DESIGN OF RECONFIGURABLE FILTENNA FOR 5g SUB 6GHz APPLICATIONS

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

BACHELOR OF TECHNOLOGY
IN
ELECTRONICS AND COMMUNICATION ENGINEERING

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Sangivalasa, Bheemili mandal, Visakhapatnam dist. (A.P) (2022-2023)

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CERTIFICATE

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ABSTRACT:

FIFTH-generation wireless network abbreviated 5G is the proposed next telecommunications standard after 4G.The development of 5G networks was driven by the ever-increasing need for faster data speeds, better coverage, increased signal efficiency, reduced latency, etc.Different spectrum bands will be supported by 5G, and they are primarily divided into Low-bands (below 1 GHz), Mid-bands (between 1-6 GHz), and High-bands (mm-wave) above 24 GHz. One major factor among several that favours the mid-band frequency over mm-wave is that higher frequencies will have more propagation losses.

A compact frequency-agile multiband filtenna is presented in this letter. The proposed reconfigurable filtering antenna performs independent switching between two operating bands 2.4 GHz (Bluetooth), and 5.1 GHz (WLAN). This switching allows the unused bands to be utilized by the secondary user, and used for applications. An elliptical wideband monopole antenna is excited through a split ring resonator filter (SRR) integrated on transmission line. The SRR comprises two distinct structures to tune to two different frequencies 2.4GHz and 5.1GHz using p-i-n diodes. The proposed filtenna has the reflection coefficient less than −10 dB for all the desired operating bands. Furthermore, this multiband filtenna offers gain of about 2.6 and 3.4 dBi at the two frequency bands.

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CHAPTER – I

INTRODUCTION

1.1 OVERVIEW

Antennas are essential and crucial parts of radar and communication systems. One of the innovations is the ability of a single system to handle several applications on various frequency bands or polarisations without the need for separate antennas for each application. Performance of the system may occasionally be constrained by their incapacity to adapt to changing operating conditions. These limitations are removed and extra levels of functionality are offered for any system by making antennas reconfigurable, allowing their behaviour to change in response to altering system needs or environmental circumstances. Since there are more systems on each platform now, there are more issues with cosite interference, cost, maintenance, dependability, weight, etc. Consequently, it is sensible to consider designing multipurpose antennas for recently invented systems.

1.2 LITERATURE REVIEW:

1.2.1 Microstrip Antenna Technology:

The use of antennas in communication and radar systems is critical and essential. One of the improvements is the capacity of one system to handle multiple applications on various bands of frequencies or polarisations with no the requirement of different antennas for each of the applications. Because of its limited ability to adjust to shifting operating circumstances, the system's performance may occasionally be limited. By permitting antennas to be reconfigurable, which enables their behaviour to vary in response to shifting system requirements or environmental situations, these restrictions are removed and additional levels of capability are available for any system. There are more problems with cosite interference, expense, maintenance, reliability, weight, etc. because each platform now has more systems. Therefore, it is sense to think about creating versatile antennas for recently developed systems.

Although the idea for a microstrip radiator was initially put out by G. A. Deschamps in the USA in 1953, Gutton and Baissinot in France eventually received a patent for it in 1955. Byron's description of a strip of conducting radiator that was isolated from a plane of ground by a dielectric substrate, however, was not published in the scientific journals until the early 1970s. At the X-band frequency, the Dolph-Chebyshev slot-array antenna created the first usable antennas. Due to their cost, size, and weight reductions, the microstrip line slots antennas look to be highly beneficial in a variety of application areas. A new kind of omnidirectional antenna for rockets and satellites is the microstrip antenna. These antennas have nearly flawless omnidirectional coverage capabilities. Munson has developed a novel low-cost, low-profile flat microstrip array with a 90% aperture efficiency. Howell released design instructions for UHF through C bands linear and circular polarised antennas. Derneryd created a similar network for microstrip radiating components with square and rectangular shapes. Additionally, a precise method for calculating the rectangular microstrip antenna's resonance frequency is provided. This technique has been applied in a variety of ways to study the microstrip antenna.

1.2.2 Reconfigurable Antennas:

The growing demand for multiband antenna has boosted the appeal of reconfigurable antennas. They increase a system's functionality by removing the requirement for intricate wideband antenna systems. Due to their permanent construction, many antenna designs that do not provide reconfigurability have limitations on the system's performance. By allowing antennas to adapt to different operating circumstances, reconfiguring them can improve their performance. Varactor and PIN diodes, as well as the usage of optically actuated switches using fibre optic cables, are some of the techniques that rely on geometric reconfiguration for tweaking the frequency that operates of a certain antenna design. Several antennas have been created that use self-similar designs to preserve their radiation properties while adjusting the aperture parameters for a new operating frequency. In order to operate at a higher frequency, another design makes use of a linear dipole antenna that has been reduced to a certain length. Because the antenna current passage is constant with respect to the resonant frequency's wavelength in the case of the reconfigurable dipole, the radiation pattern remains unchanged. Some uses of reconfigurable antennas modify the radiation pattern while keeping the resonant frequency constant. By focusing energy on the intended user, this idea can improve a system's capacity to eliminate jamming or undesired noise sources.

1.2.4 Frequency Reconfigurability:

Tunable antennas, or antennas having reconfigurable frequency response, have the ability to switch suddenly from a particular frequency band to another or carry out this function constantly. By actively manipulating the P-I-N diodes, the frequency response reconfiguration is accomplished, allowing the antenna to function in various frequency bands. Typically, to do this, a section or parts of the antennas are added or removed using mechanical,electrical, optical, or other techniques. By keeping the footprint of the antenna the same but altering the radiating current flow, the antenna resonance frequency may also be changed.

1.2.5 Radiation Pattern Reconfigurability:

Tunable antennas, sometimes referred to as antennas with reconfigurable response to frequency, have the ability to constantly or suddenly transition from a particular frequency band to another. By actively manipulating the P-I-N diodes, the frequency reconfiguration response is made possible, allowing the antenna to function over a range of frequency bands. To do this, an element or portions of the antennas are frequently added or removed using mechanical, electrical, optical, or other techniques. Modifying the radiating current flow while leaving the same antenna footprints will also change the resonance frequency of the antenna. This approach relies on the reciprocal linking of closely separated controlling and parasitic components using a single feed point to provide efficient array behaviour. differences in how the components interact.

1.2.6 Simulation And Optimization:

The usage of software for simulation is necessary for us to succeed. The programme should make it easier to calculate both the conceptual behaviour of such a structure and the position of the antenna's feed point. Ansoft Higher Frequency Structure Simulator (HFSS), an industrial Finite Element Method (FEM) solution for electromagnetic structures, is used to create the simulation models of the analysed antennas. It is most well-liked and effective uses for the sophisticated RF electronic circuit components and filters. It combines simulation, modelling, visualisation, and automating in an environment that is simple to learn. The HFSS provides an unmatched performance and thorough understanding of the real radiation phenomena in the antenna thanks to adaptive meshing and gorgeous visuals. With HFSS, one can visualise 3D electromagnetic radiation (near- and far-field) and extract parameters like S, Y, and Z. Design performance may also be improved. The inclusion of many types of port schemes in this simulation engines is a significant and beneficial feature. It offers incident wave scheme, wave port, lumped port, etc. With the use of wave port, coplanar wavelength guides and microstrip paths may be accurately simulated. For an antenna engineer to optimise the desired dimension, the parametric setup offered by HFSS is quite ideal.The first stage in HFSS system simulation is to establish the architecture of the system by specifying the boundaries and material attributes for any 3D or 2D items that are present in the HFSS window. The ideal port excitation strategy is then implemented.

The structure that needs to be mimicked is then surrounded by a radiation barrier filled with air. Now, by providing the correct operational frequency and the quantity of frequency points, the simulation engine may be started. Finally, it is possible to present the simulation results, including the, current distributions, and far field radiation pattern. Antenna engineers can precisely optimise the antenna parameters with the optimisation tool provided by HFSS. HESS offers a wide variety of boundary designs and excitation methods. In this paper, the PEC border and radiation boundary are often employed. The vector and scalar representations of the device's E. It and 1 values provide helpful insights into the simulation-related issue.

1.3 OBJECTIVES OF THE WORK

The objectives of the project are:

1. To design an Rectangular microstrip patch antenna for 2.4GHz and 5.1GHz applications and it is analyzed and simulated using HFSS and parameters are observed and optimized.

2. To design a reconfigurable filtenna for 5g sub 6GHz applications, here by inserting pin diodes on the above design, we can switch the frequency from one to other.

1.4 OUTLINE OF THE THESIS:

The rest of the thesis is organized as follows:

Chapter 2: This chapter represents the basic antenna parameters are RadiationPattern, Radiation Intensity, Field Regions, Directivity, Gain, Antenna Polarization, Bandwidth, Return Loss,VSWR etc...

Chapter 3: This chapter provides an overview of the microstrip antenna, including its method of radiation, benefits and limitations relative to its counterpart, and important applications in many sectors. All of the widely utilised feeding techniques for microstrip antennas are covered, along with their importance and methods of analysis.

Chapter 4: This chapter deals with the overview of reconfigurable antenna introduction. types of reconfigurable antennas, techniques for achieving reconfigurability, applications of reconfigurable antennas.

Chapter 5: This chapter deals with the design alongwith simulation of an Rectangular microstrip patch antenna for operating at frequencies 2.4GHz and 5.1GHz using microstrip line feeding technique. The performance of the designed antenna was simulated under different variable parameters. The antenna design and simulations were done in the Ansoft HFSS simulation tool.

Chapter 6: This chapter deals with the design and simulation of a reconfigurable filtenna for 5g and sub 6GHz applications at frequencies 2.4GHz and 5.1GHz using microstrip line feeding technique. The performance of the pin diode and its characteristics, The antenna design and simulations were done in the Ansoft HFSS simulation tool. Conclusions are discussed at the end along with references.

CHAPTER-II

FUNDAMENTAL PARAMETERS OF ANTENNA

2.1 INTRODUCTION:

Definitions for a variety of criteria are required in order to define an antenna's performance. For a thorough description of the antenna performance, not all of the characteristics must be stated because some of them are interconnected. Similar to how cellular mobile communication necessitates a circular polarised antenna with high gain, satellite communication in the downlink necessitates a high directive antenna. The IEEE Standard Definitions of Terms and Antennas (IEEE Std., 145-1983) is where the antenna's parameter definitions are found.

2.2 RADIATION PATTERNS:

The radiation pattern of an antenna, sometimes referred to as the Antenna Pattern or Far-Field Pattern, is a graphical depiction of the power emitted at certain distances from the antenna as a function of azimuth and elevation angle. The distribution of power in the space is therefore depicted by the antenna arrangement. The azimuth plane pattern and elevation plane design are terms used to describe the radiation pattern that may be produced in a 3D plane as illustrated in figure 2.1 for various azimuth and elevation angles.

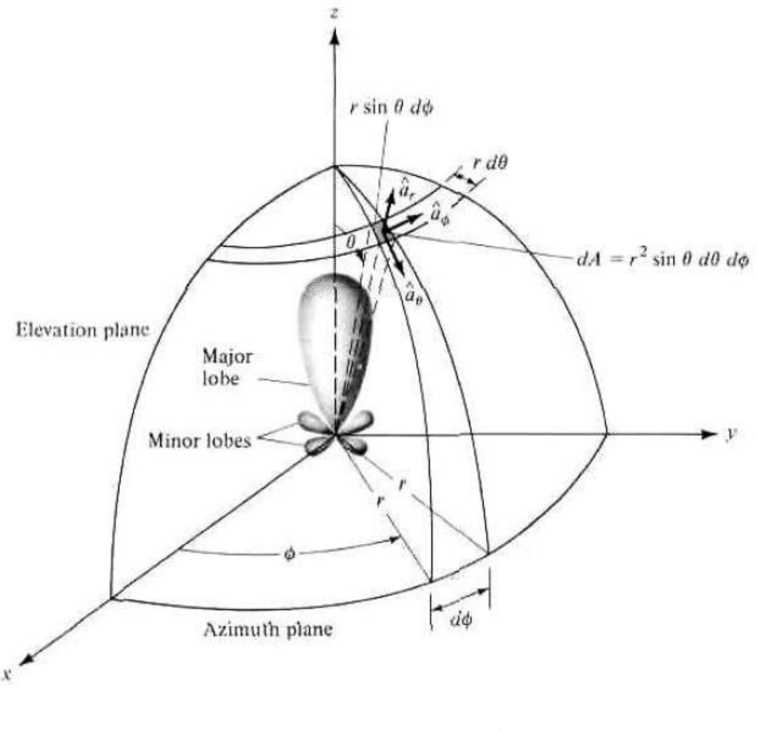


Figure 2.1: Radiation pattern of antenna

When an antenna radiation pattern includes several side lobes and these side lobes levels have a significant influence, it is beneficial to depict the radiated patterns in Euclidean (rectangular) coordinates. The following describes many antenna pattern types.Ion-beam antenna An antenna with isotropic characteristics radiates all of the supplied power with radiations that are evenly distributed in all directions. It is a hypothetical antenna that doesn't actually exist. It serves as a benchmark for comparison with other antennas.

b. Omni directional Antennas:

An antenna with an omnidirectional radiation pattern is one that emits radiation evenly and uniformly in one plane, often horizontal planes. A base station antenna must have the properties to radiate evenly in a plane for several applications, including mobile phones, FM the radio, telephones, wireless networks for computers, cordless phones, GPS, and many portable devices that are handheld. The radiation pattern of an omnidirectional antenna resembles a doughnut. Some excellent examples of poor-gain unidirectional antennas include slot and dipole antennas, whip antennas, and duck antennas. By reducing the antenna's beam width in the vertical plane, it is also possible to create omnidirectional antennas with large gains that concentrate energy in the horizontal plane.

