are close to those values which have been obtained at the center frequency. The bandwidth of a broadband antenna can be defined as the ratio of the upper to lower frequencies of acceptable operation.

1.3 Types of Antennas

Antennas come in different shapes and sizes to suit different types of wireless applications. The characteristics of an antenna are very much determined by its shape, size and the type of material that it is made of. Some of the commonly used antennas are briefly described below.

1.3.1 Half Wave Dipole

The length of this antenna is equal to half of its wavelength as the name itself suggests. Dipoles can be shorter or longer than half the wavelength, but a tradeoff exists in the performance and hence the half wavelength dipole is widely used.

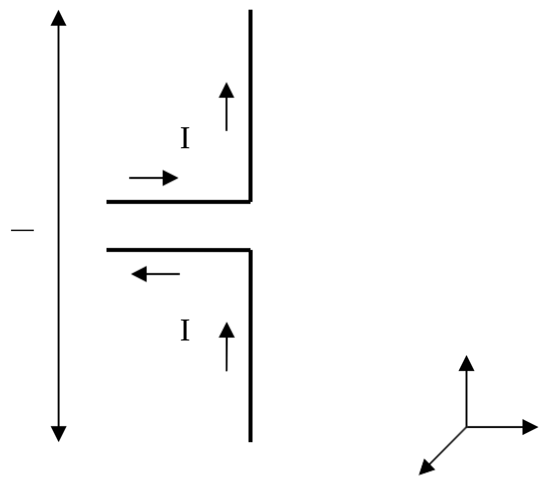


Figure 1.3: Half wave dipole

The dipole antenna is fed by a two wire transmission line, where the two currents in the conductors are of sinusoidal distribution and equal in amplitude, but opposite in direction. Hence, due to canceling effects, no radiation occurs from the transmission line. As shown in Figure 1.4, the currents in the arms of the dipole are in the same direction and they produce radiation in the horizontal direction. Thus, for a vertical orientation, the dipole radiates in the horizontal direction. The typical gain of the dipole is 2dB and it has a bandwidth of about 10%. The half power beamwidth is about 78 degrees in the E plane and its directivity is 1.64 (2.15dB) with a radiation resistance of 73 Ω [4]. Figure 2.10 shows the radiation pattern for the half wave dipole.

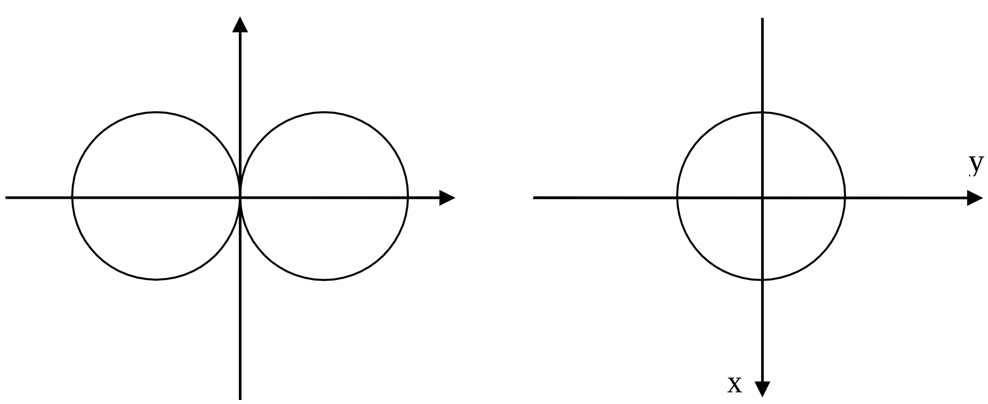


Figure 1.4: Radiation pattern for Half wave dipole

1.3.2 Monopole Antenna

The monopole antenna, shown in Figure 2.11, results from applying the image theory to the dipole. According to this theory, if a conducting plane is placed below a single element of length L / 2 carrying a current, then the combination of the element and its image acts identically to a dipole of length L except that the radiation occurs only in the space above the plane as discussed by Saunders.

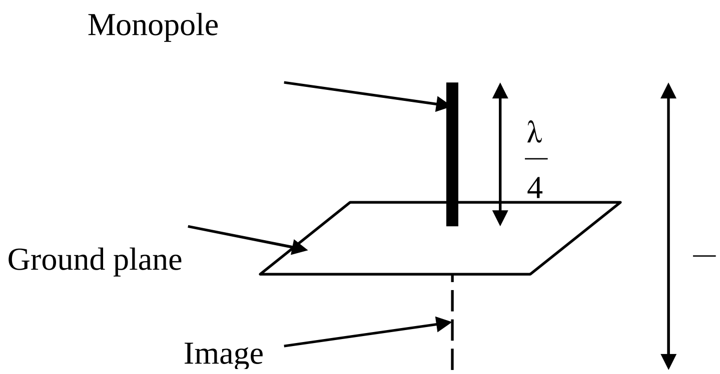


Figure 1.5: Monopole Antenna

For this type of antenna, the directivity is doubled and the radiation resistance is halved when compared to the dipole. Thus, a half wave dipole can be approximated by a quarter wave monopole. The monopole is very useful in mobile antennas where the conducting plane can be the car body or the handset case. The typical gain for the quarter wavelength monopole is 2-6dB and it has a bandwidth of about 10%. Its radiation resistance is 36.5 Ω and its directivity is 3.28 (5.16dB) [4]. The radiation pattern for the monopole is shown below in Figure 1.6.

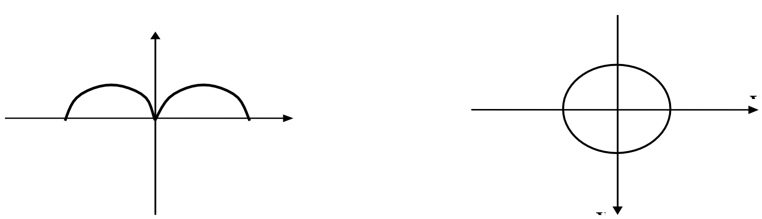
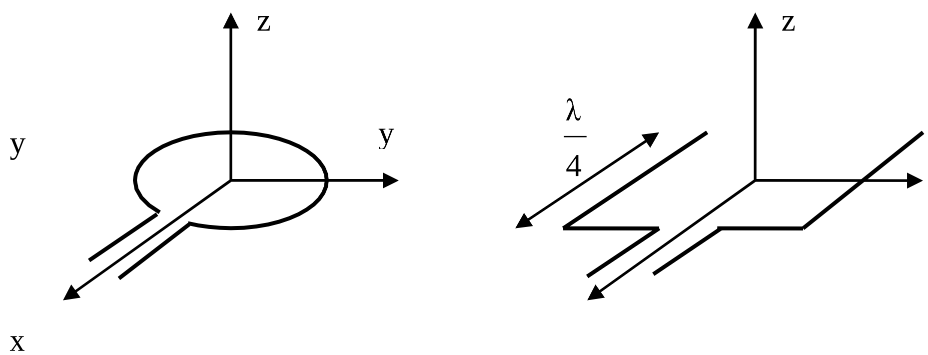


Figure 1.6 Radiation pattern for the Monopole Antenna

1.3.3 Loop Antennas

The loop antenna is a conductor bent into the shape of a closed curve such as a circle or a square with a gap in the conductor to form the terminals as shown in Figure 2.13. There are two types of loop antennas-electrically small loop antennas and electrically large loop antennas. If the total loop circumference is very small as compared to the wavelength, then the loop antenna is said to be electrically small. An electrically large loop antenna typically has its circumference close to a wavelength. The far-field radiation patterns of the small loop antenna are insensitive to shape [4].

Figure 1.7 Loop Antenna



Small Circular Loop Antenna

Large Square Loop Antenna

As shown in Figure 1.6, the radiation patterns are identical to that of a dipole despite the fact that the dipole is vertically polarized whereas the small circular loop is horizontally polarized.

The performance of the loop antenna can be increased by filling the core with ferrite. This helps in increasing the radiation resistance. When the perimeter or circumference of the loop antenna is close to a wavelength, then the antenna is said to be a large loop antenna.

The radiation pattern of the large loop antenna is different then that of the small loop antenna. For a one wavelength square loop antenna, radiation is maximum normal to the plane of the loop (along the z axis). In the plane of the loop, there is a null in the direction parallel to the side containing the feed (along the x axis), and there is a lobe in a direction perpendicular to the side containing the feed (along the y axis). Loop antennas generally have a gain from -2dB to 3dB and a bandwidth of around 10%. . The small loop antenna is very popular as a receiving antenna [4]. Single turn loop antennas are used in pagers and multiturn loop antennas are used in AM broadcast receivers.

1.3.4 Helical Antennas

A helical antenna or helix is one in which a conductor connected to a ground plane, is wound into a helical shape. Figure 2.15 illustrates a helix antenna. The antenna can operate in a number of modes, however the two principal modes are the normal mode (broadside radiation) and the axial mode (endfire radiation). When the helix diameter is very small as compared to the wavelength, then the antenna operates in the normal mode. However, when the circumference of the helix is of the order of a wavelength, then the helical antenna is said to be operating in the axial mode.

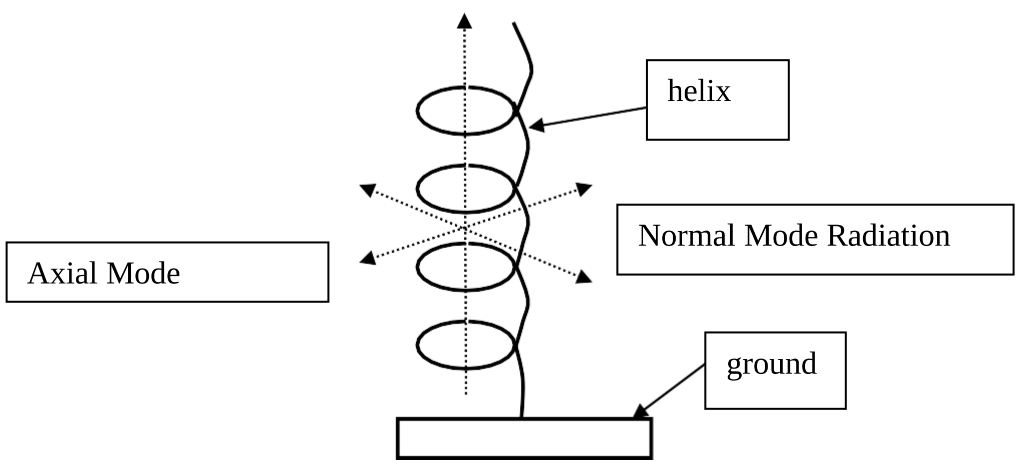
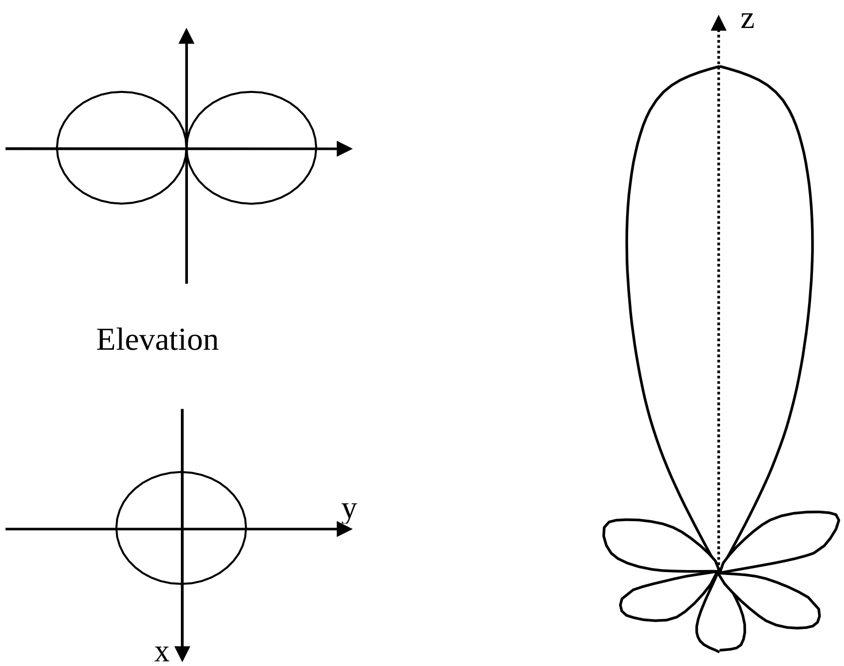


Figure 1.8 Helix Antenna

In the normal mode of operation, the antenna field is maximum in a plane normal to the helix axis and minimum along its axis.



Elevation

Azimuth

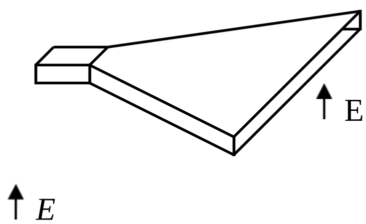
Normal Mode Axial Mode

Figure 1.9 Radiation Pattern of Helix Antenna

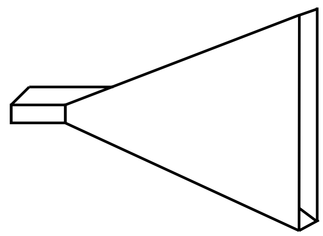
In the axial mode of operation, the antenna radiates as an endfire radiator with a single beam along the helix axis. This mode provides better gain (upto 15dB) [4] and high bandwidth ratio (1.78:1) as compared to the normal mode of operation. For this mode of operation, the beam becomes narrower as the number of turns on the helix is increased. Due to its broadband nature of operation, the antenna in the axial mode is used mainly for satellite communications. Figure 2.16 above shows the radiation patterns for the normal mode as well as the axial mode of operations.

1.3.5 Horn Antennas

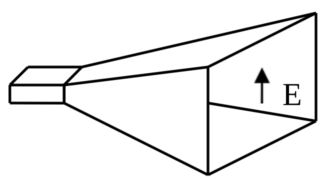
Horn antennas are used typically in the microwave region (gigahertz range) where waveguides are the standard feed method, since horn antennas essentially consist of a waveguide whose end walls are flared outwards to form a megaphone like structure.



H-plane Horn Antenna



E-plane Horn Antenna



Pyramidal Horn Antenna

Figure 1.10 Types of Horn Antenna

Horns provide high gain, low VSWR, relatively wide bandwidth, low weight, and are easy to construct [4]. The aperture of the horn can be rectangular, circular or elliptical. However, rectangular horns are widely used. The three basic types of horn antennas that utilize a rectangular geometry are shown in Figure 2.17. These horns are fed by a rectangular waveguide which have a broad horizontal wall as shown in the figure. For dominant waveguide mode excitation, the E-plane is vertical and H-plane horizontal. If the broad wall dimension of the horn is flared with the narrow wall of the waveguide being left as it is, then it is called an H-plane sectoral horn antenna as shown in the figure. If the flaring occurs only in the E-plane dimension, it is called an E-plane sectoral horn antenna. A pyramidal horn antenna is obtained when flaring occurs along both the dimensions. The horn basically acts as a transition from the waveguide mode to the free-space mode and this transition reduces the reflected waves and emphasizes the traveling waves which lead to low VSWR and wide bandwidth [4]. The horn is widely used as a feed element for large radio astronomy, satellite tracking, and communication dishes. In the above sections, several antennas have been discussed. Another commonly used antenna is the Microstrip patch antenna. The aim of this thesis is to design a compact microstrip patch antenna to be used in wireless communication and this antenna is explained in the next chapter.

2.Microstrip Patch Antenna

In this chapter, an introduction to the Microstrip Patch Antenna is followed by its advantages and disadvantages. Next, some feed modeling techniques are discussed. Finally, a detailed explanation of Microstrip patch antenna analysis and its theory are discussed, and also the working mechanism is explained.

2.1 Introduction

In its most basic form, a Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in Figure 2.1. The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

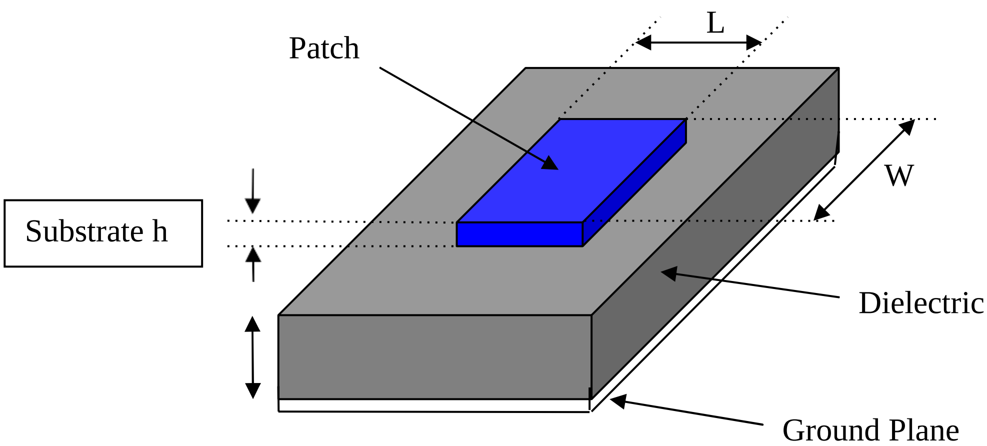


Figure 2.1 Structure of a Microstrip Patch Antenna

In order to simplify analysis and performance prediction, the patch is generally square, rectangular, circular, triangular, elliptical or some other common shape as shown in Figure 3.2.

For a rectangular patch, the length L of the patch is usually $0.3333\lambda_o < L < 0.5\lambda_o$, where λ_o is the free-space wavelength. The patch is selected to be very thin such that $t << \lambda_o$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\,\lambda_o \leq h \leq 0.05\lambda_o$. The dielectric constant of the substrate (ε_r) is typically in the range $2.2 \leq \varepsilon_r \leq 12$.

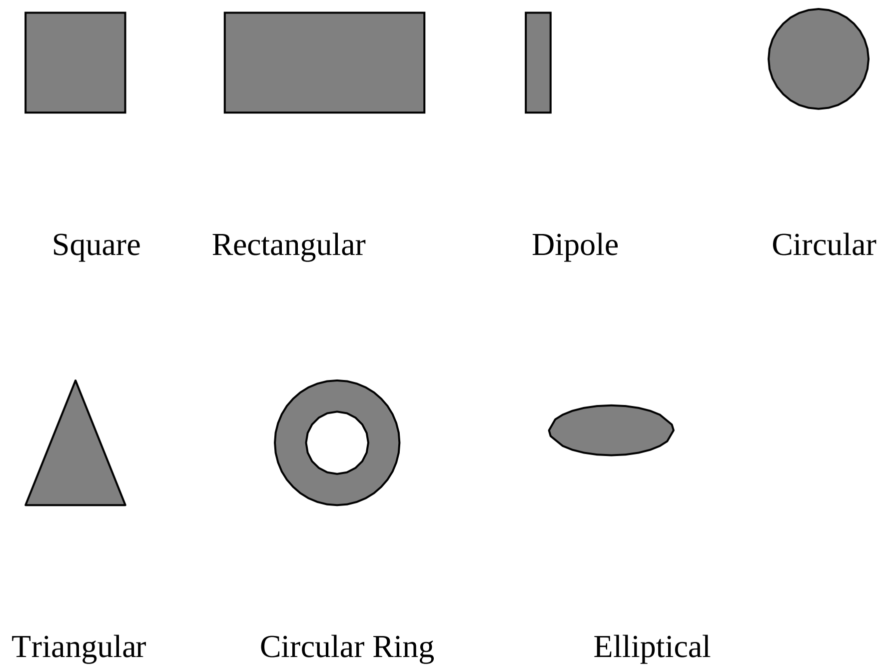


Figure 2.2 Common shapes of microstrip patch elements

Microstrip patch antennas radiate primarily because of the fringing fields between the patch edge and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation [5]. However, such a configuration leads to a larger antenna size. In order to design a compact Microstrip patch antenna, higher dielectric constants must be used which are less efficient and result in narrower bandwidth. Hence a compromise must be reached between antenna dimensions and antenna performance.

2.2 Advantages and Disadvantages

Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers etc... The telemetry and

communication antennas on missiles need to be thin and conformal and are often Microstrip patch antennas. Another area where they have been used successfully is in Satellite communication. Some of their principal advantages discussed by [5] and Kumar and Ray [9] are given below:

- Light weight and low volume.
- Low profile planar configuration which can be easily made conformal to host surface.
- Low fabrication cost, hence can be manufactured in large quantities.
- Supports both, linear as well as circular polarization.
- Can be easily integrated with microwave integrated circuits (MICs).
- Capable of dual and triple frequency operations.
- Mechanically robust when mounted on rigid surfaces.

Microstrip patch antennas suffer from a number of disadvantages as compared to conventional antennas. Some of their major disadvantages discussed by [9] and Garg et al [10] are given below:

- Narrow bandwidth
- Low efficiency
- Low Gain
- Extraneous radiation from feeds and junctions
- Poor end fire radiator except tapered slot antennas
- Low power handling capacity.
- Surface wave excitation

Microstrip patch antennas have a very high antenna quality factor (Q). Q represents the losses associated with the antenna and a large Q leads to narrow bandwidth and low efficiency. Q can be reduced by increasing the thickness of the dielectric substrate. But as the thickness increases, an increasing fraction of the total power delivered by the source goes into a surface wave. This surface wave contribution can be counted as an unwanted power loss since it is ultimately scattered at the dielectric bends and causes degradation of the antenna characteristics. However, surface waves can be minimized by use of photonic bandgap structures as discussed by Qian et al [11]. Other problems such as lower gain and lower power handling capacity can be overcome by using an array configuration for the elements.

2.3 Feed Techniques

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip line and the radiating patch [5]. The four most popular feed techniques used are the microstrip line, coaxial probe (both contacting schemes), aperture coupling and proximity coupling (both non-contacting schemes).

2.3.1 Microstrip Line Feed

In this type of feed technique, a conducting strip is connected directly to the edge of the microstrip patch as shown in Figure 3.3. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure.

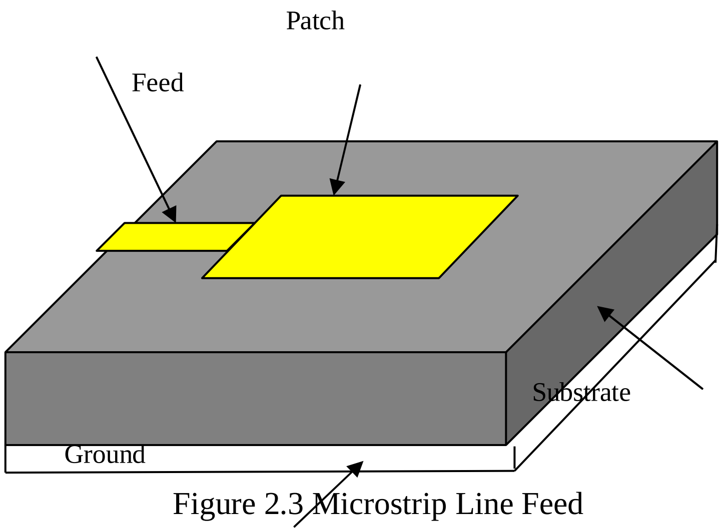


Figure 2.3 Microstrip Line Feed

The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching. However as the thickness of the dielectric substrate being used, increases, surface waves and spurious feed radiation also increases, which hampers the bandwidth of the antenna [5]. The feed radiation also leads to undesired cross polarized radiation.

2.3.2 Coaxial Feed

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. As seen from Figure 3.4, the inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane.