Directional Antennas: An antenna that emits radiation evenly and equally in one plane, frequently horizontal planes, is said to have an omnidirectional radiation pattern. For a variety of applications, such as mobile phones, FM radio, telephones, internet connections for laptops corded phones, GPS, and many other portable devices, the base station's antenna must possess the ability to radiate uniformly in a plane. An omnidirectional antenna's radiation pattern resembles a doughnut. Slot and bipolar antennas, whip antennas, and duck antennas are some great examples of poor-gain unidirectional antennas. It is also feasible to design omnidirectional antennas with significant gains that concentration energy in the horizontal plane by narrowing the length of the antenna's beam width in the vertical direction. As a result, a narrow beamwidth antenna.

2.3 FIELD REGIONS:

When we move away from an antenna, the radiation it emits changes. Both the far field area and the near field (Fresnel) region are possible field regions. The area outside of the Fraunhofer distance is referred to as the far field region. After that, the radiation pattern remains constant regardless of distance. The bigger dimension of the antenna is connected to the Fraunhofer distance, which may be computed as follows:

$$R = \frac{2D^2}{\lambda}$$

Where, R=antenna distance

D= Antenna larger dimension

λ= wavelength in the free space

2.4 RADIATION INTENSITY:

A definition of radiation intensity reads, "The power emitted from an antenna per unit rigid angle." An easy way to calculate the radiation intensity, a far-field parameter, is to simply multiply the radiation density by the square of the length. It is written as follows in mathematical form:

$$U = r^2 W_{rad}$$

Where U = radiation intensity (W/unit solid angle)

W_{rad}= radiation density (W/m²)

2.5 DIRECTIVITY:

An antenna's directivity measures how much radiation it can emit in a certain direction. When an antenna is being used as a receiver, it is a crucial necessity. The directivity of an antenna is I or 0dB when measured with respect to an isotropic antenna if it radiates equally in all directions. The simple definition of directivity is the ratio of the greatest radiation intensity to the average radiation intensity.

Directivity is equal to the product of the maximum and average radiation intensities.

$$D = \frac{U}{U_o} = \frac{4\pi U}{P_{rad}}$$

Where D = Directivity

U = Radiation intensity (W/unit solid angle)

U_o = isotropic source's radiation intensity (W/unit solid angle).

P_{rad}= Total Radiated Power (W)

When referring to an antenna at the transmitting end, the directivity of an antenna with a specific angle demonstrates that the antenna radiation are more concentrated in that particular direction. In contrast, a receiving antenna will effectively receive electricity coming from a certain direction.

2.6 GAIN:

Gain can also be shortened to Gain or Power gain. This combines the directivity and efficiency of the antenna. It displays for an antenna that transmits how well the antenna can radiate the supplied power towards space in a certain direction. While in the case of a receiving antenna, it demonstrates how well the antenna transforms the electromagnetic waves it receives into electrical power. Power Gain is the term used when it is computed with effectiveness and directivity D.

$$Power\ Gain\ =\ E_{antenna}$$

Directive Gain refers to the amount of directivity that is delivered in a specific direction.

$$Directive\ Gain\ (\theta, \pi) - E_{antenna}.D\ (\theta, \pi)$$

2.7 ANTENNA POLARIZATION:

An antenna's polarisation is the polarisation of the radio waves it emits. The direction or route that the vector of the electric field on a wave takes as a function of time is known as polarisation. Polarization can be categorized in three parts

a. Linear polarization

b. Circular polarization

c. Elliptical polarization. The polarisation is linear if the route taken by the wave's electric field vector at a particular location in space is linear. There are two forms of linear polarisation: vertical and horizontal. Electric field vectors with circular and elliptical polarisations go in these directions, respectively. If the electric field vector tracks the route in a clockwise direction, they can be left hand polarised, and if it does so in an anticlockwise direction, they can be right hand polarised.

2.8 HALF POWER BEAM WIDTH:

"In a plane containing the path of the highest of a beam, the angle between the two directions in which the intensity of radiation is one-half the maximum value of the beam," is how the term "half power beam width" is defined. Alternatively, "The resolving capability of an antenna to discriminate between two different sources is equal to a half the initial null beam width (FNBW/2), which is often used to approximation the half-power beam width (HPBW).

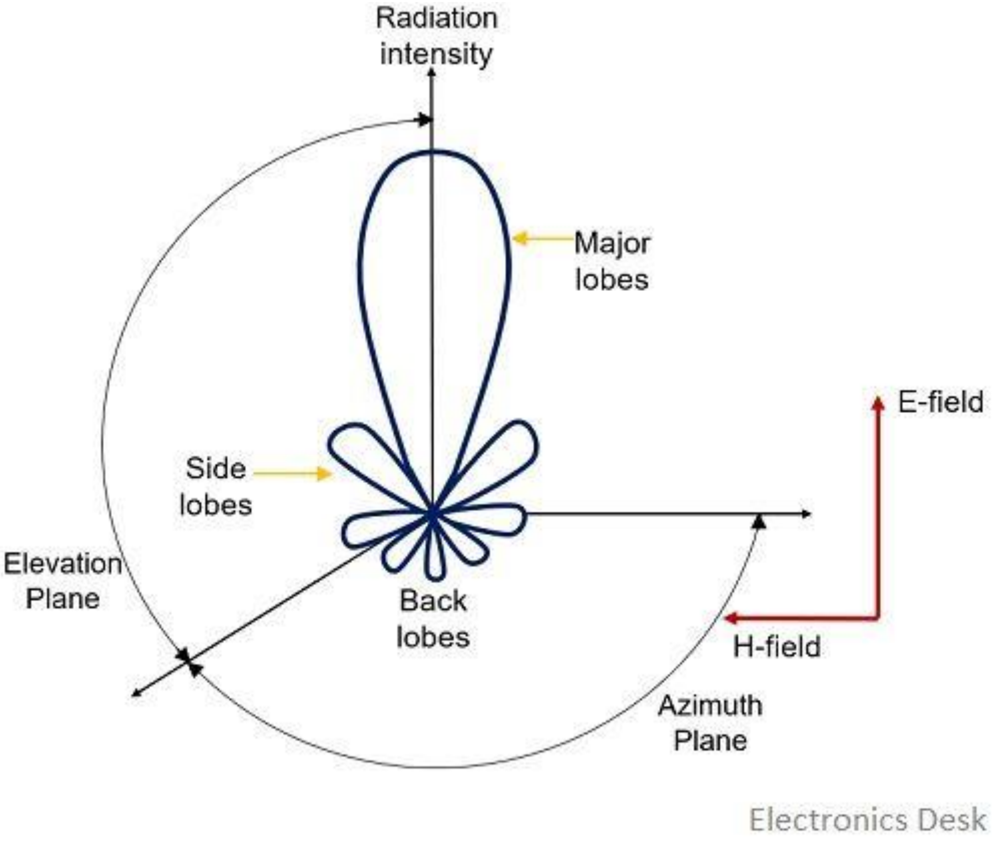


Figure 2:2: Radiation lobe of an antenna pattern.

2.9 ANTENNA BANDWIDTH:

Another crucial aspect of an antenna is its bandwidth, which is the range of frequencies throughout which it performs certain functions. By shifting the frequency of a test signal with constant strength above and below the centre frequency and monitoring power output, bandwidth may be determined. The frequency range across which the input impedance of the antenna precisely corresponds to the characteristic impedance of the feeding line for transmission is known as the impedance bandwidth. Q factor-related impedance bandwidth may be defined as

$$BW \ = \ s - \frac{1}{Qt\sqrt{s}}(VSWR\ S{:}\ 1)$$

Generally Fractional bandwidth is used for microstrip Given by

$$BW \ = \frac{f_h - f_l}{f_c}$$

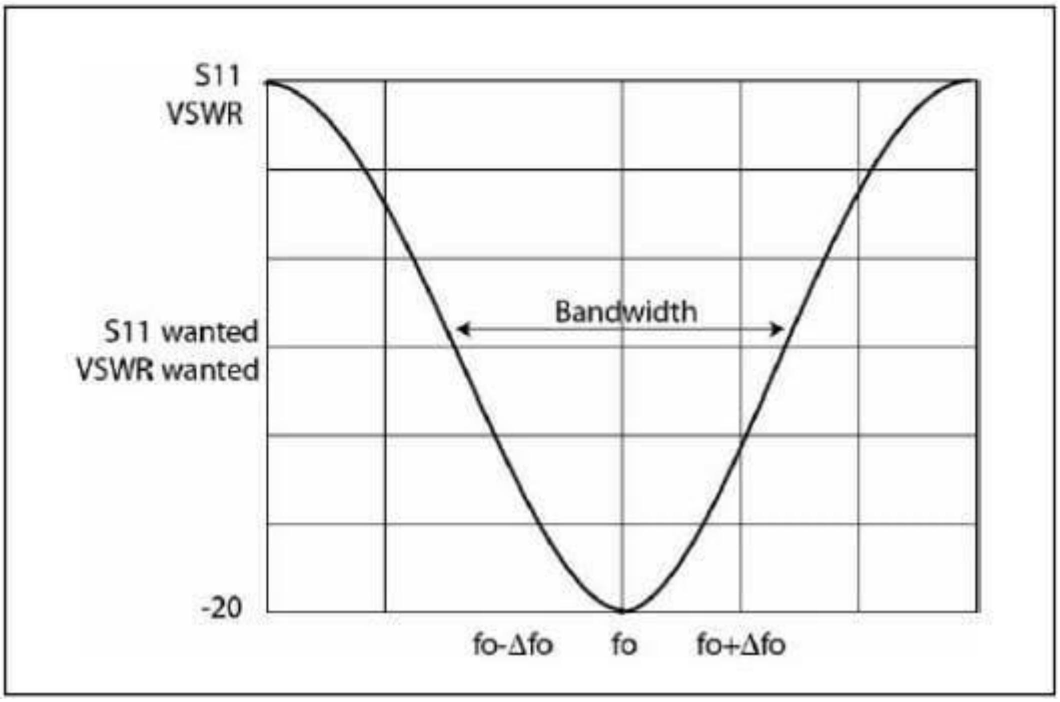


Figure 2.3: Bandwidth of antenna

Where fh and fl are the upper and lower frequencies where the vswr matches to S: 1. Generally VSWR is taken 2:1 and ideally it is 1:1. Proper matching of impedance is necessary to maximise the resistance bandwidth for VSWR 2:1. This means that we must feed at the source of power point, where the antenna impedance is typically Z0 = 50 ohm. By feeding at the position where the resistance of the antenna is 65 ohm, a little bit additional bandwidth may be obtained.

2.10 RETURN LOSS:

Return loss is a metric for determining how well electricity is sent from a line of transmission to a load, such an antenna. If the amount of power incident on the antenna-under-test (AUT) is Pin and the energy reflecting back to the source is Pref, the ratio Pin/Pref indicates the amount of ref unbalance between the source of the incident and rebounded power in the travelling waves. The better the amount of load and line are matched in Pref, the higher this power ratio, which is expressed in dB.

$$Return\ Loss\ =\ 10\ log_{10}\left(\frac{P_{in}}{P_{ref}}\right)dB.$$

2.11 VOLTAGE STANDING WAVE RATIO (VSWR):

The amount of energy returned from the antenna as a result of impedance mismatching is measured by VSWR. VSWR would be one for an antenna with ideal impedance. Return loss is frequently utilised since it demonstrates the gain drop that would be brought about by the antenna's mismatch. Because signals received from satellites are often quite faint (on the scale of -160W), VSWR is crucial for wireless communication because reflections are undesirable on the transmission line linking the antenna and receiver. For the majority of wireless applications, VSWR less than 2:1 (corresponding to a return loss of -9.5dB) is regarded as acceptable since any reflections normally have a short time delay, resulting in minimal receiver error.

$$VSWR\ =\ \frac{1+|\Gamma|}{1-|\Gamma|}$$

CHAPTER-III

MICROSTRIP ANTENNA

3.1 INTRODUCTION:

Since the 1970s, microstrip antennas have drawn a lot of interest. despite the fact that a patent for a microstrip antenna was only issued in 1955. One of the key benefits of microstrip antenna is how easily it can be mounted on both planar and non-planar surfaces. When high performance applications like those for aeroplanes, spacecraft, missiles, and communications via satellite supplied the push in the early 1970s, this was the major reason conformal microstrip antennas gained the serious attention of researchers. After almost two years, Howell introduced a straightforward rectangular-shaped microstrip antenna powered by a microstrip transmission line. Microstrip antenna received a lot of interest from researchers at the time.

3.2 MICROSTRIP ANTENNA:

A microstrip antenna is made up of two thin metal layers , one of which serves as the radiating patch and the other as the ground plane, with a substrate made of dielectric sandwiched in between. The conductor patch is utilised as a radiating element and is attached to the dielectric substrate. A conductive layer serving as a ground plane is provided on the substrate's reverse, as seen in figure 3.1. Typically, copper and gold are employed as metallic layers. Any shape may be used to build a radiating patch, although simple forms are typically employed since they are straightforward to analyse using theoretical models and have predictable performance. rectangle, square, dipole,Circular, rectangular and dipole are the most often used shapes because of easy of analysis and fabrication. For the substrate, a range of dielectric materials with dielectric constants of 2.2 r 12 are available. The height of the substrate has a significant impact on the antenna parameters, which typically fall between 0.003 to h0.05.

Microstrip antennas have a relatively limited frequency range. Microstrip antennas are helpful in applications where restricted bandwidth is necessary, such as security for the government systems. Microstrip antenna bandwidth is inversely related to substrate height. The two basic methods for increasing bandwidth are circuit theory and structural.

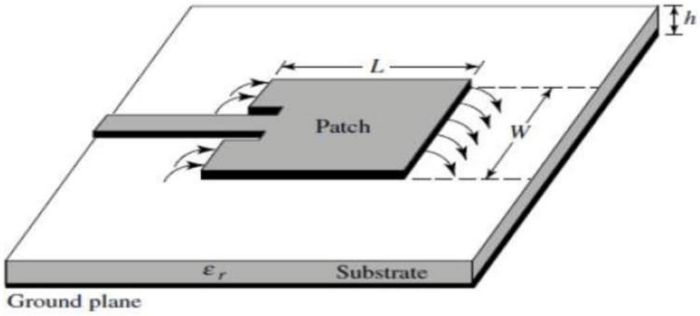


Figure 3.1: Basic Microstrip Antenna

The TX-line and antenna combinations have an impact on an antenna's properties in addition to the antenna element itself. The characteristic resistance of the TX line is real (often 50 ohm) while the input resistance of a microstrip antenna is typically complicated. This generates a voltage standing wave pattern on the transmission line, which results in poor impedance bandwidth, and impedance mismatching. Resistance matching networks between the antenna and transmission line are one technique to solve this issue. The circuit concept deals with impedance matching methods, which are accessible in a variety of forms. The change of substrate characteristics like height and the constant of dielectric is the focus of structural technique. We may improve the bandwidth by raising the height. However, it will additionally create surface waves, which worsen performance and characteristics by increasing power loss. Researchers have developed a variety of techniques, including stacking, ground planes with defects, parasitic patches, and increasing the bandwidth of microstrip antennas. This is still a fascinating area for research. One may simply create an antenna with the required frequency of resonance radiation pattern and polarisation by selecting a certain shape. By simply using loads like PIN diodes and varactor diodes, it is simple to create an antenna with a microstrip with reversible polarisation, resonance frequency, and radiation patterns.

3.3 CONFIGURATIONS:

As shown in figure 3.2, several configurations have been developed and studied to enhance the efficiency of the microstrip antenna from the early stages of its development. Rectangle, triangle, and circle are a few of the typical forms that are seen in the illustration. It is known that a number of forms, including pentagon and ellipse, produce circular polarisation. To enhance the antenna properties, several combinations of microstrip antenna have been used as opposed to a single patch. For example, creating a flat array by placing patches next to one another on the substrate will result in increased directivity and gain. If antennas were placed on top of one another with spaces between them, a broader bandwidth might be attained.

(a) Square

(b) Rectangular

(c) Dipole

(d) Circular

(e) Elliptical

(f) Triangular

(g) Disc sector

(h) Circular ring

(i)Ring sector

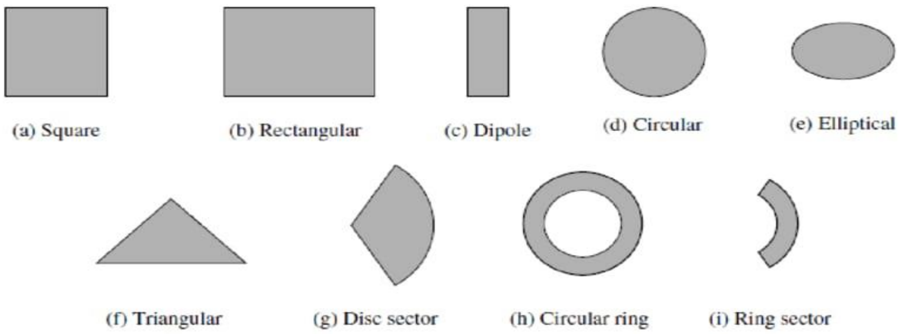


Figure 3.2: Different shapes of microstrip patch antenna

3.4 ADVANTAGES AND DISADVANTAGES:

Microstrip antennas are low profile, lightweight, and relatively simple to install, which makes them particularly common in portable wireless devices like mobile phones and pagers as well as in some high performance communications systems like those found in satellites, missiles, spacecraft, aeroplanes, and other similar objects. Following is a list of some of the primary benefits of microstrip antennas as mentioned by Ramesh Garg:

- Cheap and simple to construct.
- It is simple to plant on any surface.
- It is simple to obtain reconfigurable qualities.
- Has no trouble creating antennas with the required polarisation.
- Compatible with MICS, or microwave integrated circuits.
- For maximum growth and focus An array of antennas is simple to create.

On the other hand, as compared to other antennas, microstrip antennas also have a variety of drawbacks and limits. Following are some of the main drawbacks of microstrip antennas:

- High quality component.
- Cross-polarization.
- Ineffective polarisation efficiency.
- Experiences erroneous feed radiation.
- Limited impedance bandwidth (without any approach, 5% to 10%)
- Significant conductor and dielectric losses.
- Sensitive to environmental factors including humidity and temperature.

- When a highly dielectric material is utilised, surface wave occurs.

- Capability for managing power and low gain.

There are several ways to get around these restrictions. For example, by adopting unique techniques like the defective ground plane approach, stacked patches, slotted patches, and parasitic patches, the bandwidth of microstrip antennas may be increased. An antenna array can be created to increase gain and an antenna's capacity to handle power. The antenna properties are also improved by the use of met materials and Electromagnetic Band Gap (EBG) structures.

3.5 APPLICATIONS:

Due to a number of benefits, microstrip antennas have found great usage in a variety of applications after some initial constraints. Microstrip antenna are often used in defence systems including missiles, aircraft, satellites, and rockets. Today, commercial businesses utilise microstrip antennas because they are inexpensive to create and take use of cutting-edge printing circuit technology. Because of advancements and ongoing research in the field of a microstrip antenna, it is projected that ultimately most regular antenna will be substituted with microstrip antenna. Some of the primary applications for microstrip antennas include the following:

- Mobile Communication:-

Mobile application antennas should be compact and minimal in weight. This complete criteria is met by microstrip antenna. The majority of mobile applications are found in handheld devices or small pieces of equipment, cell phones, UHF pagers, and radar systems in cars, aircraft, and ships. For radar applications including maritime radar, radar for surveillance, and radar for remote sensing, a variety of designs are created and employed.

Satellite communication includes:

Antenna used for satellite communication has to be circularly polarised. One of the main advantages of microstrip antenna is the ease with which polarization-required antennas may be designed utilising dual feed networks and other methods. In satellite communication and satellite broadcasting, parabolic antennas are employed. In its stead, a parabolic reflector can be replaced by a flat antenna with a microstrip array.

The Global Positioning System (GPS):

Originally mainly employed for military purposes, the satellite-based GPS technology has found widespread usage in daily life and is now utilised commercially. In order to track the precise location and position, GPS was proven to be a crucial need in cars, ships, and aeroplanes. A total of 24 GPS satellites orbit the planet every 12 hours at a height of 20,200 kilometres. Numerous stations on earth receive the signal from the GPS satellite utilising two L-band frequencies. Circular polarisation should be applied to the reception antenna. The beam of an omnidirectional microstrip antenna is broad.

System for Direct Broadcast Satellite:

In many countries, television services are delivered via the direct broadcasting method. A high gain (-33db) antenna should be used at the user side. The most common antennas used are parabolic reflectors, which are heavy, space-intensive, and susceptible to snow and rain. For direct broadcasting reception, an array of circularly polarised microstrip antennas can be utilised. which are simple to install, are less affected by snow and rain, and are also less expensive.

- Pedestrian Antenna: Given the limited amount of room available, pedestrian antennae should be as small as is practical. Low profile, lightweight and small construction antennas are frequently used in portable pocket equipment. A microstrip antenna is the best solution for it. Numerous techniques are available.Radar applications:-

For radar applications like man-pack radar, maritime radar, and secondary surveillance radar, the appropriate gain and beam width are required. To get the proper gain and beamwidth, one can use a number of microstrip antennas. There are several uses for synthetic aperture radar.like detecting underwater wave direction and velocity and figuring out the grades of the ground soil. This method uses two arrays of patches of antennas that are appropriately spaced apart.

- Application in Healthcare Science: Microwave energy is utilised to generate hyperthermia in the treatment of malignant tumours in the medical field. The energy radiator used in the microwave for this purpose has to be portable and flexible enough to adapt to the area being treated. A microstrip patch antenna is the only antenna that can satisfy that requirement. Microstrip antennas with a circular disc and an annular ring are two examples.

3.6 FEEDING TECHNIQUES

Microstrip antennas may be fed using a variety of feeding mechanisms. Each one of them has strengths and weaknesses of their own. The best sort of feeding for the antenna's design depends on a number of elements. Effective power transmission from the feed line to the antenna emitting element, which is correct matched between the feed and antenna, is the primary factor. Impedance matching is accomplished using a variety of methods, including stubs and impedance transformers. Feed structure should be made in a way that makes it simple to build these complementary structures with radiating elements. Another important element that depends on the feeding techniques and influences the antenna characteristics is spurious feed radiation, which includes surface wave losses. Surface waves reduce an antenna's effectiveness, while erroneous feed radiation causes unwanted. The ability of the feed network to create an array should be a key component as well. There are two primary types of feeds: contacting feeds and non-contacting feeds or electromagnetically linked feeds. The feed line is directly linked to the radiating element in contacting feeds. The primary disadvantage of contacting feeds is that they exhibit intrinsic asymmetry, which generates higher order modes and raises the intensity of cross polarisation. Non-contacting feeds are employed to reduce this. Aperture paired and closeness coupling are two non-contacting couplings that are used often and are briefly discussed here. Microstrip line feed and coaxial probe feeding are two of the most common direct contact feedings.

3.6.1 Microstrip Line Feeding:-

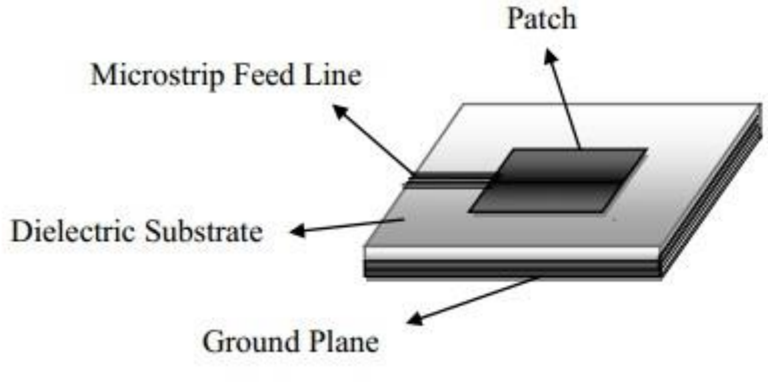


Figure 3.4: Microstrip line feeding

In this method of feeding, the patch as illustrated in figure 3.4 is directly fed by a microstrip feed line that is much narrower than the patch. It is the most basic and popular technique of feeding. because a microstrip line may be constructed on the same substrate as a radiating patch and be considered as an extended component of it. This form of feed is particularly compatible with impedance matching methods and is simple to construct. However, this feed has numerous flaws as well, including limited bandwidth, surface wave losses, and erroneous feed radiation.

3.6.2 Coaxial Probe Feed:-

one of the most popular microstrip antenna feedings. Using solder, the coaxial cable's core is attached to the patch in this method of feeding while the outside cables are attached to the ground. A hole in the substrate is used to introduce the core conductor. The main advantage of this feeding approach is that we may connect or feed the inner conductor directly to the feed location where the source impedance is equal to the particular impedance of the feed line, as illustrated in figure 3.5. one of the most used techniques for feeding microstrip antennas. In this method of feeding, the outside cables are connected to the ground while the inner core of the coaxial cable is attached directly to the patch. The core conductor is inserted into the substrate through a hole.

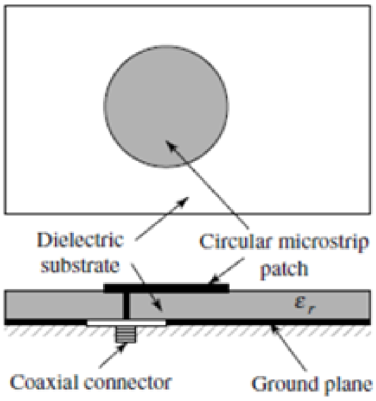


Figure 3.5 Probe Feed

3.6.3 Proximity Coupled Feed:-

This method of feeding employs two different types of dielectric substrates. Microstrip line is placed between the substrates and is not directly attached to the patch; it is left open-ended. The radiating patch receives energy from the feed line via electromagnetic coupling. To enhance the bandwidth, the microstrip line can be expanded as a stub. The selection of the substrate's dielectric constants plays a key role in maximising bandwidth while minimising spurious feed electromagnetic waves from the feed line. The radiating patch receives energy from the feed line via electromagnetic coupling. To enhance the bandwidth, the microstrip line can be stretched as a stub. Figure 3.6 depicts the structural aspect of this sort of feeding.

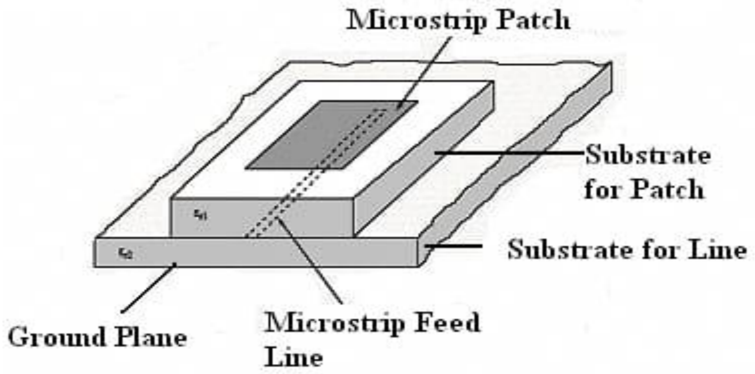


Figure 3.6: Proximity-Coupled feed

3.6.4 Aperture Coupled Feed:-

Because lower the dielectric constant, the more the fringing field and the more the radiation from the patch, thick material with a low dielectric constant is chosen for upper substrates, while thin substrate with a high dielectric constant is chosen for lower substrate. In comparison to other feeding methods, this one has the biggest bandwidth. It is simple to predict and has little spurious feed radiation, but because the feed line must be precisely aligned, manufacturing is more challenging. To adjust the antenna properties, the width to line ratio of the patch and the length of the longer stub may be optimised.

Figure 3.7 depicts the structural aspect of this sort of feeding. As seen, this feeding also makes use of two different substrate types, a ground plane that is positioned in the space between them, and a microstrip line that is typically utilised to feed and is positioned below the lower substrate.