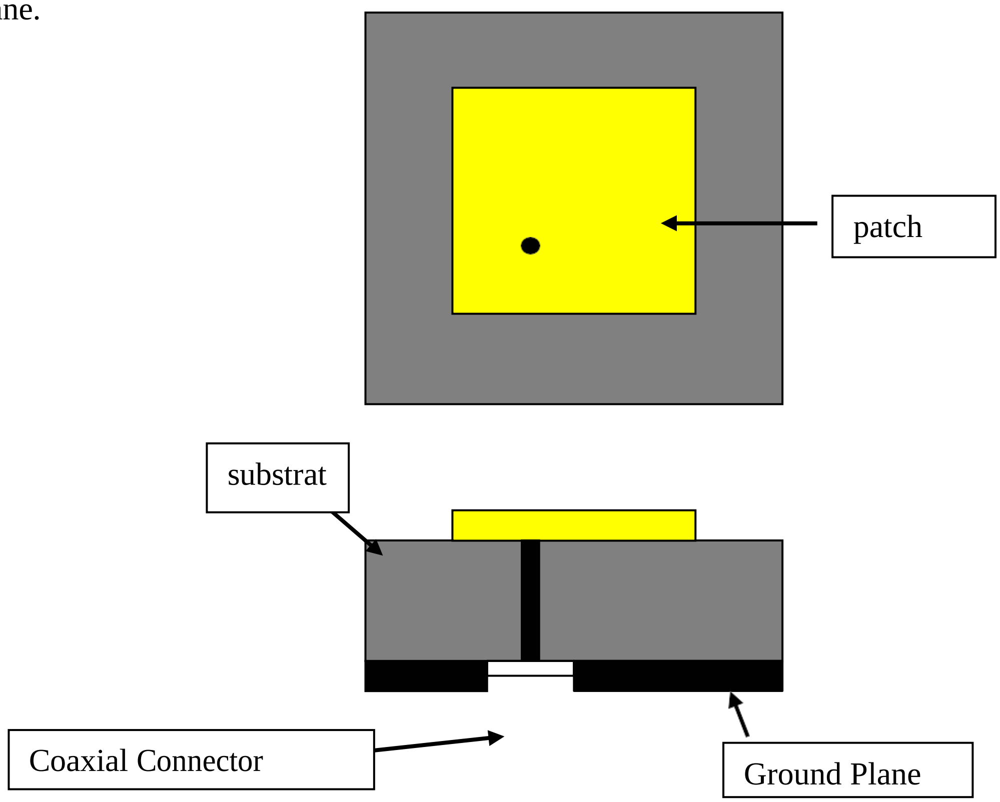


Figure 2.4 Probe fed Rectangular Microstrip Patch Antenna

The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance. This feed method is easy to fabricate and has low spurious radiation. However, its major disadvantage is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, thus not making it completely planar for thick substrates ($h > 0.02\lambda_o$). Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems [9]. It is seen above that for a thick dielectric substrate, which provides broad bandwidth, the microstrip line feed and the coaxial feed suffer from numerous disadvantages. The non-contacting feed techniques which have been discussed below, solve these problems.

2.3.3 Aperture Coupled Feed

In this type of feed technique, the radiating patch and the microstrip feed line are separated by the ground plane as shown in Figure 3.5. Coupling between the patch and the feed line is made through a slot or an aperture in the ground plane.

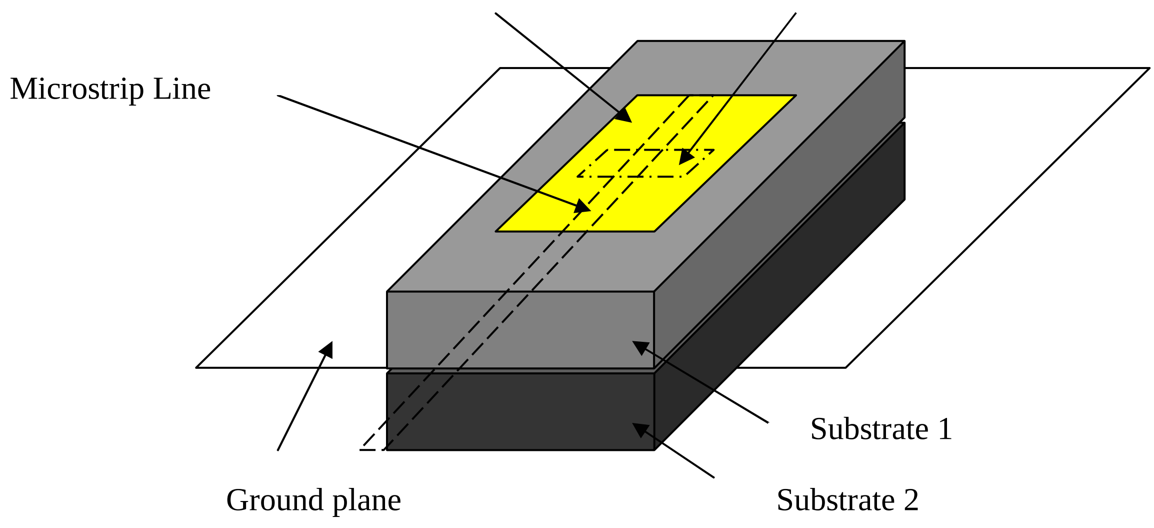


Figure 2.5 Aperture-coupled feed

The coupling aperture is usually centered under the patch, leading to lower cross- polarization due to symmetry of the configuration. The amount of coupling from the feed line to the patch is determined by the shape, size and location of the aperture. Since the ground plane separates the patch and the feed line, spurious radiation is minimized. Generally, a high dielectric material is used for the bottom substrate and a thick, low dielectric constant material is used for the top substrate to optimize radiation from the patch [5]. The major disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which also increases the antenna thickness. This feeding scheme also provides narrow bandwidth.

2.3.4 Proximity Coupled Feed

This type of feed technique is also called as the electromagnetic coupling scheme. As shown in Figure 3.6, two dielectric substrates are used such that the feed line is between the two substrates and the radiating patch is on top of the upper substrate. The main advantage of this feed technique is that it eliminates spurious feed radiation and provides very high bandwidth (as high as 13%) [5], due to overall increase in the thickness of the microstrip patch antenna. This scheme also provides choices between two different dielectric media, one for the patch and one for the feed line to optimize the individual performances.

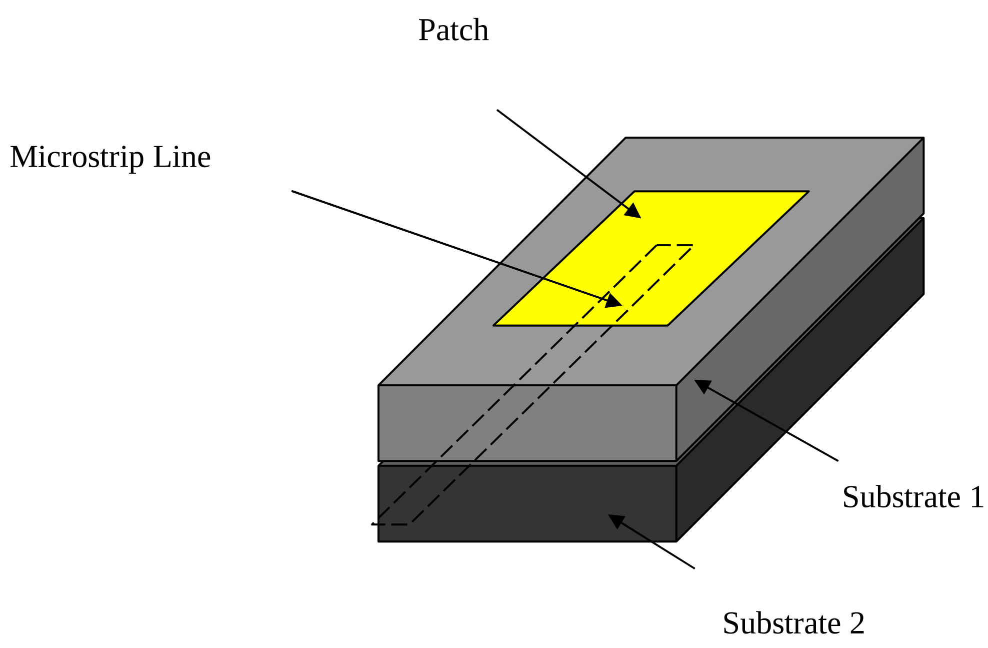


Figure 2.6 Proximity-coupled Feed

Matching can be achieved by controlling the length of the feed line and the width-to-line ratio of the patch. The major disadvantage of this feed scheme is that it is difficult to fabricate because of the two dielectric layers which need proper alignment. Also, there is an increase in the overall thickness of the antenna. Table 2.1 below summarizes the characteristics of the different feed techniques.

Table 2.1 Comparing the different feed techniques.

Characteristics	Microstrip Line Feed	Coaxial Feed	Aperture coupled Feed	Proximity coupled Feed
Spurious feed radiation	More	More	Less	Minimum
Reliability	Better	Poor due to soldering	Good	Good
Ease of fabrication	Easy	Soldering and drilling needed	Alignment required	Alignment required
Impedance Matching	Easy	Easy	Easy	Easy
Bandwidth (achieved with impedance matching)	2-5%	2-5%	2-5%	13%

3. ANTENNA STRUCTURE

3.1. INTRODUCTION

Nowadays, the importance of wireless communications is growing rapidly. To meet the present day requirements, there is a need for very high-speed data rate achieved over a wide area. This can be achieved using WiMAX technology. WiMAX technology stands for Worldwide Interoperability for Microwave Access [1]. Hence there is a necessity to design an antenna efficiently working in this range. A microstrip antenna is widely used for this purpose because of its light weight, robustness, low cost of production and low profile nature. It can also be used in mobile phones and other wireless gadgets [2]. It has its applications in satellite communications, radar communications and in the areas of guidance weaponry as well [3]. A microstrip patch antenna has a substrate that is sandwiched between two conducting materials, one material being the patch and the other is the ground. The antenna can be fed through stripling feed between the patch and the ground.

The fringing fields [4] produced between these two conducting materials are responsible for the radiation. In spite of several advantages, the microstrip antennas have some disadvantages like narrow bandwidth and less gain. To improve these characteristics several techniques have been applied in the past few years. One of those techniques is cutting slots along the conducting material. Implementation using H and U slots are discussed in [5-8]. The use of microstrip patch employing dual H and dual U slots is discussed in [9]. Use of DGS (Defected ground structure) for K and Ka band was discussed in [10]. As the name itself indicates, the structure of the ground is intentionally made defective or faulty. This helps in effective coupling of inductance and capacitance with the transmission line [11]. In general, DGS deals with modifications in the ground plane. A gap induced or a slot cut in the ground plane provides a necessary coupling effect in an efficient manner [12-13].

In this chapter, Section 3.1 deals with the necessary introduction to the antenna configurations considered. Section 3.2 deals with the conventional MPA (microstrip patch antenna) and the slotted MPA. Section 3.3 gives the results from the antenna configurations considered in the previous section. Section 3.4 proposes the quad-L slotted MPA with DGS (defected ground structure) and Section 3.5 deals about the observations and results from Section 4 and finally findings are tabulated and the last section concludes the paper.

3.2. CONVENTIONAL MICROSTRIP PATCH ANTENNA

The conventional microstrip patch antenna is constructed with a rectangular patch and FR4 epoxy as a dielectric substrate having relative permittivity 4.4. The W x L (in mm) are considered to be 18.26 mm X 13.74 mm. These values are taken by using the conventional microstrip patch antenna equations discussed in [13]. The substrate height is considered to be of a value of 1.6 mm. The antenna is fed with strip-line feeding. The conventional patch antenna is shown in fig.3.1 below.

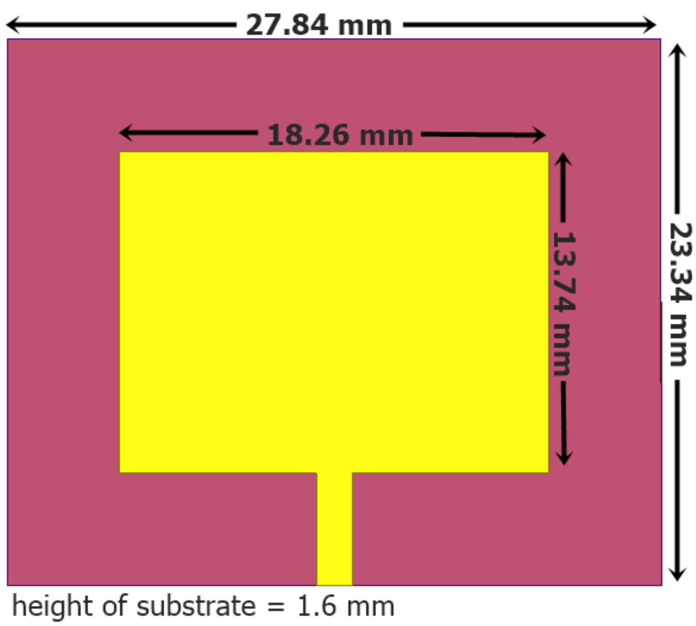


Fig.3.1 Conventional Antenna

3.3 Quad L – Shaped Slot Microstrip Patch Antenna

In order to improve the radiation characteristics, slots are introduced to the conventional MPA. Two L shaped slots are cut on the conventional antenna. The dimensions and position of these slots are chosen in such a way that the patch antenna is optimized for better performance. The length of each slot is taken to be 2 mm and the slot width is considered to be 0.5 mm. Fig.3.2 below shows the design structure of the slotted antenna.