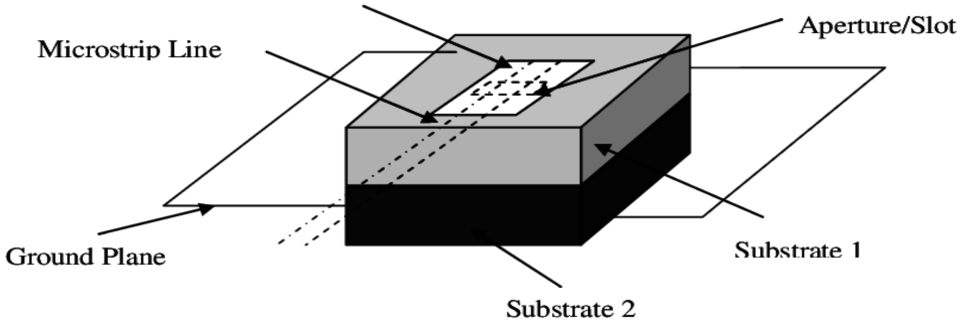


Figure 3.7: Aperture-Coupled feed

Through an aperture or slit cut out of the ground plane, the energy is through electromagnetic radiation connected to the patch. There are many different sorts of aperture shapes, but generally speaking, rectangular and circular forms are most common. Slots with cross or annular shapes are utilised to excite circular polarisation. To enhance the characteristics of the antenna, slots' parameters are employed. In order to achieve superior radiation and bandwidth, substrates for proximity coupled feeding are chosen based on their dielectric constant. For the top substrate, a thick substrate with a dielectric constant that is low is employed to get excellent radiation and bandwidth. The top substrate is made of a thin, highly dielectric substance to provide effective energy transmission from the feed line to the patch. to get the greatest coupling. We may infer that the magnetic field is strongest in the patch's centre and that the electric field is strongest at the patch's ends based on the voltage as well as the current distributions throughout the length of the patch. A length of additional the microstrip feed line is added and utilised as a stub. Stub admittance is parallel to slot admittance and functions as an open-circuit transmission line. The reactive components of the slot can be cancelled out to those of the extended feed line (stub) by optimising it, which will improve impedance matching.

(a) Microstrip line

(b) Probe

(c) Aperture-coupled

(d) Proximity-coupled

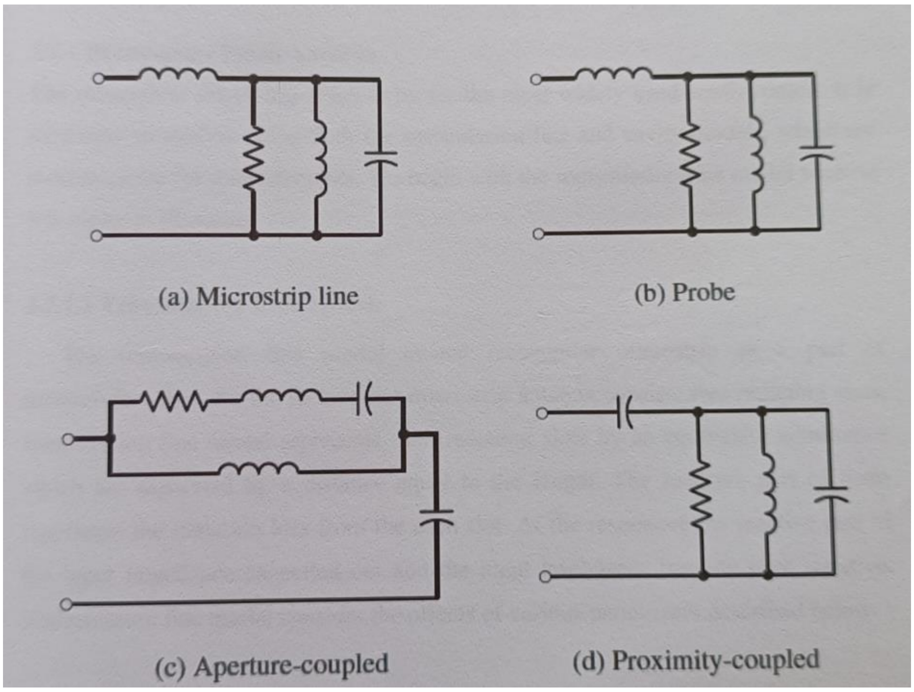


Figure 3.8 Equivalent Circuits for Feeding Techniques

To reduce emission below the ground plane, the area of the slot is maintained modest. In comparison to microstrip and coaxial probe feeding, this kind of feeding has superior polarisation purity, less spurious feed radiation, and a larger bandwidth. Figure 3.8 above displays the analogous circuit for every single one of them.

3.7 METHODS OF ANALYSIS

Microstrip antennas may be analysed using a variety of techniques. The transmission model, cavity model, and full wave models—which mostly use integration and moment techniques—are the most often used models. The electrical transmission model is the simplest and provides the best physical understanding, but it is less precise and coupling is more challenging to construct. The cavity model is both more sophisticated and more precise than the transmission line model. Though it has been utilised successfully, it also provides physical insight and is pretty hard to represent coupling. The complete wave models can handle single components, finite and unlimited arrays, stacked components, arbitrary structured elements, and coupling and are generally correct and quite adaptable when used appropriately. But they are the most difficult.

3.7.1 Rectangular Patch Antenna

The most popular configuration is unquestionably the rectangular microstrip patch. The transmission-line and cavities models, especially are most correct for thin substrates, make the analysis fairly simple. The transmission-line model is used to start since it is simpler to demonstrate. In the electrical transmission concept, rectangular microstrip was treated as a transmission line component. Since a microstrip antenna with a rectangular shape contains two radiating slots, the transmission line model represents each radiating slot by an equivalent admittance that splits it by a length-related distance. The resistive component of them represents the radiation's electromagnetic loss from each slot. The source impedance's reactive component cancels out at resonance, leaving just the resistance component. transportation system.

a . Fringing Field:

The radiating edges in the image below are where the fringing field of the rectangular microstrip antenna seen in figure 3.9 originates. The constant of dielectric and the length L to height h ratio have a significant impact on the fringe field. Since the L/h ratio is often less than 1, the bordering fields are smaller.

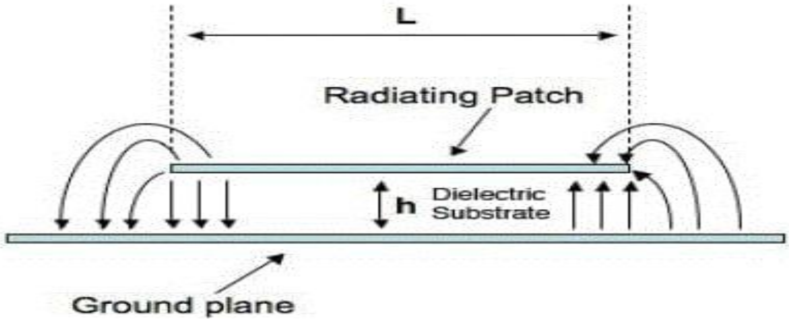


Figure 3.9 Fringing Field Effect

Bounded electric fields are more tightly contained in the substrate when using a substrate with a higher dielectric constant, as in the case of microstrip lines. They will go further away from the patch because substrates with lower dielectric constants have loosely confined electric fields. More bent fringing fields were caused by substrate materials with lower dielectric constants. We are aware that the radiations from microstrip antennas are caused by the fringing fields. Therefore, higher radiations and greater fringing fields combined with a lower dielectric constant improve efficiency and antenna performance. Figure shows that fringing field lines extend deeper into the atmosphere in addition to being encased in substrate. Since the field lines move through both the substrate and the air.

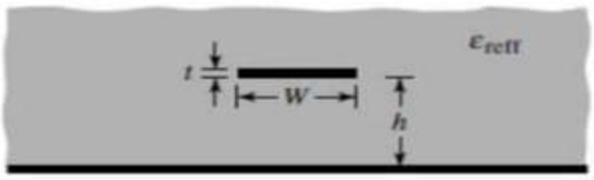


Figure 3.10 Effective Dielectric constant

The dielectric constant for which the attributes of the antenna are the same as those of the real antenna is known as the material's effective dielectric constant. The range of effective dielectric constants is 1 r. Frequently, the reff value is near to r. If air is used as a substrate, the effective electromagnetic coefficient is equal to the dielectric constant, or reff = r. The reff is also impacted by the frequency. As the frequency at which it runs increases, the value of the effective dielectric constant approaches the real value of the material used. The effective dielectric constant varies with frequency, as seen in Figure 3.11 below. The effective constant of dielectric does not change for lower frequencies, but it does change as the frequency rises.

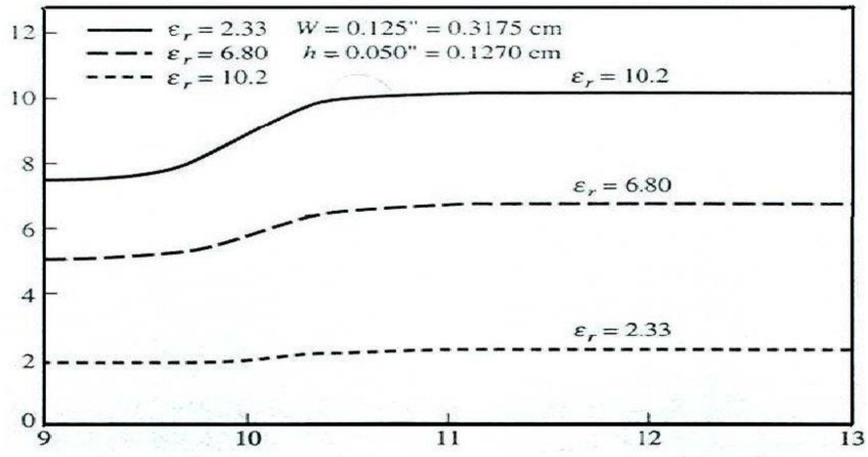


Figure 3.11 Effective Dielectric constant Vs Frequency

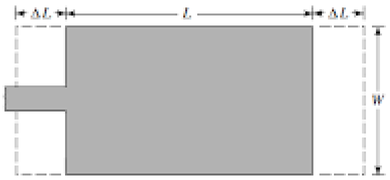
$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+\frac{12h}{W}\right)^{-½} \qquad \text{…..3.1}$$

b. Effective Length, Resonant Frequency, and Effective Width:

The patch of the antenna's microstrip seems larger than its actual size electronically due to the effects of fringing. When the width-to-height ratio (W/h) and effective dielectric constant (reff) are both equal, the patch's dimensions along its length have been stretched on either end by a distance L. Equation 3.2 provides a widely used and useful approximation for the normalised extension of the length.

$$\frac{\Delta L}{h} = 0.412\,\frac{(\varepsilon_{reff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{W}{h}+0.8\right)} \qquad \text{......3.2}$$

The patch's length has been increased by L on each side, resulting in the effective length of the patch seen in figure 3.12.



(a) Top view

(b) Side view

Figure 3.12 Length Extension

The effective constant of dielectric and its width to height ratio are the key determinants of this L value. Due to this length expansion, the patch's length is about 0.48 instead of 0.5. As a result, to obtain the patch's true physical length equal to /2, we must take into account its extension at both ends, which is represented by equation 3.3.

$$L = L_{eff} - 2\Delta L \qquad \dots .3.3$$

As we know for dominant mode the length of patch is equal to λ/2 therefore the $L_{eff}$is given by equation 3.4, 3.5.

$$L_{eff} = \frac{c}{f_r} \qquad \dots . .3.4$$

$$L_{eff} = \frac{C_o}{2f_r\varepsilon_{eff}} \qquad \dots \dots .3.5$$

Where C0 is the velocity of light in free space and The resonance frequency, or fr, is the one an antenna is to be designed for.There are no surrounding fields along the breadth of the dominant mode TM010, hence the true dielectric constant is not necessary to take into account. Equation 3.6 provides the formula to determine the patch's width.

$$W = \frac{C_{\{0\}}}{2f_r} * \left(\frac{\varepsilon_r + 1}{2}\right)^{\left(-\frac{1}{2}\right)} \qquad \dots . .3.6$$

Equation 3.7 states that the antenna will resonate for the dominant mode TM010 at the frequency

$$f_r = \frac{c_o}{2L\sqrt{\varepsilon_{eff}}} \ldots..3.7$$

radiate at this frequency when the effective length and effective dielectric constant are taken into account.

c. Input Impedance:

Finding the Feed position or Driving point—also known as the patch dimension—where the input resistance is equal to that of the feed line is crucial for achieving perfect impedance matching. Driving Point Impedance is the input impedance at the feed point or driving point. Figure depicts the distribution of current and voltage over the patch's length. The middle has the highest current and the highest voltage. As is well known, the resistance is determined by the voltage to current ratio. As a result, the resistance will be highest at the approaches and lowest in the middle.

The transmission line model can determine the rectangular patch antenna's input impedance along the centre line at any position. The graphic depicts the signal line model for a rectangular patch antenna. The parallel equivalent admittance y illustrates each radiating edge, which is isolated from one another by a distance equal to length L-22. Equivalent conductance G and susceptance B make up the edge admittance. The source point is situated LI from the edge. Equation 3.8 may be used to get the input susceptibility y at the end of a transmission line of length L with typical admittance y.

$$Yin = y_o\left(\frac{y_l + Jy_o\tan(BL)}{y_o + Jy_l\tan(BL)}\right) \quad \ldots..3.8$$

where the phase constant is present. Equation 3.9 may be used to express the input impedance at the driving point using the previous equation.

$$y_{driving\,point} = y_o((\frac{y_e + jy_o\tan(BL_1)}{y_o + jy_e\tan(BL_1)} + \frac{y_e + jy_o\tan(BL_2)}{y_o + jy_e\tan(BL_2)})) \quad \ldots..3.9$$

Equation 3.10-3.14 provides the total input admittance at the edge of the patch.

$$y_{in} = 2y_e \quad \ldots\ldots..3.10$$

Where,

$$y_e = B_e + G_e \quad \ldots\ldots 3.11$$

Approximated values of Ge and Be can be given by

$$G_e = 0.00836 \frac{w}{\lambda_e} \ldots\ldots 3.12$$

$$\frac{Be = 0.01668 \frac{\Delta L}{h} w}{\lambda_e} e_{reff} \quad \ldots\ldots.3.13$$

The imaginary components of the edge admission are equal and out of phase at the resonance, and they will cancel one another out. The entire input admittance near the resonance's edge therefore becomes real and equals.

$$y_{in} = 2G_e \quad \ldots\ldots 3.14$$

As a result, at resonance, the equation given by 3.15 describes the whole input impedance as pure real.

$$R_{in} = \frac{1}{2G_e} \quad \ldots\ldots 3.15$$

The input impedance will change when we take mutual conductance into consideration, as shown in equations 3.16-3.17.

$$R_{in} = \frac{1}{2G_e \pm G_{12}} \ldots.3.16$$

Analysis of model expansion The following formula 3.17 may be used to determine the input resistance at a location y_o distant from the patch's edge along the centre line:

$$R_{in}(y = y_o) = \left(\frac{1}{2G_e \pm G_{12}}\right) cos^2\left(\left(\frac{\pi}{L}\right) y_o\right) \quad \ldots\ldots 3.17$$

Figure 3.13 depicts the graph below, which demonstrates how the rectangular patch antenna's input impedance varies according to the square of the cosine. This graph demonstrates that the input resistance is greatest at the patch's corners and zero in the middle.

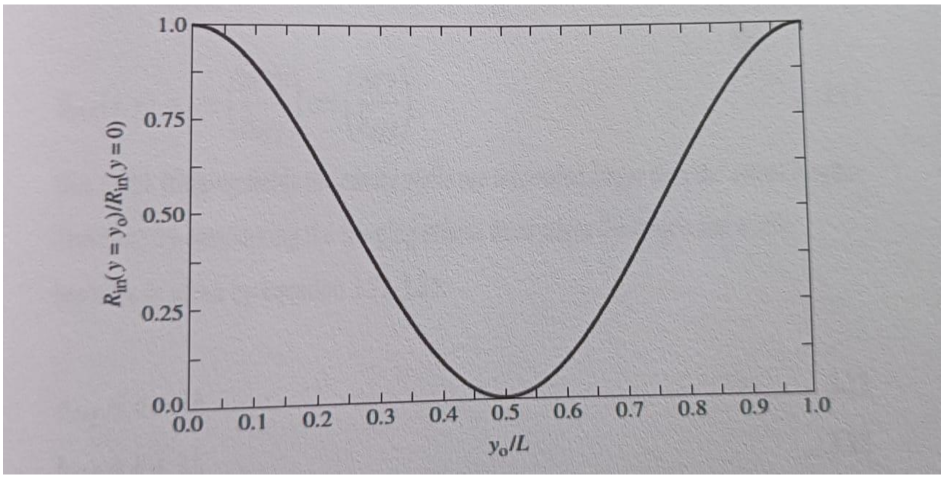


Figure 3.13 Normalized input Resistance

CHAPTER-IV

RECONFIGURABLE MICROSTRIP PATCH ANTENNA

4.1 HISTORY

The concept of changing an antenna's configuration is not new. In order to detect the direction of arrival of a signal, the nulls of a two element array were directed in the early 1930s using a regulated variable phase changer. "The ability to change the beam shapes on command" was the definition of reconfigurability in 1979. The coverage area for the communication satellite was dynamically changed by the authors using a six-beam antenna. more reconfigurable space-based arrays were published in several more articles as follows: A research team in England reported their efforts in the 1990s to change the parabolic-reflector antenna's reflecting surface in order to regulate the radiation pattern. The majority of the reconfigurable antenna project from the mid-1990s to the present has utilised microstrip antenna and other semiconductor technologies

4.2 WHAT IS RECONFIGURABLE ANTENNA?

All personal electronic gadgets, microwave and satellite communications systems, radar systems, and military reconnaissance and surveillance platforms all require antennas as a key and required component. Many of these systems must execute a wide range of tasks across many frequency bands and operational bandwidths. Most often, a single antenna is unable to meet these criteria; instead, a number of antennas with various form factors and geometries must be used. The cost of manufacture, the weight and volume of the system, as well as the resources needed for maintenance and repair, all rise as a result.

Reconfigurable antennas show significant potential for solving these system needs because of their ability to modify their form and behaviour to respond to changes in the environment or system demands (such as expanded bandwidth, a change in operating frequency, polarisation, radiation pattern, etc.).With the use of dynamically changing and adaptive single-antenna shape, reconfigurable antennas may provide the same performance as a multi-antenna system without requiring more space to house them. In applications like cognitive radio, MIMO systems, RFIDs smart antennas, etc., reconfigurable antenna scan therefore provide significant adaptability. Antenna engineering's ultimate goal is to modify antennas in order to preserve system-level performance under a variety of difficult environmental factors, the incidence of faults or failures, and changing operational requirements.

4.3 NEED FOR RECONFIGURABLE ANTENNA:

While maintaining other parameters at acceptable operating levels, static single-antenna structures can be adjusted to match specific needs, such as bandwidth, operational frequency, radiation pattern, and directivity. However, when even a little amount of the listed criteria are changed. It is possible to make the intended antenna structure worthless. Applications of today's technology require flexibility and adaptability. Static single-antenna designs are no longer a possibility since they have become important features in antenna design. Reconfigurable antennas have been steadily rising in favour over the years due to this, along with low-cost implementation and sophisticated simulation environments. The antenna structure's reconfigurability may be done in a variety of ways, for as by changing the antenna's physical composition or its feeding strategy. putting antenna arrays into use, etc. The design constraints and targeted performance levels directly affect the reconfiguration technique selection.

Following is a succinct list of the benefits of employing reconfigurable antennas over multi-band/wideband antennas or numerous antennas:

1-The capacity to support many wireless standards

a) Reduces expenses.

b) Reduces the need for space.

b) Makes integration simpler.

d) Effective separation between various wireless protocols.

2. Less difficult up front

Front-end filtering is not necessary, and there is good out-of-band rejection.

3. The most suitable candidate for SDR

a) The ability to change and grow.

b) Automated via microcontroller or a field programmable gate array (FPGA).

4.4 TYPES OF RECONFIGURABLE ANTENNA

The frequency pattern and polarisation reconfigurable antennas, two of the three primary types of reconfigurable antennas, are discussed together with their potentials.

a) Antennas with adjustable frequency:

An antenna that can electronically change its operational frequency, either abruptly or gradually, is known as a frequency reconfigurable antenna. Other characteristics of this antenna, such as its emission pattern or its polarisation, should never change. The most common methods for achieving frequency reconfiguration include changing the antenna's effective length or field distribution. In order to cover several services dispersed across a large frequency range, we are seeing more and more being combined into a single wireless device nowadays.

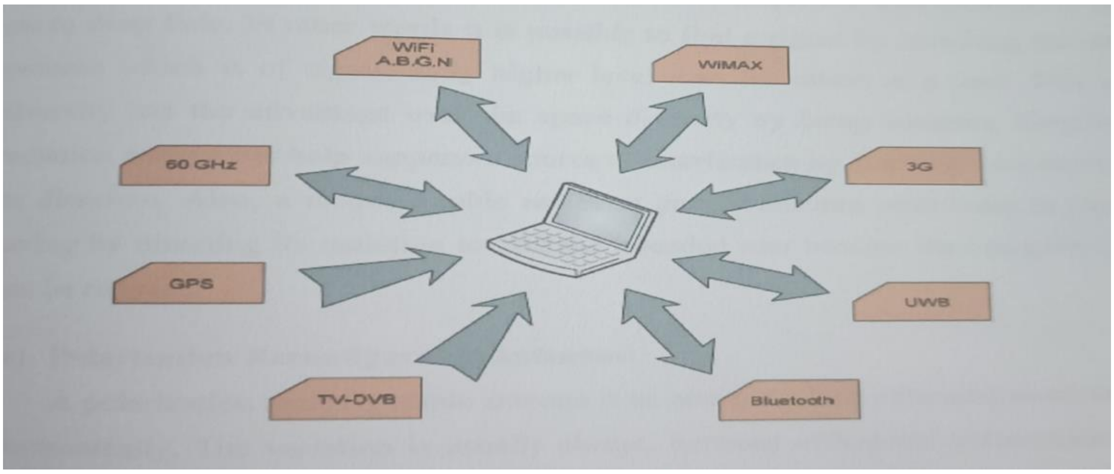


Figure 4.1: Possible communication standards supported in a single laptop.

For instance, as shown in Fig. 4.1, laptop computers will soon need to accommodate a subscriber to communication standards. Other wireless mobile systems are also being developed and are in a very similar state.

b) Antennas with pattern reconfigurability An antenna whose radiation pattern can be electrically changed, either continuously or suddenly, is known as a pattern reconfigurable antenna. The resonance frequency ought to never change. Due to the fact that reconfiguration is typically linked to activating a certain current distribution (mode) of an antenna, in practise the polarisation frequently changes along with the radiation pattern. Another way to realise pattern reconfiguration is to utilise antenna arrays with reconfigurable reactive loading, reconfigurable feeding networks, and reconfigurable reflect arrays, which are other examples of pattern reconfiguration technologies. The performance of the system can be enhanced by a pattern reconfigurable antenna by utilising a diversity strategy like switched combining. This works particularly well in multipath propagation situations when it is improbable that all of the signals collected by all of the antenna's radiation patterns are in deep fade. In other words, switching radiation patterns with a much greater level than each one at a time will help you identify a signal. Due to its compactness, this type of variety has an advantage over space diversity. By pointing the shape of the null in its direction, changing the pattern of radiation can aid in the suppression of an interference source. Additionally, a reconfigurable patterns of radiation antenna helps reduce power consumption by aiming its radiation.

c) Polarization Reconfigurable Antennas:

An antenna whose polarisation can be changed electrically is known as a polarisation reconfigurable antenna. Between orthogonal polarisations, between linear and circular polarisations, and between linear polarisations with various skews, the variation is often sudden. There are three main ways to accomplish this: by modifying the current path of the antenna, by modifying the current distribution of the antenna, and by using a reconfigurable phase shifter to regulate the phase difference between oppositely polarised components. Although there are cases where this isn't the case, the antenna resonance frequency should stay the same. Antennas with polarisation reconfigurability are beneficial in various situations. They can offer polarisation variety, which has advantages comparable to those of pattern diversity. The polarisation reconfigurable antenna may also be utilised with frequency reuse transceivers when using a microwave. For sending and receiving in this application, two orthogonal polarisations are employed. increasing the channel capacity by twofold.

d) Combination of Reconfigurable Antennas for Polarisation, Pattern, and Frequency

It combines the traits of the first three categories to display a wide range of qualities. For instance, it is possible to combine polarisation diversity with a frequency reconfigurable antenna.

Table 4.1: The process of achieving the required reconfigurability

Types	**Process**
Frequency Reconfigurable Antennas	Change the surface current distribution
Pattern Reconfigurable Antennas	Change the radiating edges, slots or the feeding network
Polarization Reconfigurable Antennas	Change the antenna surface structure or the feeding network
Combination of three types	Combination of the above processes depending on the antenna functionality

CHAPTER-V

A RECTANGULAR CONVENTIONAL PATCH ANTENNA WITH T-SLOT FOR 5g SUB 6GHz APPLICATIONS

5.1 INTRODUCTION

The printed antenna design, which will constitute the radiating component of the suggested filtenna, is the subject of this section. The ease of construction, low profile, low cost, and other appealing qualities of this type of antenna make it popular. Printed antennas, however, often offer a limited fractional bandwidth (FBW) of a few percent. Numerous publications suggest using multilayer patch antennas to improve FBW. A 48,8% tiny strip antenna utilising multilayer parasitic components was described by Nasimuddin et al. Multilayer antennas do, however, have huge dimensions, which can restrict some uses. As shown in Figure 1, a standard patch antenna has been created first utilising an Arlon Di Clad 880 substrate. The dielectric constant of 2.2, thickness of 1.524 mm, and loss tangent of 9 x 10-4 are its primary characteristics. Figure 1 shows the numerical results of the antenna reflection that were produced using ANSYS HFSS. Only 1,54% of the antenna's original bandwidth is centred at 6.5 GHz. The redesigned patch antenna with a taper matching impedance arrangement between the antenna feeding line and patch radiators is shown in Figure 2 along with a truncated ground plane. The antenna input impedance is made roughly real over an extensive frequency range by the truncated ground plane, which also generates a capacitive load to compensate for the patch inductance. The taper construction reduces the sharpness of with the purpose of further improving the impedance matching. Utilising ANSYS HFSS, the dimensions of a shortened ground plane and a tapered microstrip line have been determined. Figure 3 displays the antenna reflection coefficient. The results show a broad bandwidth of 1.917 to 7.387 GHz (FBW = 117.58%). The wide-band antenna is printed on the x-y plane in Figure 2, thus it radiates linear polarisation with an x axis.

5.2 ANTENNA DESIGN:

Figure 5.2 depicts the proposed elliptical patch antenna. The antenna has a height of 1.6mm and is composed of Arlon Di Clad 880 substrate with a dielectric constant of 2.2.The substrate is made up of an oval patch with a ground plane on the opposite side and an annular slot on the top side. To lessen cross polarisation, two metallic plates are arranged symmetrically with regard to the supply. The antenna is excited by the microstrip line feed method. The following table lists the proposed patch antenna's dimensions.