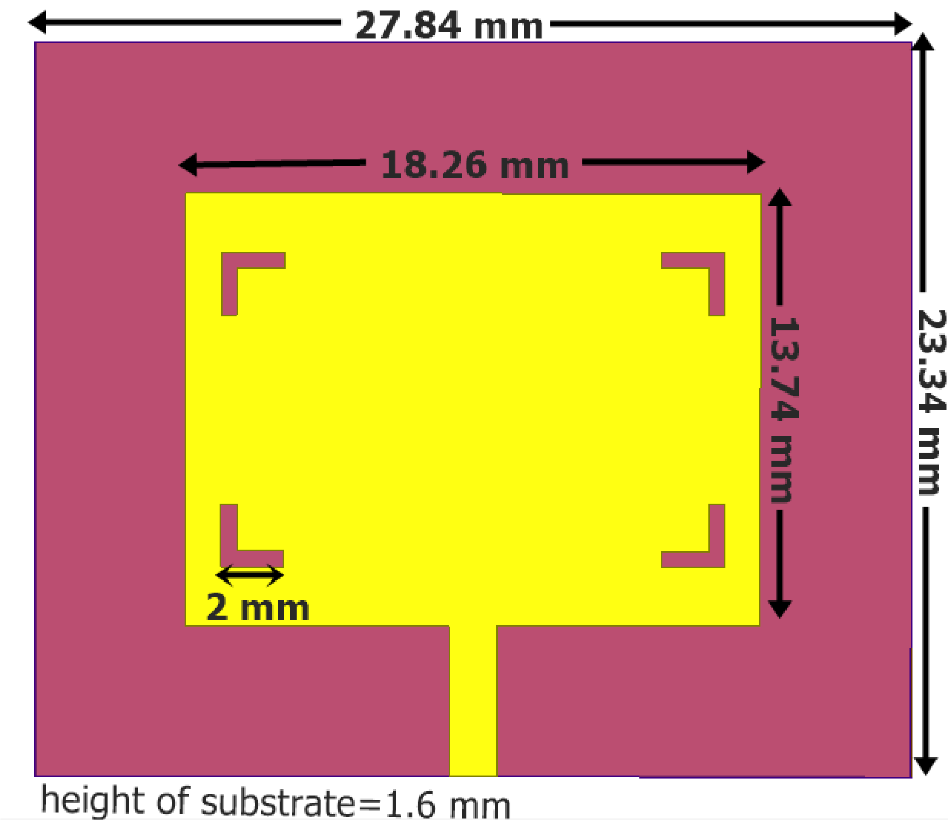


Fig.3.2 Quad L-Slotted Patch antenna

3.4 OBSERVATIONS FROM THE CONVENTIONAL MPA AND SLOTTED MPA

Simulations are carried out in HFSS software Firstly, the S11 parameter is calculated. As the microstrip antenna has only one port S11 parameter can be treated as return loss. The return loss of an antenna should be always less than -10dB. The return loss for conventional MPA is found out to be -32.17 dB. Fig.3.3 shows the return loss of the conventional antenna.

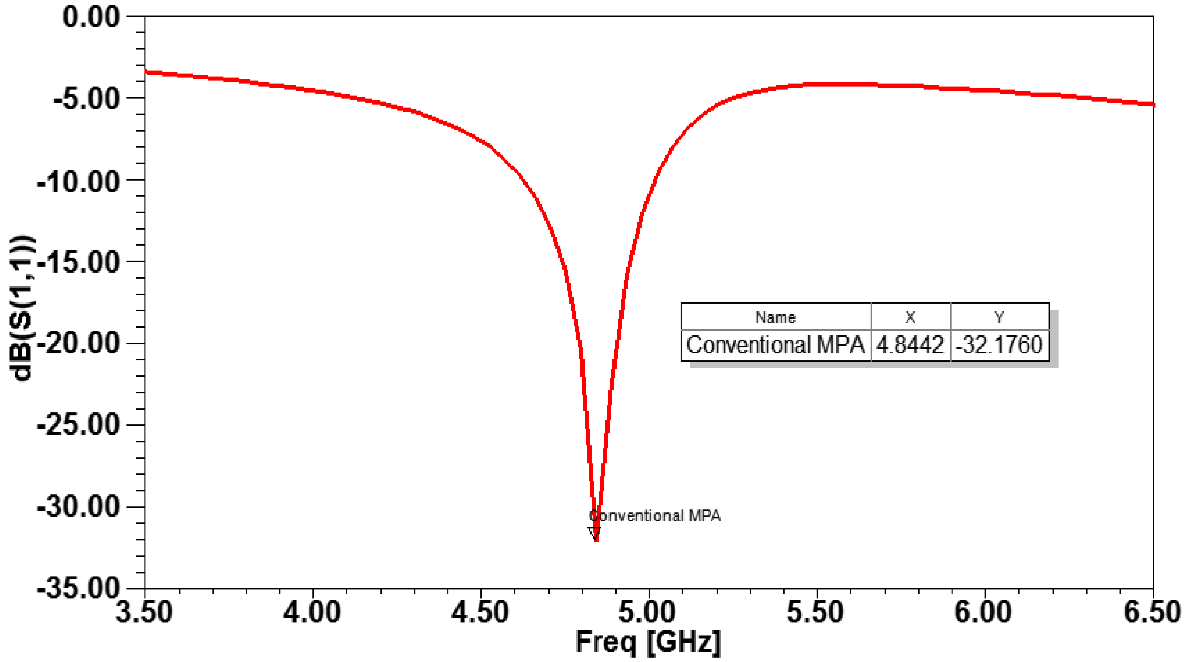


Fig.3.3 Return loss of conventional MPA

The VSWR is then calculated which is found out to be 1.05. The VSWR should be less than 2 for good agreement of the patch antenna. This is shown in fig.3.4 below.

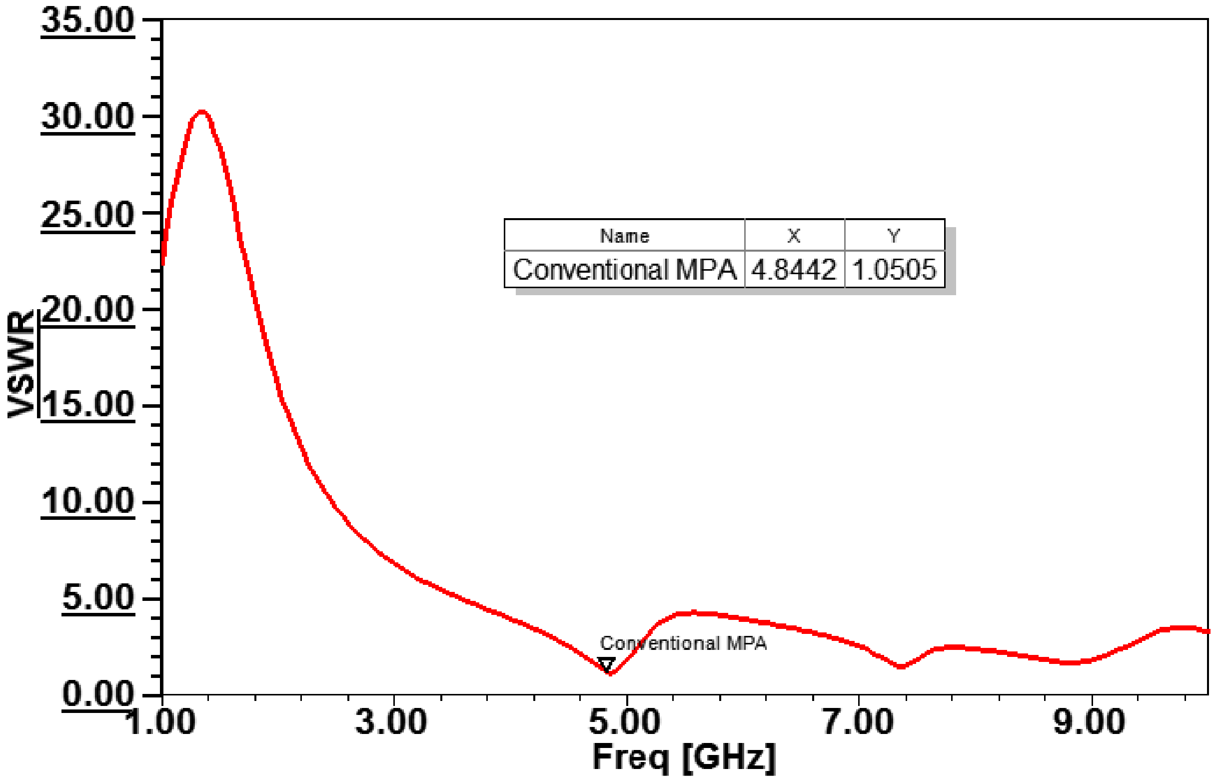


Fig.3.4 VSWR of conventional MPA

Now L-shaped slots are cut on the patch and the corresponding return loss and VSWR are calculated. The following fig.3.5 and fig.3.6 shows the return loss and VSWR plots for the slotted MPA.

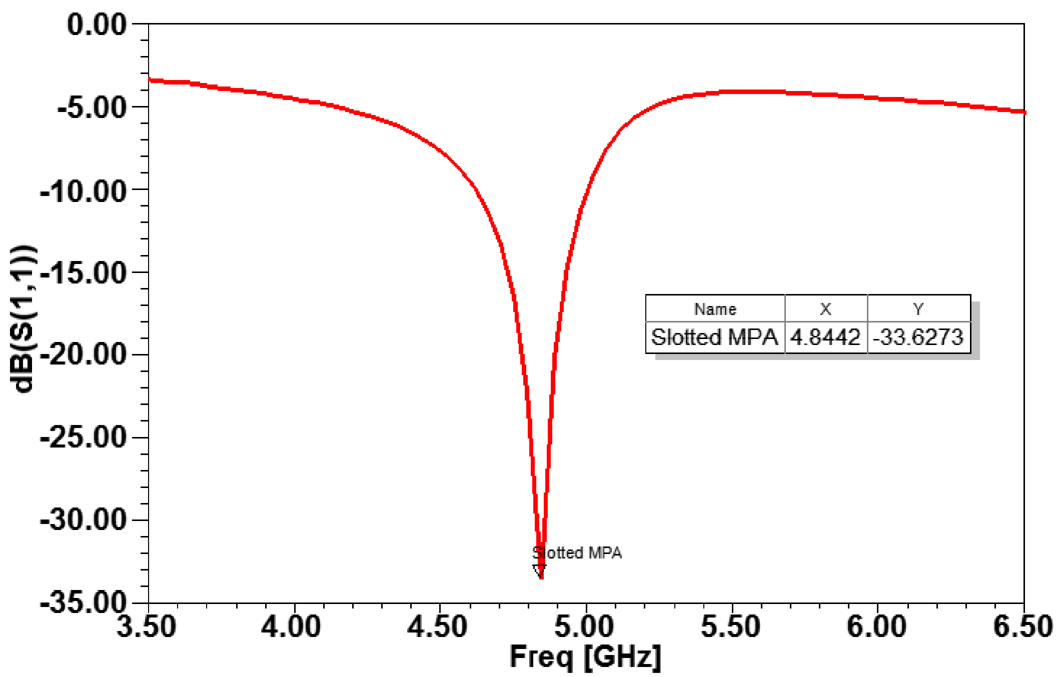


Fig.3.5 Return loss for Quad L slotted MPA

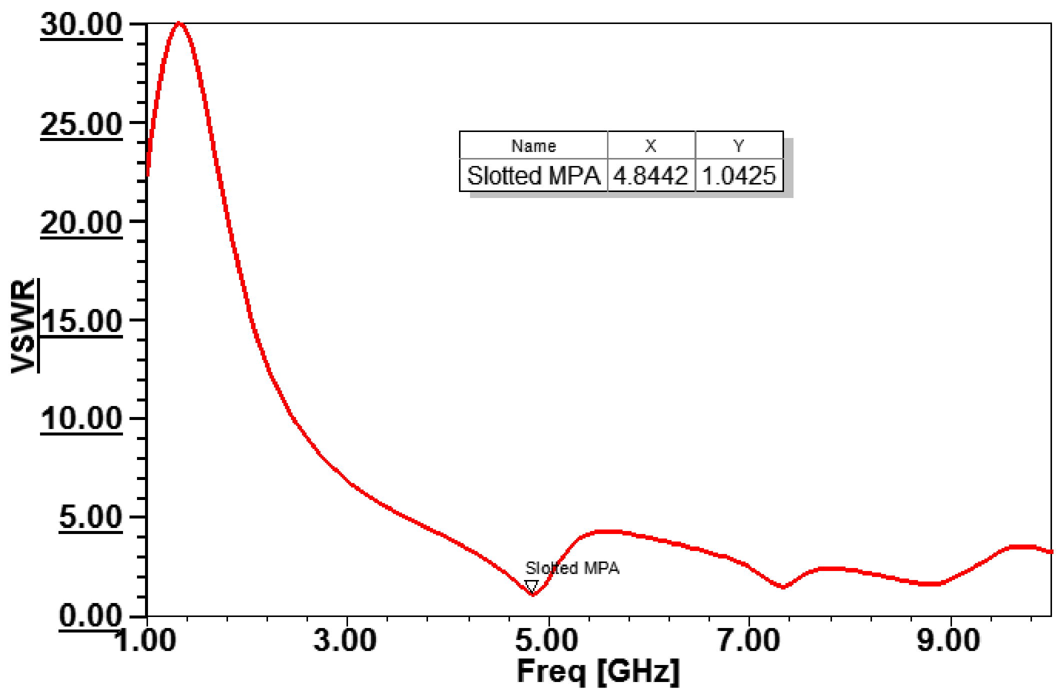


Fig.3.6 VSWR plot for Quad L slotted MPA

3.4. PROPOSED DESIGN

To go for further improvement in the gain characteristics and overall antenna characteristics, defected ground is introduced to the L slotted MPA. The defected ground in this consideration is truncated ground in which a horizontal L shaped Slot is cut in the ground plane. Its dimensions are considered to be W x L (in mm) 26.26 mm x 21.74 mm.

The proposed L slotted MPA with the defected ground is shown in fig.3.7 below.

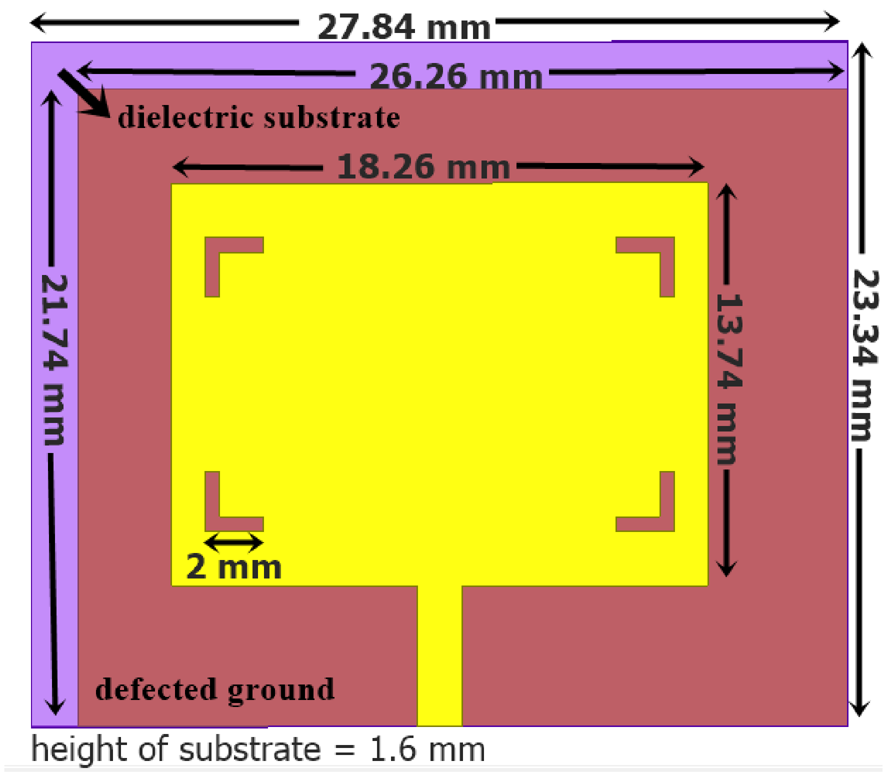


Fig.3.7 Proposed Quad L-Slotted MPA with DGS

3.5. OBSERVATIONS FROM THE PROPOSED ANTENNA

The simulated results for L slotted MPA with DGS is shown in fig.3.8 and fig.3.9. The results are simulated after cutting an L-shaped slot in the ground. From this result it is clear that the return loss is improved from -33.62 dB (Slotted MPA) to -36.61 dB which is a significant improvement.

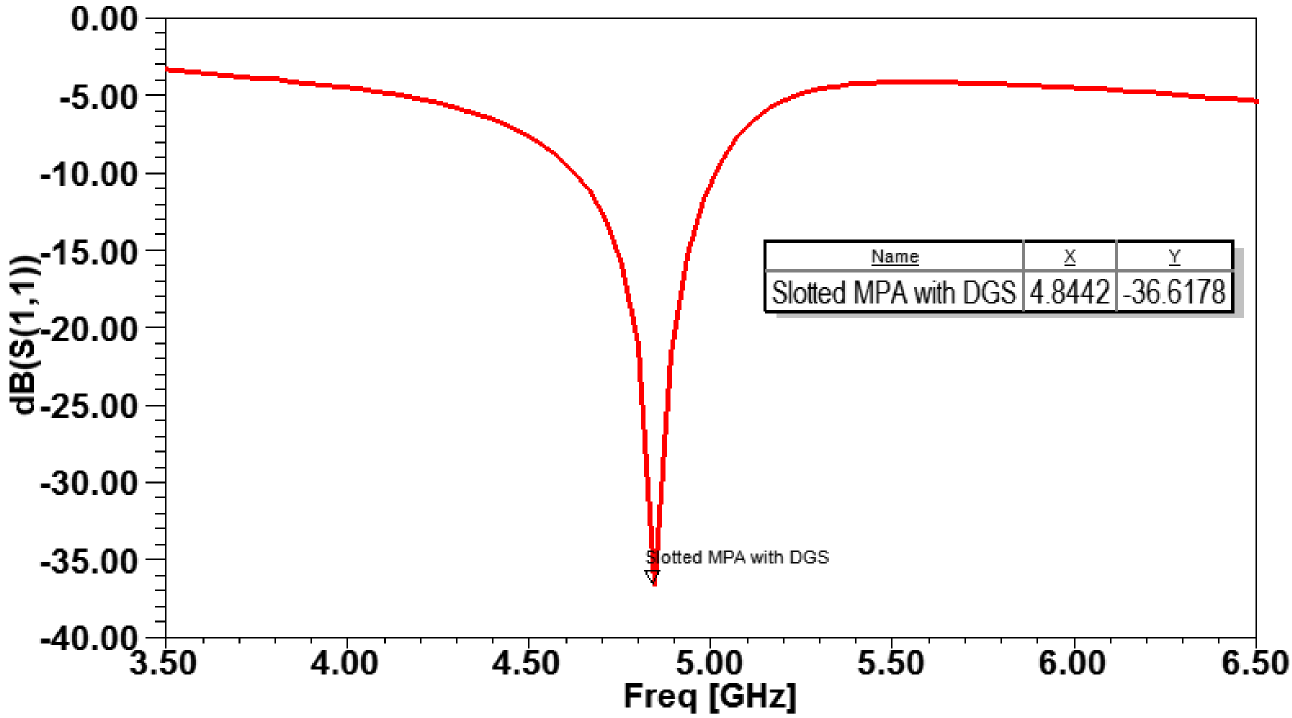


Fig.3.8 Return loss plot for the proposed slotted MPA with

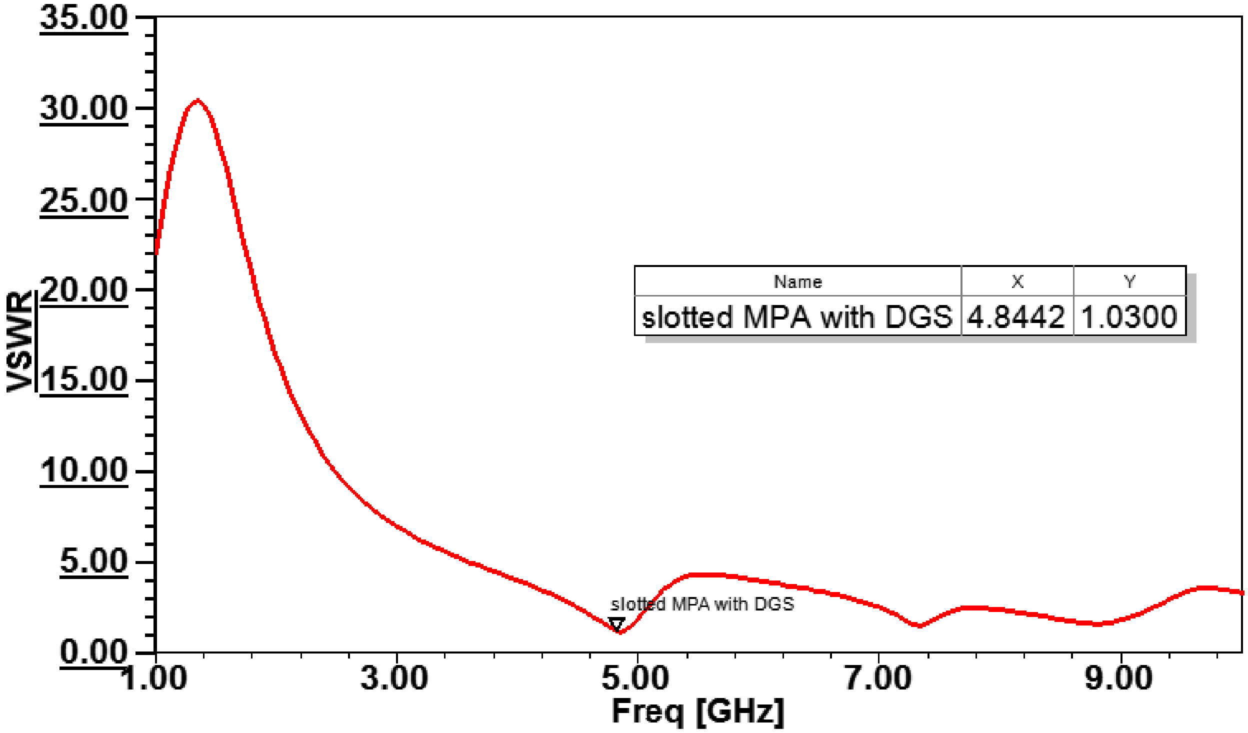


Fig.3.9 VSWR Plot for the Proposed Slotted MPA with DGS

The gain plots are compared are compared for all the three versions of the considered microstrip patch antenna. These are given in fig.3.10 below.