Table 5.1: Dimensions of the proposed antenna

Parameters	Dimensions(mm)
W	60
W1	30
L	70
L1	21.5
L2	30
L3	3
L4	5.8

5.2.1 Conventional patch antenna

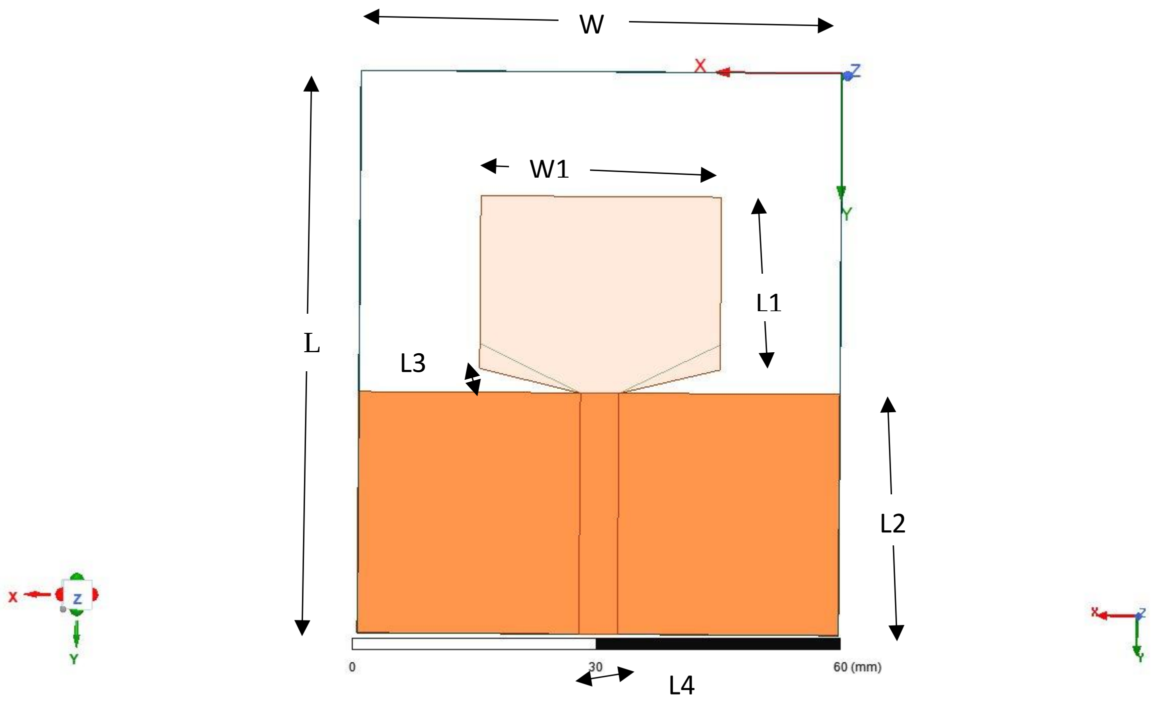


Figure 5.2 :Geometry of the broad band printed antenna

5.3 SIMULATIONS AND RESULTS

The frequency for the 5G sub-6GHz application may be obtained, as was stated in the preceding section, by altering the fundamental characteristics of the suggested antenna. A parametric research is carried out to look into the properties of the suggested antenna in order to attain optimal performance. The High- Frequency Structure Simulator (HFSS) is used to simulate this antenna.

Obtained Results

5.3.1 RETURN LOSS

Return loss is a metric for how well electricity is delivered from a transmission line to a load, such an antenna. In Pref, the greater this power ratio, which is stated in dB, the more effectively the load and line are matched.

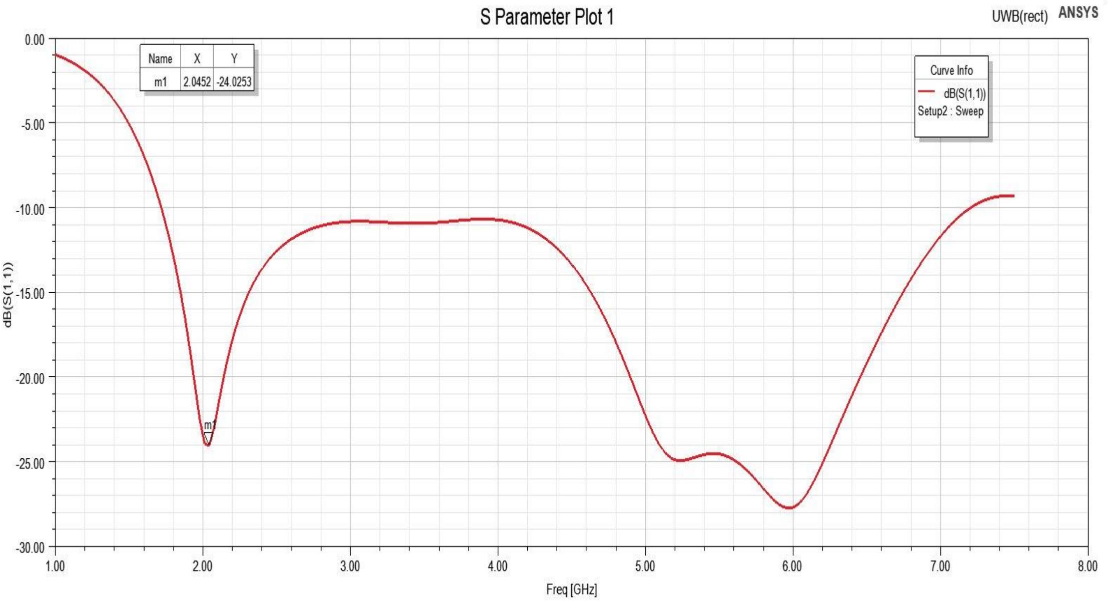


Figure 5.3: The broadband printed antenna reflection coefficient.

Figure 5.3 the graph represents information about the return loss w.r.t frequency, which depicts that it resonates at 2.0452GHz to 7.4GHz with S11 value of -24.0253dB.

5.3.2 VSWR

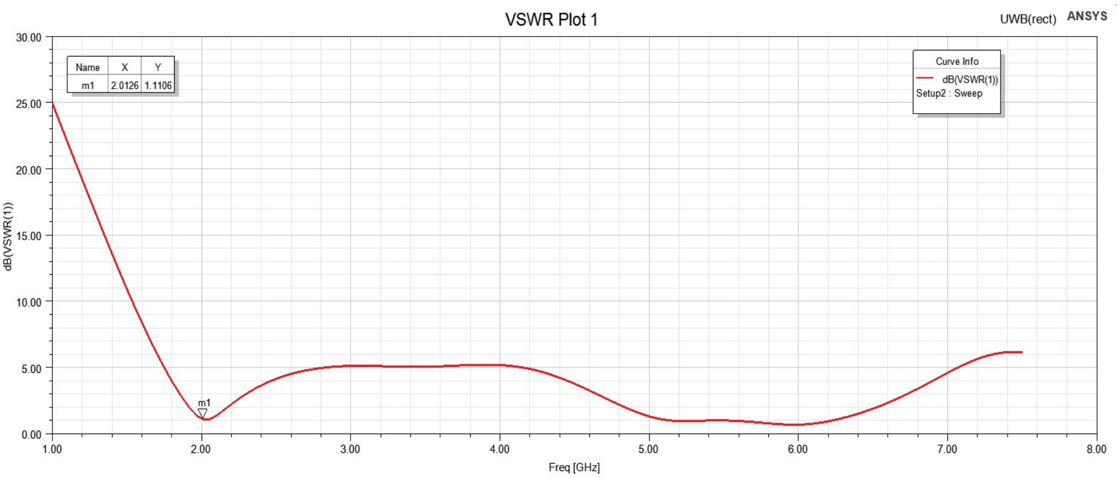


Figure 5.4: The broadband printed antenna VSWR.

figure 5.4 variation of VSWR w.r.t frequency was presented.at frequency 2.0126GHz VSWR value was found to be 1.1106 which is well below the cut off value means that a good impedance matching is mismatched between feed and antenna.

5.3.3 RADIATION PATTERN

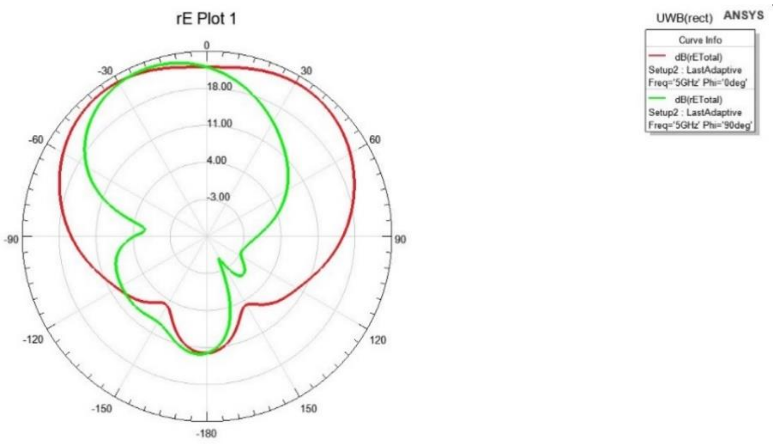


Figure 5.5: The broadband printed antenna radiation pattern

5.4 The Reconfigurable Filtenna Design

A filtenna is an integrated antenna and RF filter that is often installed in the ground plane or antenna feeding line. Filtennas enable bandwidth reconfiguration without affecting the radiating element. Figure 5.6 illustrates the programmable DMS bandpass filter and broadband printed antenna that make up our reconfigurable filtenna system. The PIN diodes have been incorporated in the Filtenna numerical model in two different ways: as a silicon component for the "OFF" state and as a PEC (perfect electrical conductor) boundary parameter for the "ON" state. Two operational modes are offered by the proposed filtenna over the 2.4 and 5.1 GHz frequency ranges. The goal of Figure 5.7 is to illustrate the two operational modes of the filtenna reflection coefficient (S11), the first of which has a bandwidth centred around 2.45 GHz and the second of which has a bandwidth centred around 5.18 GHz. These simulated findings show that by varying the gap line capacitances, the filtenna bandwidth may be switched between two operational frequency bands.Additionally, ANSYS HFSS has been used to numerically analyse the filtenna radiation pattern in order to assess the effects of including the DMS architecture into the antennal feeding line.

In the azimuth (v.) and elevation (x-v.) planes at 2.4 and 5.1 GHz, Figure 5.8 compares the filtenna and original printed antenna layouts. No discernible deterioration in the radiation pattern is shown in any of the examples, proving that the suggested structure enables frequency response reconfiguration without affecting the antenna's primary electromagnetic characteristics. For 2.4 and 5.1 GHz, the filtenna's maximum gain is 3.34 and 3.77 dBi, respectively.

Two pin diodes are used to control the gap line capacitances in the reconfigurable filtenna. Thus, the bandwidth reconfigurability is guaranteed by the use of the two pin diodes, the filtenna described in the preceding section, and discrete SMD capacitors. The semiconductor switches are cut from silicon wafers with high resistivity (p > 6000xcm).For this reason, we have incorporated teeny, 1.3 x 0.9 mm dice. If pin diodes are appropriately lighted, they can transition from an insulator state to a close to conductor state. In this method, the dielectric constant of silicon is lowered while its conductivity is raised.

Since the gap capacitance (0.13 pF) is less than the discrete capacitance (1.8 pF), the capacitances connected to SMD capacitors change the operating frequency to the 5.1 GHz range. W=4.8mm, L=30mm, L1= 6.841 mm, W1=1.143 mm, L2 = 2 mm, and W2 = 0.428 mm are the final dimensions of the DMS T-shape.

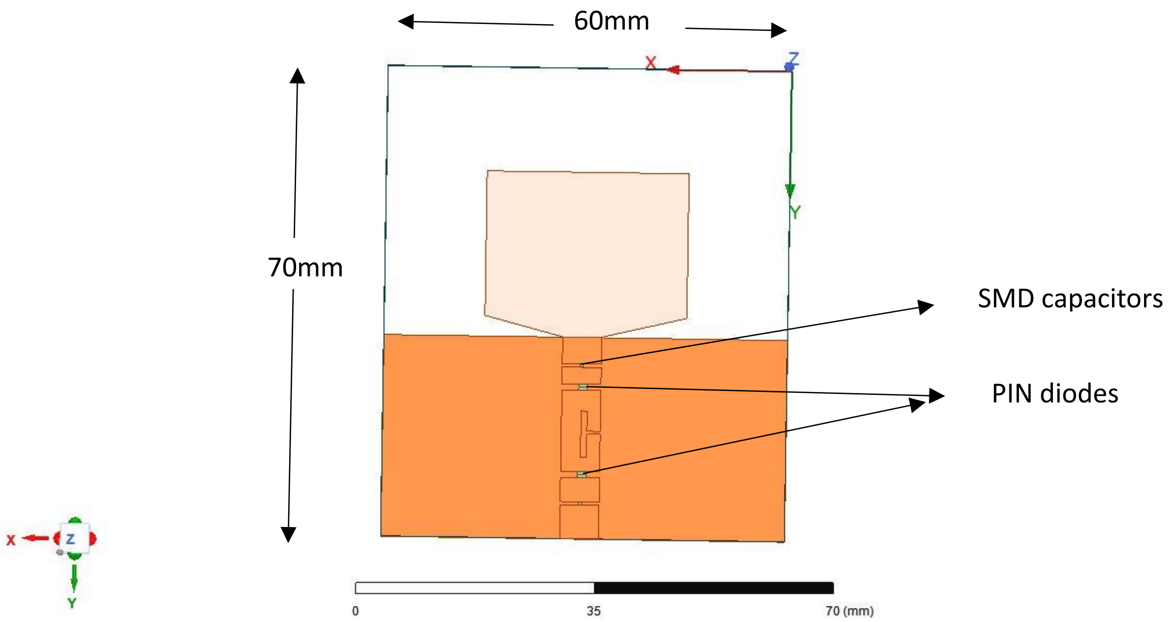


Figure 5.6: The reconfigurable filtenna concept.