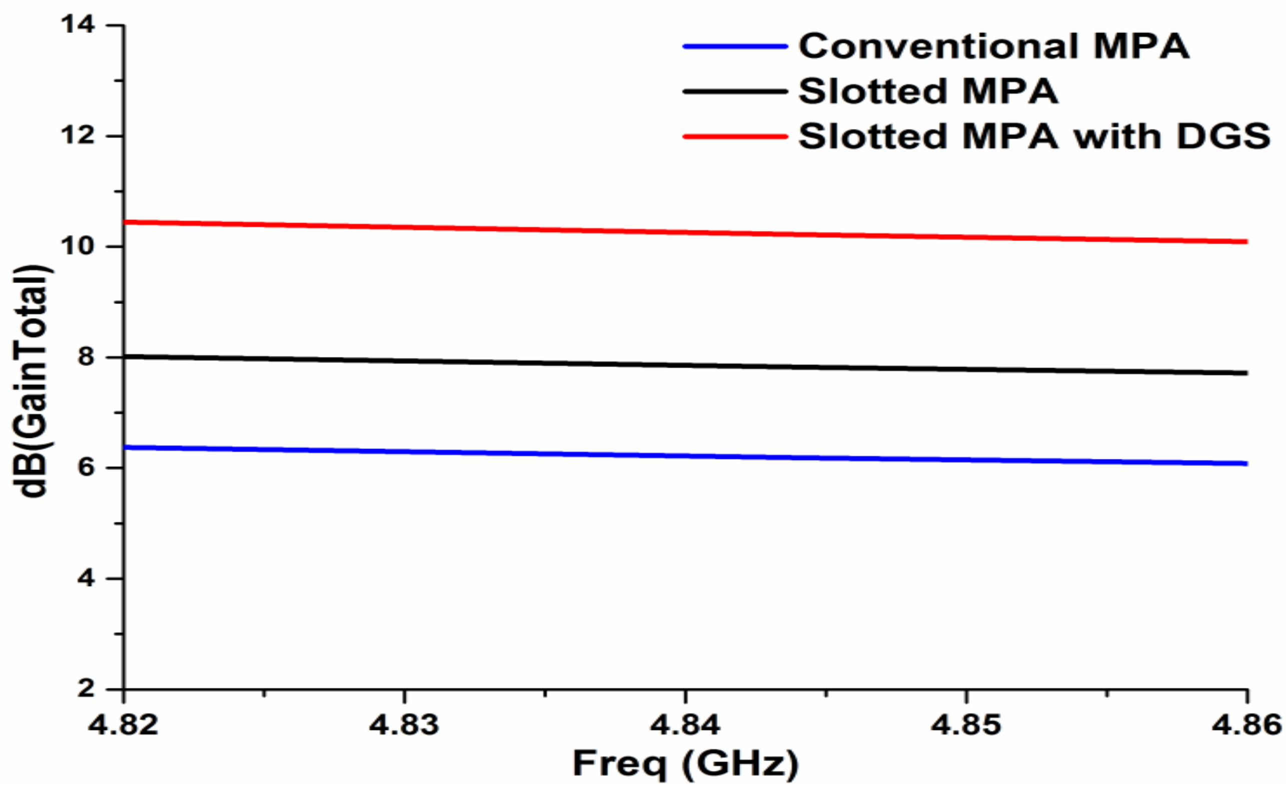


Fig.3.10 2D Gain comparison plot for the three MPA configurations

Table 3.1: Comparison table for the considered antenna configurations

Parameter	**Conventional MPA**	**Slotted MPA**	**Slotted MPA with DGS**
Center Frequency (GHz)	4.8442 GHz	4.8442 GHz	4.8442 GHz
Return loss (dB)	-32.17 dB	-33.62 dB	-36.61 dB
VSWR	1.0505	1.042	1.03
Gain (dB)	6.23 dB	7.88 dB	10.28 dB

4.PRINTED MONOPOLE PATCH ANTENNA FOR UWB APPLICATIONS

4.1. INTRODUCTION

Present time is witnessing a very rapid growth of wireless communications,for which antennas with very large bandwidth are in strong demand,so that various applications are covered with fewer or preferably with a single antenna. It will be preferred that an antenna has bandwidth in excess of frequency range from 800 MHz to 11 GHz or even more, to include all the existing wireless communication systems such as AMPC800, GSM900, GSM1800, PCS1900, WCDMA/UMTS (3G), 2.45/5.2/5.8-GHz-ISM, U-NII, DECT, WLANs, European Hiper LAN I, II, and UWB (3.1–10.6 GHz). Out of all the above-mentioned wireless systems, ultra-wide bandwidth (UWB) wireless technology is most sought for very high-data-rate and short-range wireless communication systems, coding for security and low probability of interception, rejection of multipath effect, modern radar systems, and so forth. As mentioned above, this technology uses ultra-wide bandwidth of 7.5 GHz, ranging from 3.1 GHz to 10.6 GHz.

Planar and printed monopole antennas are the good candidates for use in UWB wireless technology because of their wide impedance bandwidth and nearly omni-directional azumuthal radiation pattern. Many shapes of planar, also known as planar disc, monopole antennas are reported, which yield very large bandwidth. Some of these reported configurations have bandwidth in excess of that required for UWB applications [14]. But, the planar disc configurations are not the most preferred one for these applications, because they are generally mounted on large ground plane, which are perpendicular to the plane of monopole (which makes them three-dimensional structure). Also, the large size ground plane limits the radiation pattern to only half hemisphere. On the other hand, printed monopole antennas (PMAs) are truly planar and have radiation patterns similar to that of a dipole antenna. These monopoles can be integrated with other components on printed circuit board, have reduced size on dielectric substrate, are without backing ground plane and are easy to fabricate. Printed antennas, commonly fabricated on FR4 substrate, are very cost effective, which is ideally suited for UWB technology-based low-cost systems.

4.2. Design Considerations of Antennas for UWB Technology

Some of the main features required for antennas for the application of UWB technology are as follows.

(i)It should have bandwidth ranging from 3.1 GHz to 10.6 GHz in which reasonable efficiency and satisfactory omnidirectional radiation patterns are necessary.

(ii)In this ultra-wide bandwidth, an extremely low-emission power level should be ensured. In 2002, the Federal Communication Commission (FCC) has specified the emission limits of dBm/MHz.

(iii)The antenna propagates short-pulse signal with minimum distortion over the frequency range.

The first point is the most important one for antenna designers, which translates into the requirement that antenna should have impedance bandwidth ratio of over which . Such a high impedance bandwidth is only realised using multiresonance printed monopole antenna, which generally exhibit high pass impedance characteristics. For such broadband antenna, unlike single resonance tuned dipole or monopole antennas, some special design considerations have to be taken into account. Instead of resonance or operating frequency, lower band-edge frequency and total bandwidth achieved become the design parameters for these printed monopole antennas. The lower band-edge frequency depends primarily on maximum height of the monopole, whereas bandwidth of the antenna depends on how impedance of various modes is matched with the microstrip or coplanar feed line. These parameters are discussed in details for all the regular geometries of printed monopole antennas.

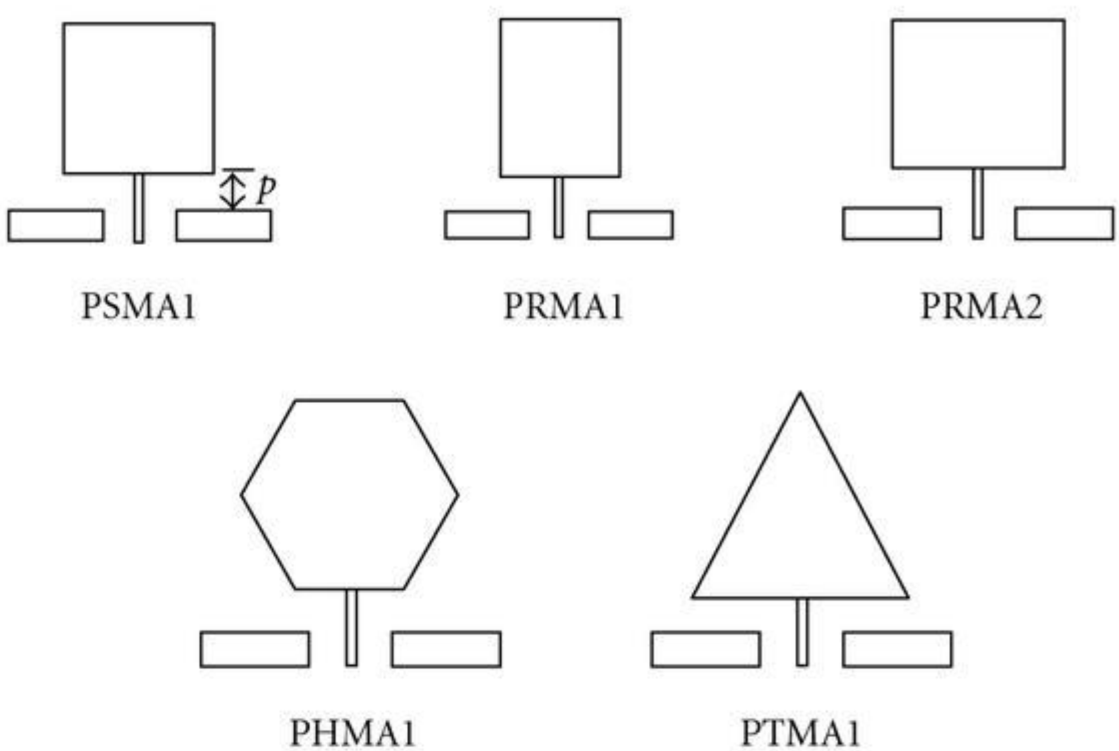
4.3 Printed Monopole Antenna Design

The printed monopole antennas give very large impedance bandwidth with reasonably good radiation pattern in azumuthal plane, which can be explained in the following two ways. The printed monopole antenna can be viewed as a special case of microstrip antenna configuration, wherein the backing ground plane is located at infinity [15]. A patch is fabricated on dielectric substrate (commonly FR4). Beyond the substrate it can be assumed that a very thick air dielectric substrate exists. It makes a microstrip antenna configuration on a thick substrate with closer to unity, which yields large bandwidth.

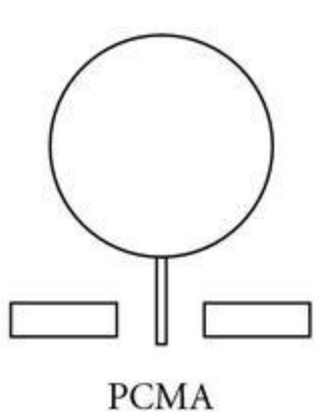
Alternatively, printed monopole antennas can be seen as a vertical monopole antenna. A monopole antenna usually consists of a vertical cylindrical wire mounted over the ground plane, whose bandwidth increases with increase in its diameter. A printed monopole antenna can be equated to a cylindrical monopole antenna with large effective diameter. This second analogy has been used to determine the lower band-edge frequency of all regular shapes of printed monopole antennas for various feed configurations.

4.4 Lower Band-Edge Frequency of Printed Monopole Antennas

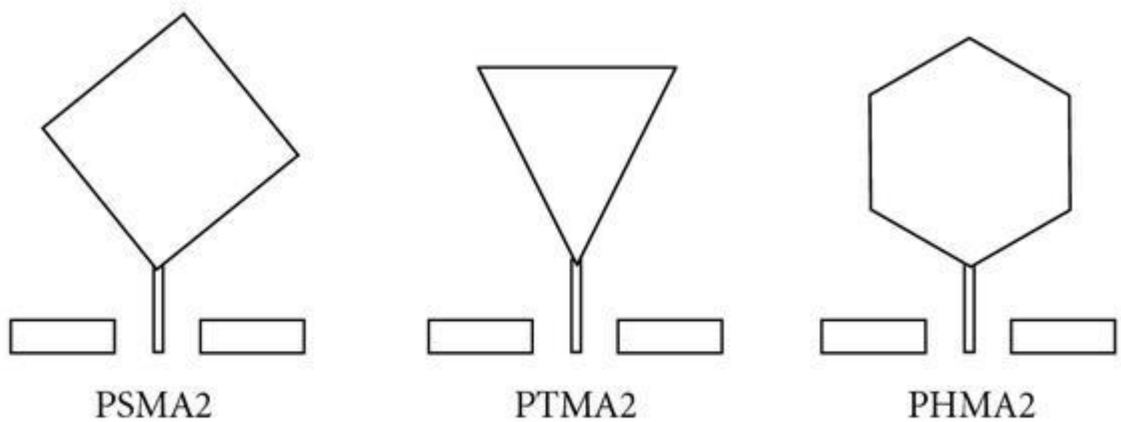
Various regular shaped printed monopole antennas such as printed square monopole antenna (PSMA), printed rectangular monopole antenna (PRMA), printed hexagonal monopole antenna (PHMA), printed triangular monopole antenna (PTMA), printed circular monopole antenna (PCMA), and printed elliptical monopole antenna (PEMA) for different feed positions are shown in Figure 4.1. For different feed locations, the suffix 1 or 2, as shown in Figure 4.1, are put for these monopole antennas. These antennas are generally fabricated on FR4 substrate with backing ground plane removed. These patches can be fed by 50 Ω microstrip line or by coplanar waveguide. For both these cases, the optimum width of the backside ground plane in the case of microstrip feed or coplanar ground plane is 1 cm.



(a)



(b)



(c)

Figure 4.1: Various regular-shaped PMAs with different feed configurations.

5. PROPOSED ANTENNA STRUCTURE

5.1 Introduction

Nowadays in this digital world, most of the communication is made wireless. To meet the requirements of these wireless applications, antennas are to be designed in such a way that they are compact in size and also cost-effective. Printed antennas exactly suit for this purpose. They are compact, cost-effective can be easily fabricated and integrated with other components on PCB. Bandwidth is also an important parameter to be considered. It refers to the range of frequency over which the antenna properties are acceptable. If the bandwidth is more then the antenna can be used for more number of applications. Inorder to get the large bandwidth printed monopole antennas are used. The Federal Communications Commission has approved bandwidth range is 3.1 to 10.6 Ghz.

Hence the study of different bio-inspired patch structures[16] on monopole antenna has arouse the intrest of our research. In this chapter, three bio-inspired antennas i.e Single petal antenna, two petal antenna and three petal antennas were discussed.

5.2 SINGLE PETAL ANTENNA

A leaf shaped patch with a width 30 mm and length 41 mm is taken on a substrate with dimensions 40 mm x 60 mm. The substrate used is FR4 epoxy with a height of 1.6 mm. The feed line has a width of 2.4 mm.

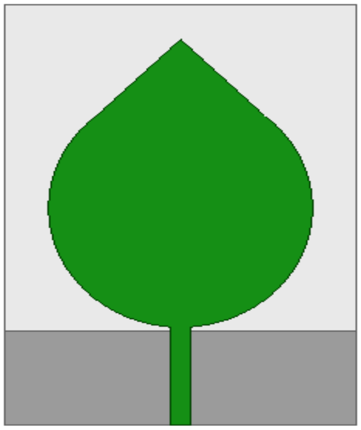


Fig 5.1 Single Petal Leaf structured patch

This structure gives a bandwidth of 10.76 Ghz ranging from 1.7 to 12.45 Ghz. The VSWR value for this antenna is less than 2 throughtout the bandwidth but this structure does not meets the FCC stipulated bandwidth. These results are shown in Fig 5.2 and Fig 5.3 below.

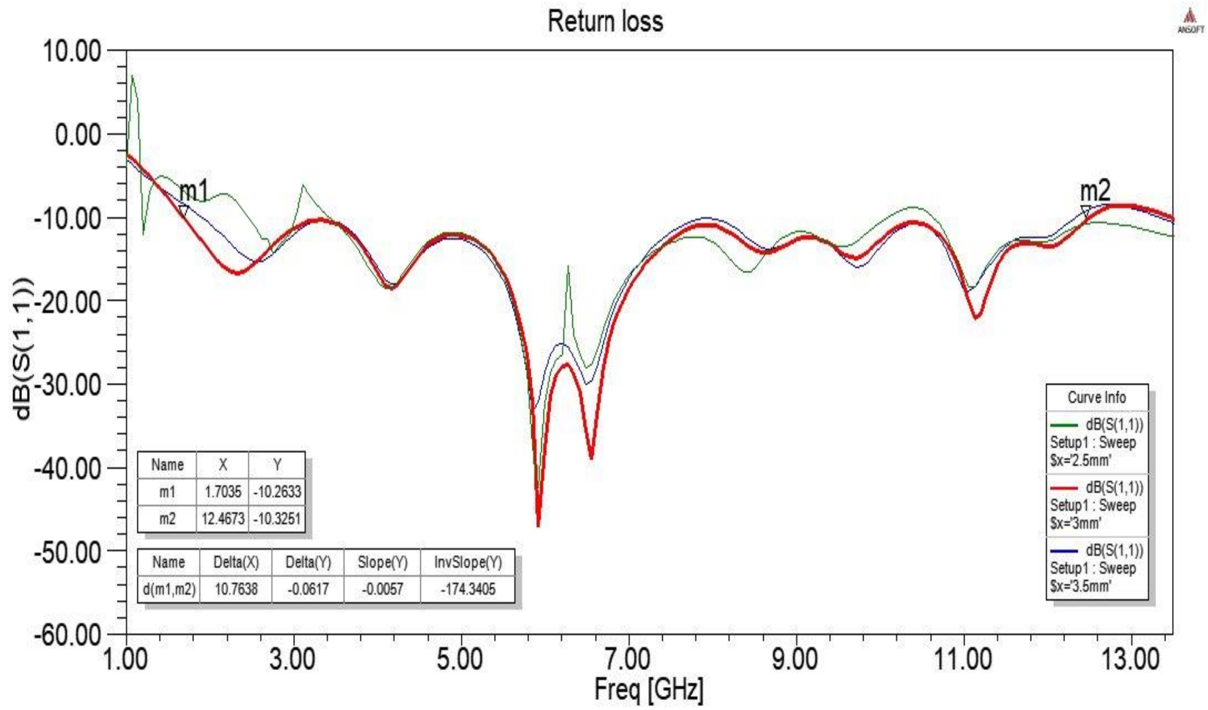


Fig 5.2 S11 plot for Single Petal Monopole antenna

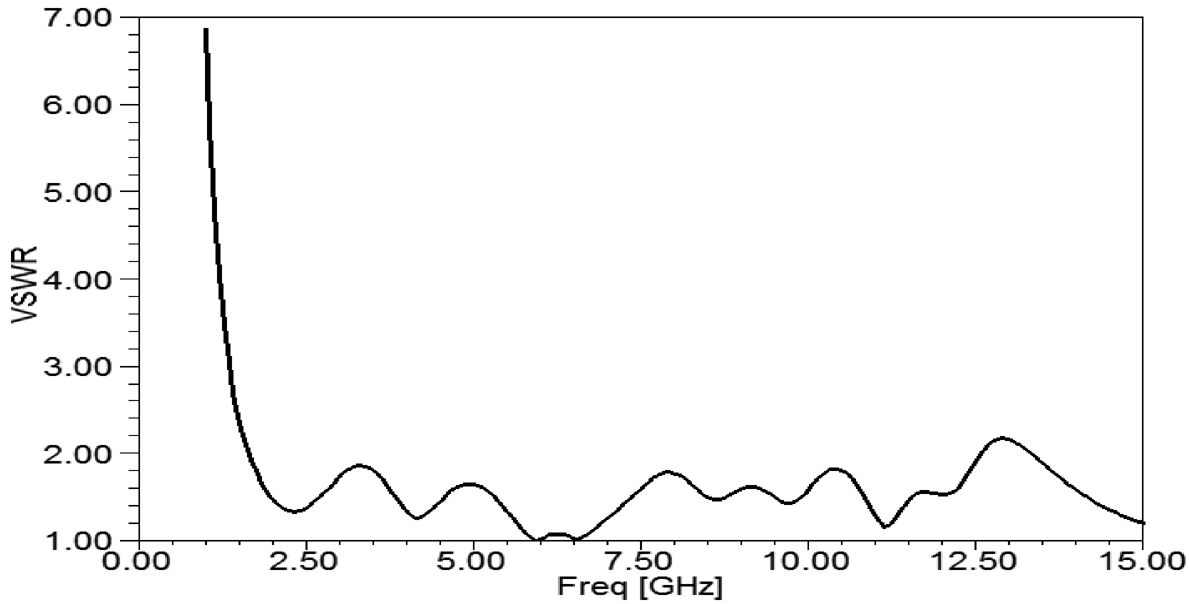


Fig 5.3 VSWR for Single Petal Monopole antenn

5.3 TWO PETALS MONOPOLE ANTENNA

Inorder to further increase the bandwidth two petal monopole antenna is considered in Fig 5.5.

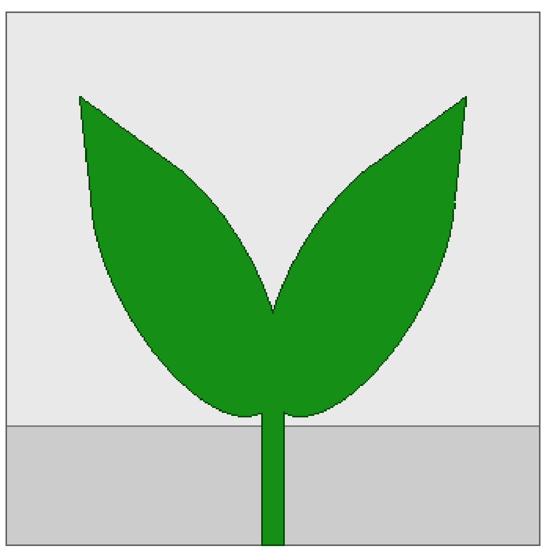


Fig 5.4 Two petal design structure

0In this design, two similar petals are taken as the patch which has a width of 43.38 mm and a length of 36 mm. The substrate is FR4 epoxy with a height of 1.6 mm. The dimensions of substrate are 60 mm x 60 mm.

The bandwidth for this antenna is observed to be 14.10Ghz ranging from 2.17 to 16.28 Ghz. The VSWR value is less than 2 as shown in Fig 5.7