5.4.1 RETURN LOSS (ON condition)

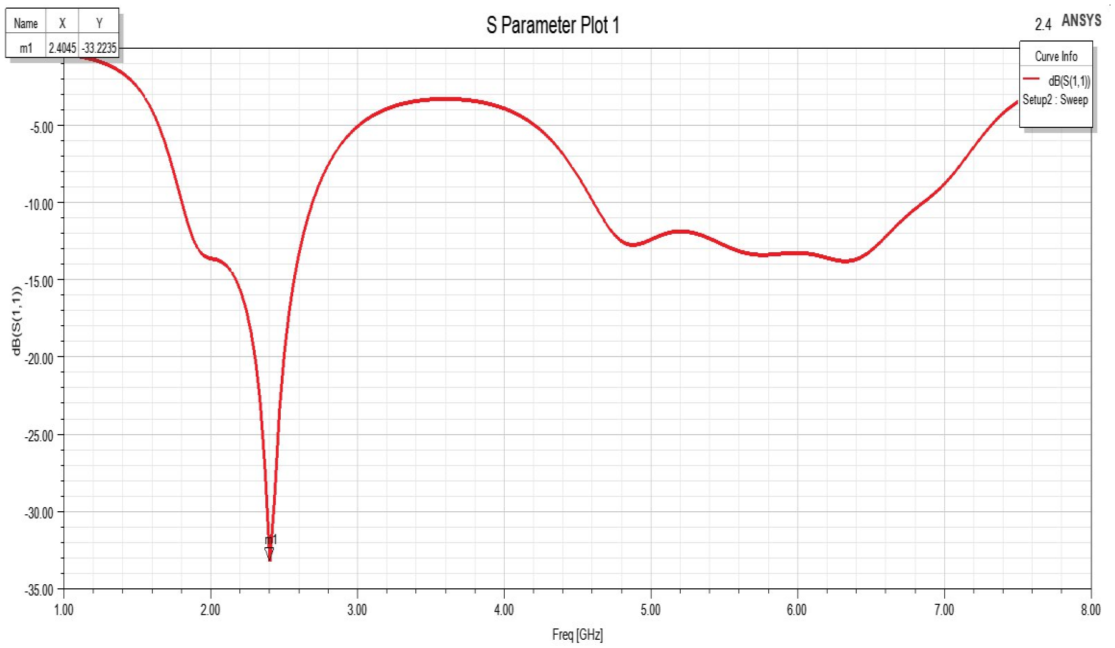


Figure 5.7: Numerical results of the reconfigurable filtenna reflection coefficient.

Figure 5.7 the graph represents information about the return loss w.r.t frequency, which depicts that it resonates at 2.4045GHz with S11 value of -33.2235dB.

5.4.2 RADIATION PATTERN

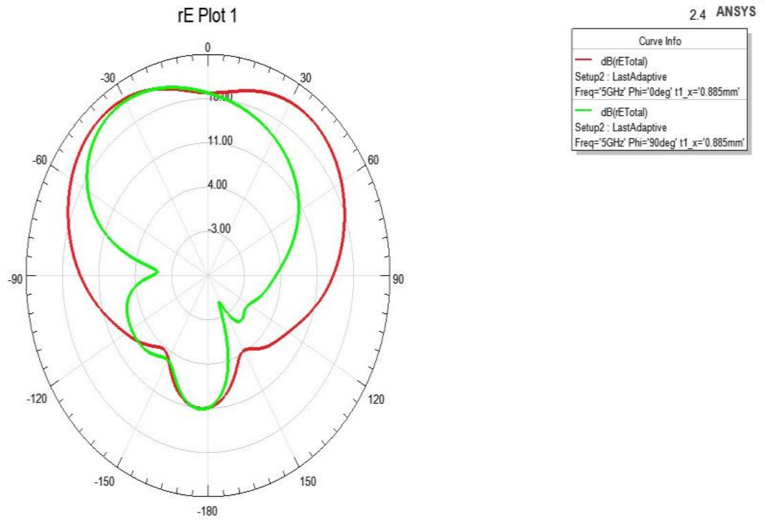


Figure 5.8: The reconfigurable filtenna Radiation pattern.

Figure 5.8 represents the radiation pattern with respect to the frequency at phi-0° and phi-90°

5.4.3 RETURN LOSS (OFF condition)

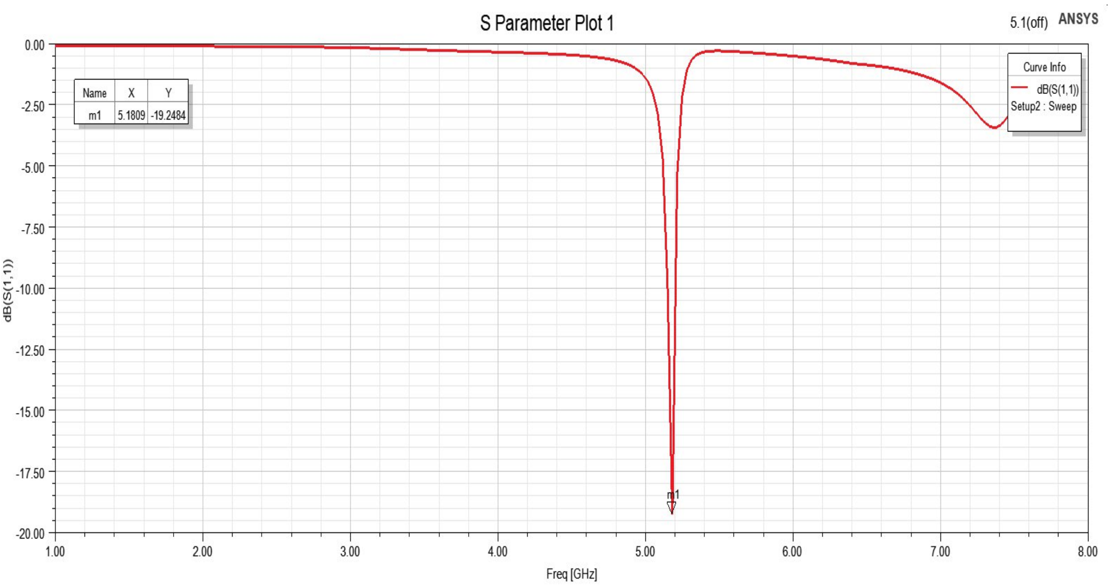


Figure 5.9: Numerical results of the reconfigurable filtenna reflection coefficient

Figure 5.9 the graph represents information about the return loss w.r.t frequency, which depicts that it resonates at 5.1809GHz with S11 value of -19.2484dB.

5.4.4 PARAMETRIC SWEEP

In the parametric analysis we simulate the design for different values of a parameter. This is useful for selecting the desired parameter value of the design. By choosing so and redesigning with the best values from the parametric sweep, the required antenna properties are obtained.

5.4.4.1 Variation of Capacitance

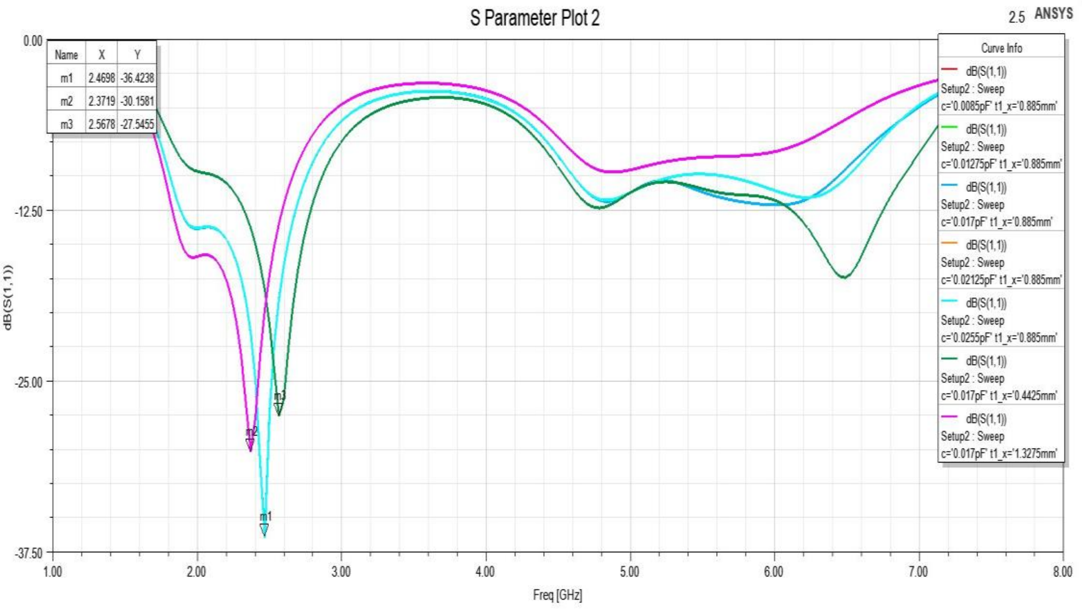


Figure 5.10: Reconfigurable filtenna (ON condition)

Here the above figure 5.10 represents the parametric analysis of Return loss Vs Frequency w.r.t Resistance and capacitance by observing the above plot we notice the C=0.0255pF we get the antenna is operated at 2.4 GHz.it is the case for both diodes are on case and here for these values we got Return loss about – 36.42dB at 2.4698 GHz. In this three cases antenna is simulated and analysed by using HFSS software and Results are observed.

5.4.4.1 Variation of width of T-slot:

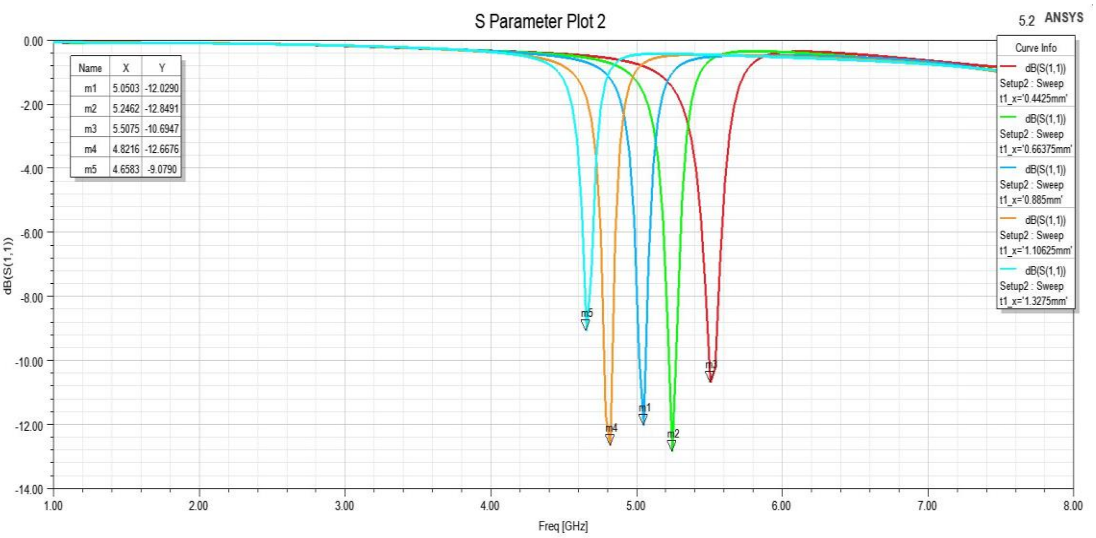


Figure 5.11: Reconfigurable filtenna (OFF condition)

Here the above figure 5.11 represents the parametric analysis of Return loss Vs Frequency w.r.t width of T slot by observing the above plot we notice the W1=0.885mm we get the antenna is operated at 5.1 GHz.it is the case for both diodes are off case and here for these values we got Return loss about – 12.029dB at 5.0503 GHz. In this three cases antenna is simulated and analysed by using HFSS software and Results are observed.

5.4.5 RADIATION PATTERN

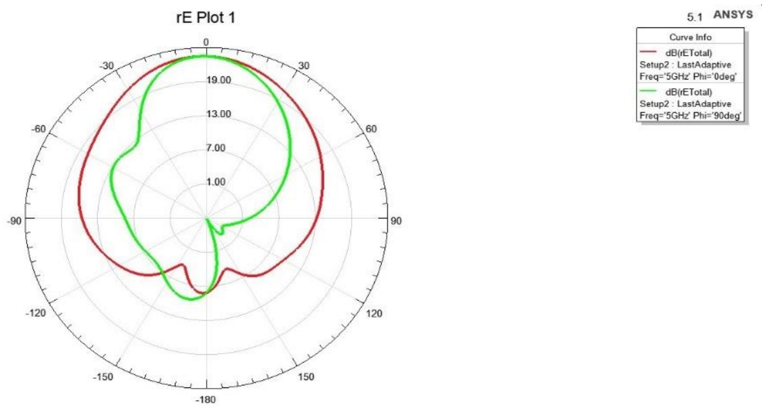


Figure 5.12: The reconfigurable filtenna Radiation pattern.

Figure 5.12 represents the radiation pattern with respect to the frequency at phi-0° and phi-90° .

CHAPTER-VI

A ELIPTICAL PATCH ANTENNA WITH SRR FILTER FOR 5g SUB 6GHz APPLICATIONS

6.1 INTRODUCTION:

In this work a elliptical patch with SRR filter is proposed for 5g sub 6GHz applications. This is operated at 2.4 GHz and 5.1GHz. Ansoft HFSS simulation tool was used to achieve the design and the optimization of the strip line feeding using Transmission line model. The three essential parameters for the design of a Patch Antenna are:

Operating Frequency (f) = 2.4GHz, 5.1GHz.

The substrate's dielectric constant (K) is 2.2

and its height (h) is 1.6 mm.

Here, we'll create an elliptical patch. Therefore, after we are aware of the three crucial variables, we must determine the radius of the eliptical patch.

6.2 ELIPTICAL PATCH ANTENNA:

The second most popular shape for a microstrip patch antenna is an elliptical patch. While the length and breadth of a rectangular microstrip antenna provide us with two degrees of freedom to alter the antenna properties, we only have the elliptical patch's radius here. In figure 6.1 below, an elliptical microstrip antenna is depicted. 'Rx'-radius metallic elliptical patch above the ground plane.

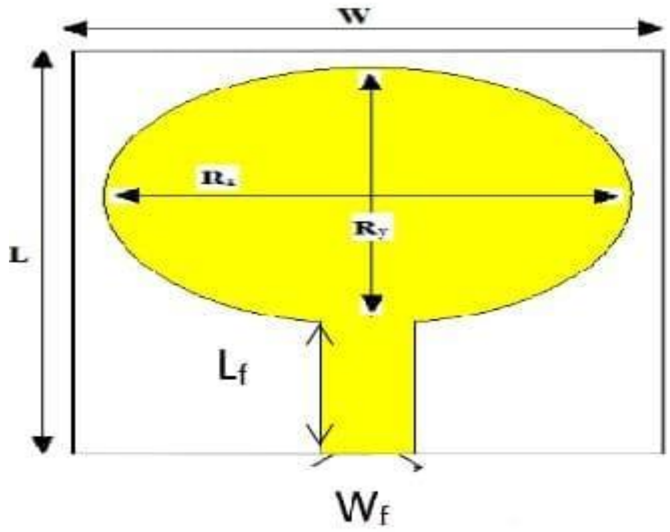


Figure 6.1 : Eliptical Patch Antenna

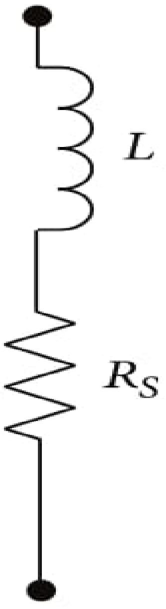
6.3 ANTENNA DESIGN:

Figure 5.2 depicts the proposed eliptical patch antenna. The antenna has a height of 1.6mm and is composed of Arlon Di Clad 880 substrate with a dielectric constant of 2.2.The substrate is made up of an eliptical patch with a plane of ground on the opposite side and an SRR filter on the top side.Regarding the feed, two P-I-N diodes are arranged symmetrically. The antenna is excited by the microstrip line feed method. Below table 6.1 are the suggested patch antenna's dimensions.