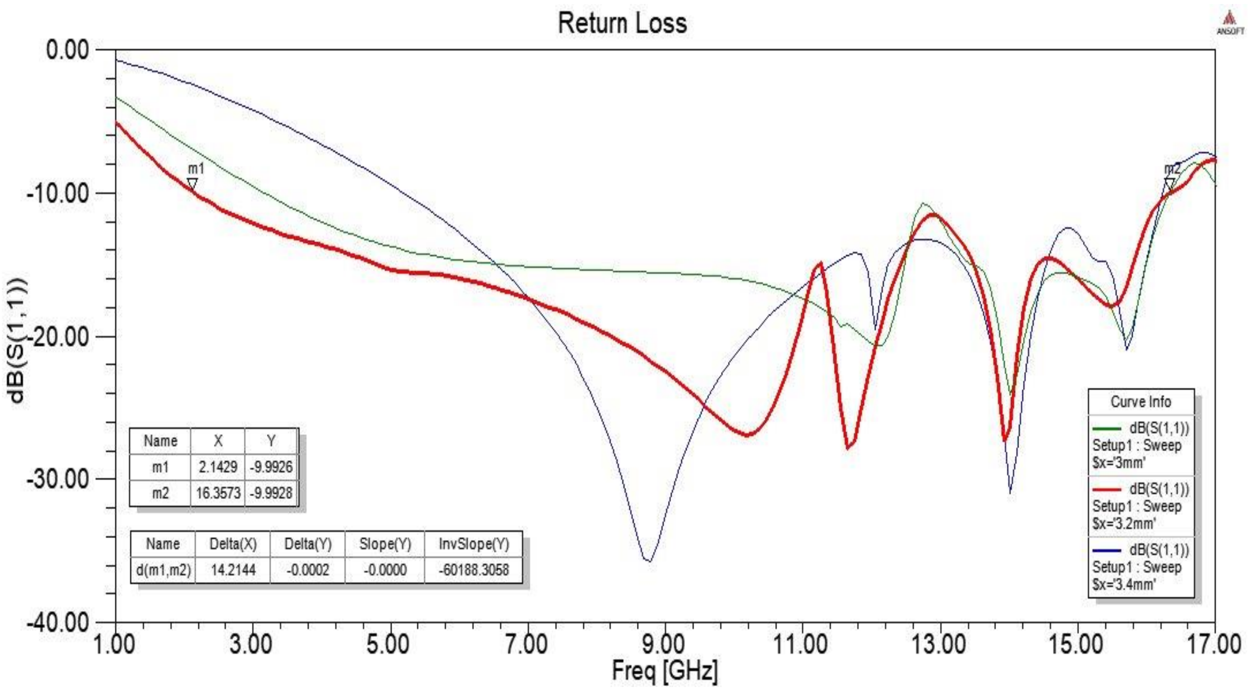


Fig 5.5 S11 plot for two petal antenna

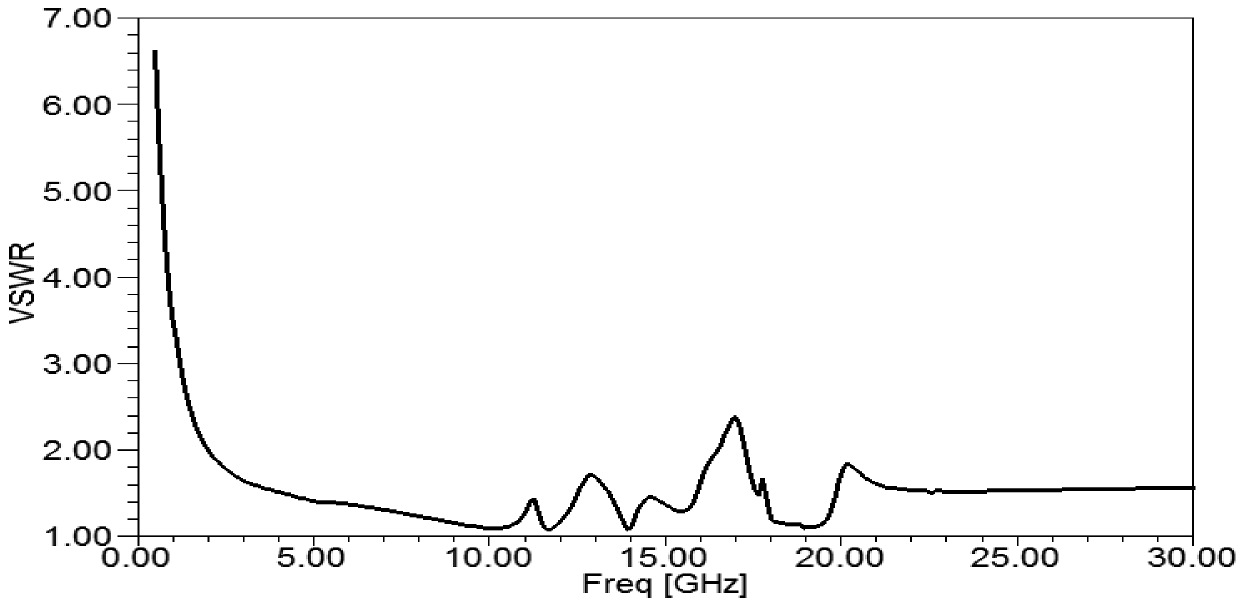


Fig 5.6 VSWR for two petal antenna

Though the bandwidth is beyond the FCC stipulated range, the bandwidth can be still increased for three petal antenna.

5.4 THREE PETAL ANTENNA

In this design, three petals are taken as the patch which has a width of 43.48 mm and a length of 55 mm. The substrate is FR4 epoxy with a height of 1.6 mm. The dimensions of substrate are 60 mm x 60 mm.

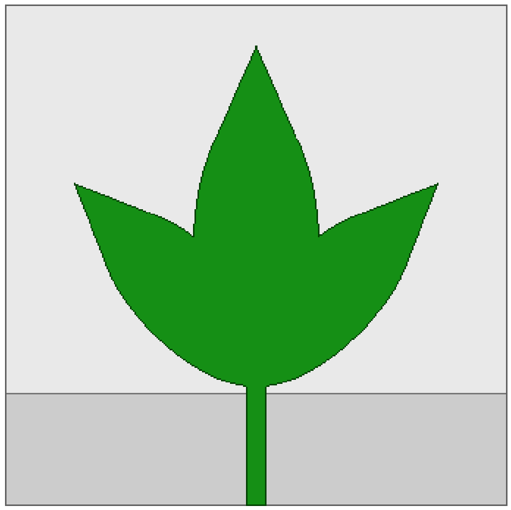


Fig 5.7 Three petal antenna design structure

The S11 plot shown in Fig 5.10 clearly shows that a bandwidth of 15.52 Ghz ranging from 1.47 to 1.7 Ghz. The VSWR plot for this antenna is shown in Fig 5.11

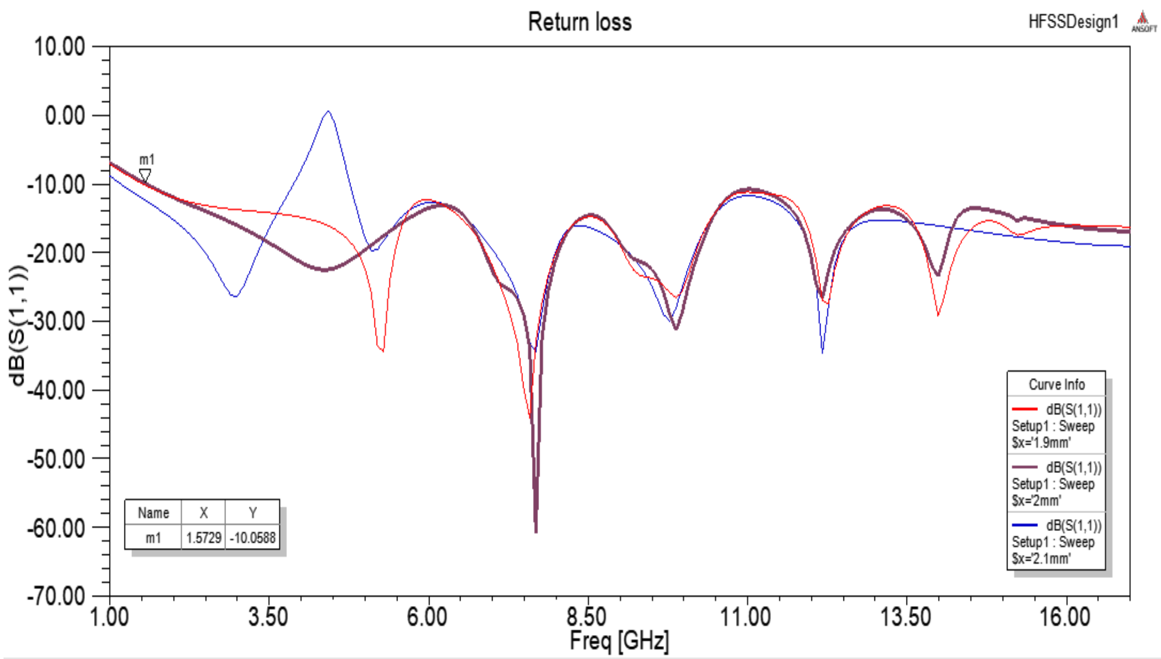


Fig 5.8 S11 plot for Three petal antenna

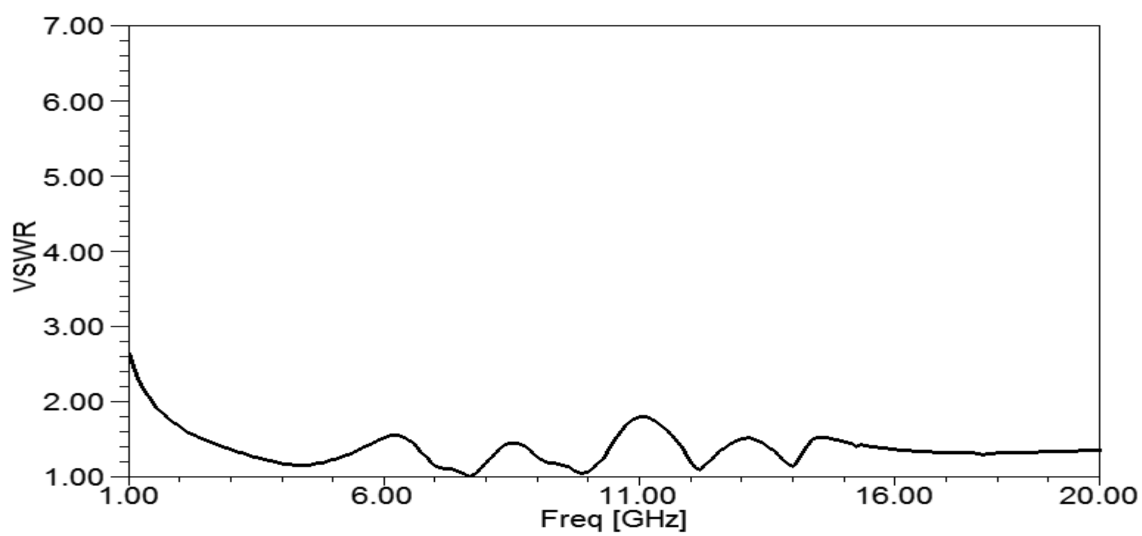


Fig 5.9 VSWR plot fro Three petal antenna

5.5 Comparision of results

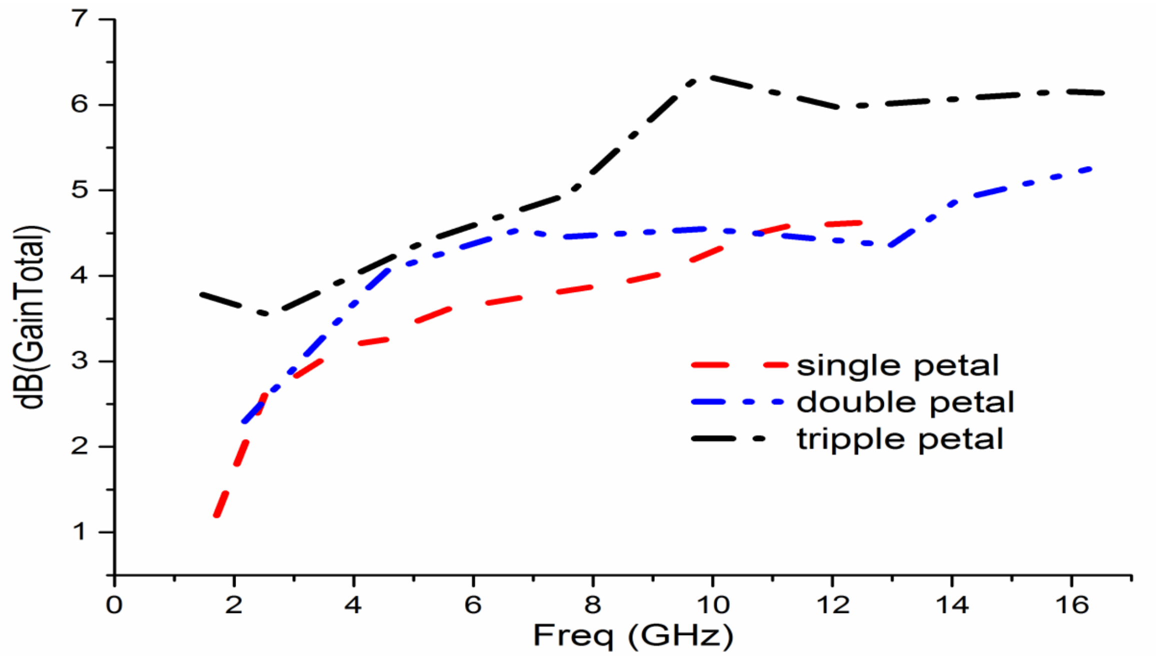


Fig 5.10 2D Gain plot comparision

5.6 Comparision of results

Parameter	Single Petals	Two Petals	Three Petals
Frequency range(GHz)	1.7035 to 12.4573	2.1773 to 16.2860	1.47 to 17
Bandwidth (GHz)	10.7638	10.7638	15.5226

Conclusion

A monopole antenna with bio inspired patch for UWB applications is designed for single petal and two petals and the bandwidth improvement is observed. The bandwidth obtained for single petal is 10.76 GHz ranging from 1.7 GHz to 12.46 GHz and that for two petals is 14.21 GHz ranging from 2.14 GHz to 16.35 GHz. The bandwidth for three petals has further increased to 15.52 GHz ranging from 1.47 GHz to 17 GHz. The comparision of two dimentional Gain plot shows that the gain is significantly increased from single petal structure to three petal structure.

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