6.3.1 PIN diodes

The most common types of diodes used to date in a variety of applications are those with a P-N junction. The PIN diode is one of those kinds of circuits. There are several applications for this type of diode. RF switching applications benefit greatly from it, and photodiodes may make good use of the structure. a diode having a large intrinsic semiconductor area that is undoped in between the p- and n-type semiconductor regions. The pin diode behaves like a virtually constant capacitance when reverse-biased. It behaves as a current-controlled resistance that is variable when forward-biased.

PIN diode equivalent circuit:



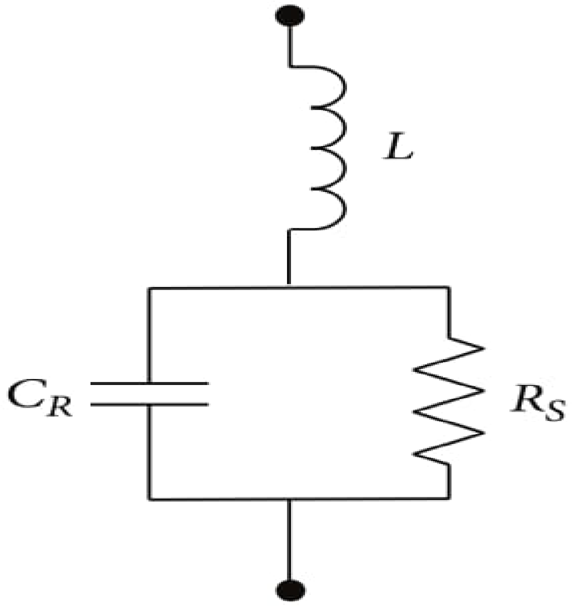


Fig (a):Forward bias(ON condition) Fig (b):Reverse bias(OFF condition)

Table 6.1: Dimensions of the proposed antenna

Parameters	Dimensions(mm)
L	70
W	60
W1	20
W2	5.8
L1	40
L2	30

Design model 1:

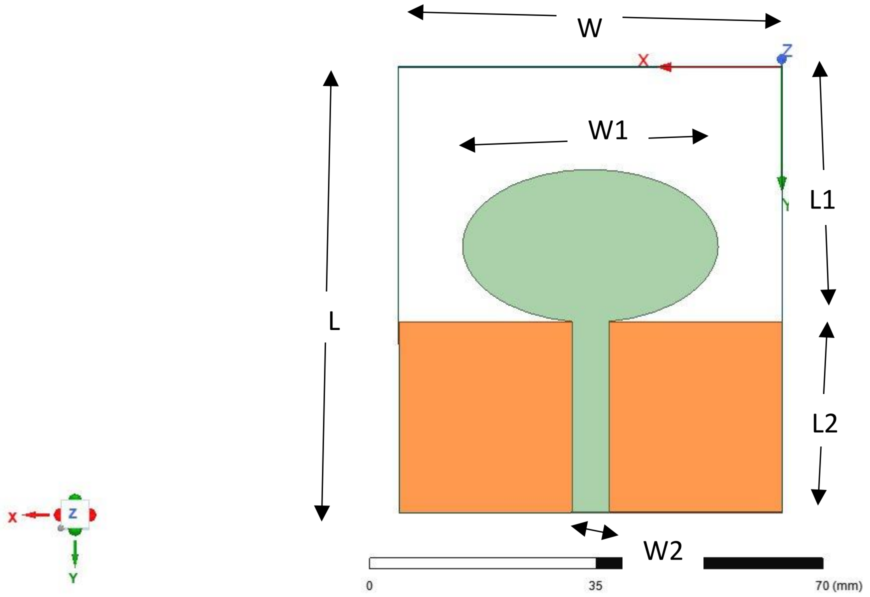


Figure 6.2 : Geometry of proposed antenna

6.4 SIMULATION RESULTS

The frequency for the 5G sub-6GHz application may be obtained, as was stated in the preceding section, by altering the fundamental characteristics of the suggested antenna. A parametric research is carried out to look into the properties of the suggested antenna in order to attain optimal performance. High Frequency Structure Simulator (HFSS) is used to simulate this antenna.

Obtained Results

6.4.1 Return loss

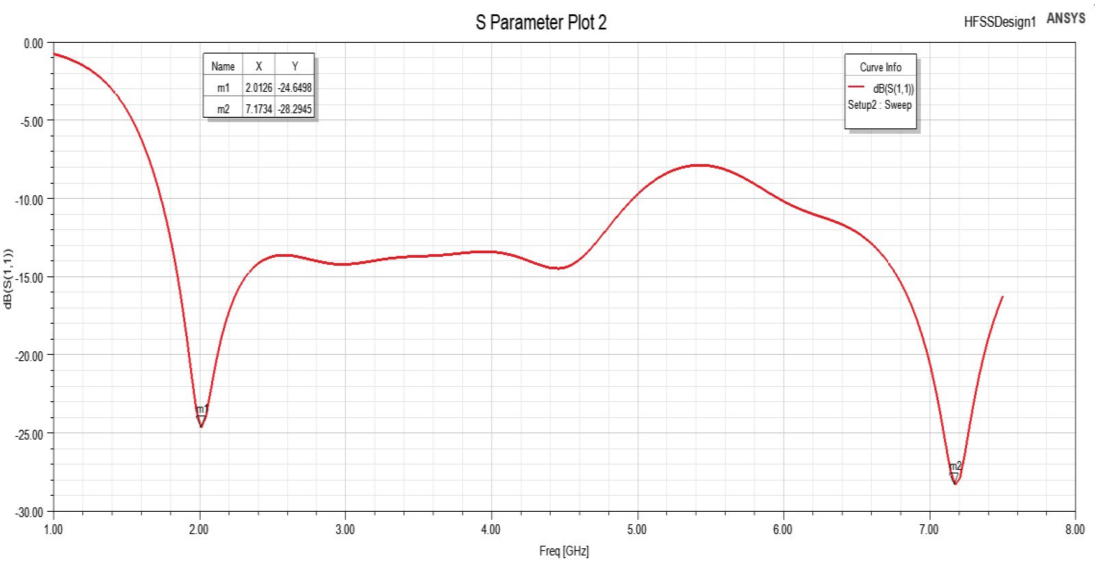


Figure 6.3 : Return loss(S11) Vs Frequency

Figure 6.3 the graph represents information about the return loss w.r.t frequency, which depicts that it resonates at 2.0126GHz with S11 value of -24.6498dB.

6.4.2 VSWR

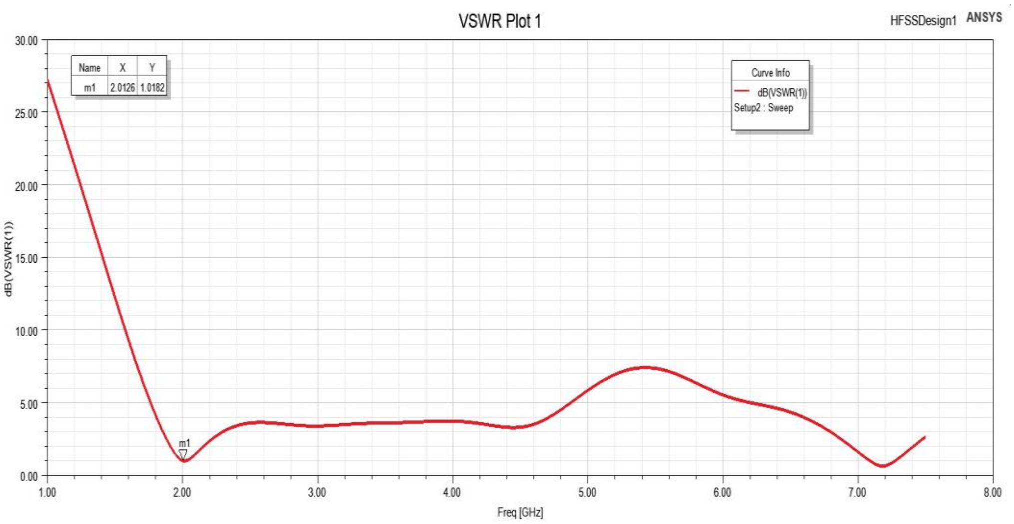


Figure 6.4 : VSWR Vs Frequency

Figure 6.4 variation of VSWR w.r.t frequency was presented.at frequency 2.0126GHz VSWR value was found to be 1.0182 which is well below the cut off value means that a great impedance matching is mismatched between feed and antenna.

6.4.3 Radiation pattern

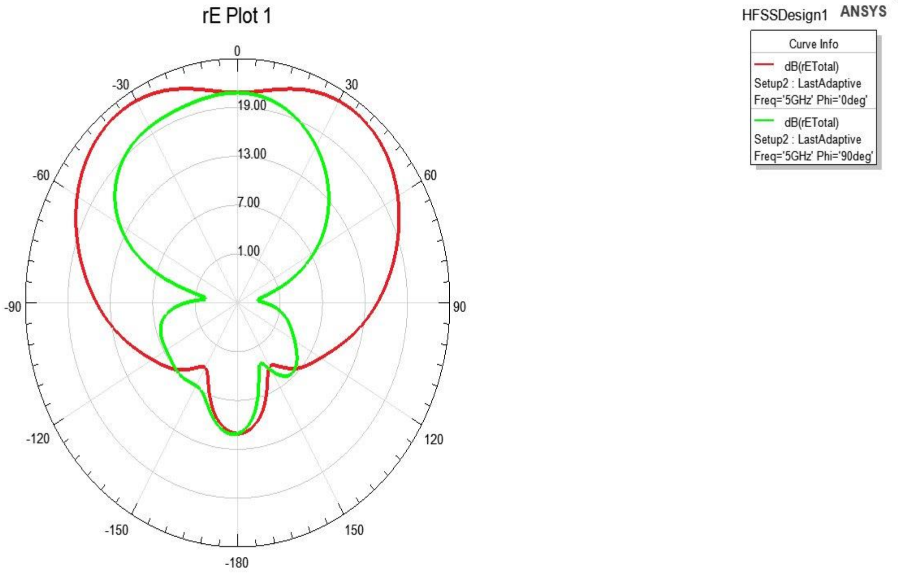


Figure 6.5 : Radiation pattern of antenna

Figure 6.5 represents the radiation pattern with respect to the frequency at phi-0° and phi-90°

6.4.4 3D Gain Plot

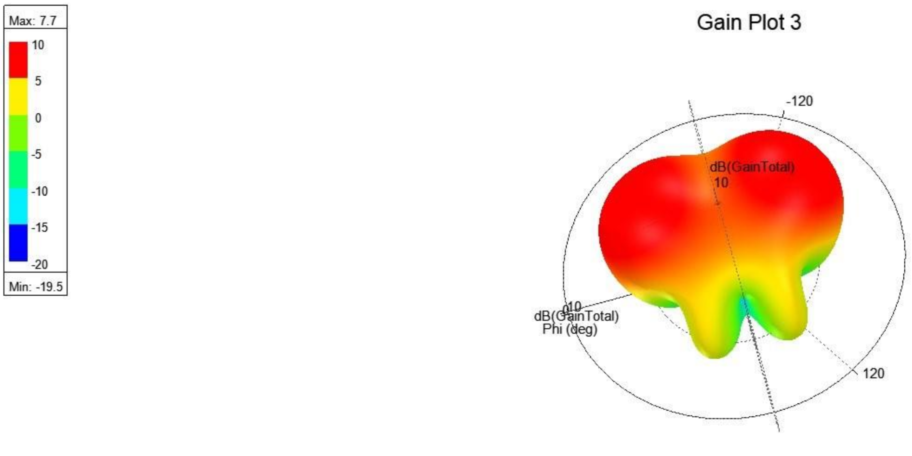


Figure 6.6 : 3D Gain plot of antenna

Figure 6.6 represents 3D Gain plot of the antenna and here the Gain is about 10 dB is observed.

Table 6.2: Summery of the results

Parameter	Value
Return loss	-24.64dB
VSWR	1.0182
Gain	10dB

Design model 2:

The designed antenna consists of an oval patch with a feed line and a split ring resonator(SRR) placed on the feed line. The round patch antenna has a bandwidth of roughly 2.4 GHz, while the SRR can be used to switch the frequency band to5.1 GHz. The SRR acts as a commutable element, allowing the antenna to be reconfigured without the need for fresh tackle or control signals. The SRR is made up of a ring of conductive material with a small gap that acts as a capacitor. By placing the SRR on the feed line of the antenna, we can control the quantum of current flowing through the gap and hence change the frequency resonance of the antenna. When the SRR is in the" on" position, the gap acts as a short circuit, and the antenna is reverberative at2.4 GHz. Again, when the SRR is in the" off" position, the gap acts as an open circuit, and the antenna is reverberative at5.1 GHz. By toggling the capacitance in pin diode, we can switch between the two frequency bands. In the design of our reconfigurable antenna, the SRR is placed on the feed line to achieve the asked frequency response. When the SRR is in " on" state, it provides fresh resonance at 2.4 GHz, which effectively narrows the bandwidth of the antenna and improves its performance at that frequency. On the other hand, when the SRR is in " off" state, the fresh resonance disappears, and the antenna has a wider bandwidth centered around5.1 GHz.

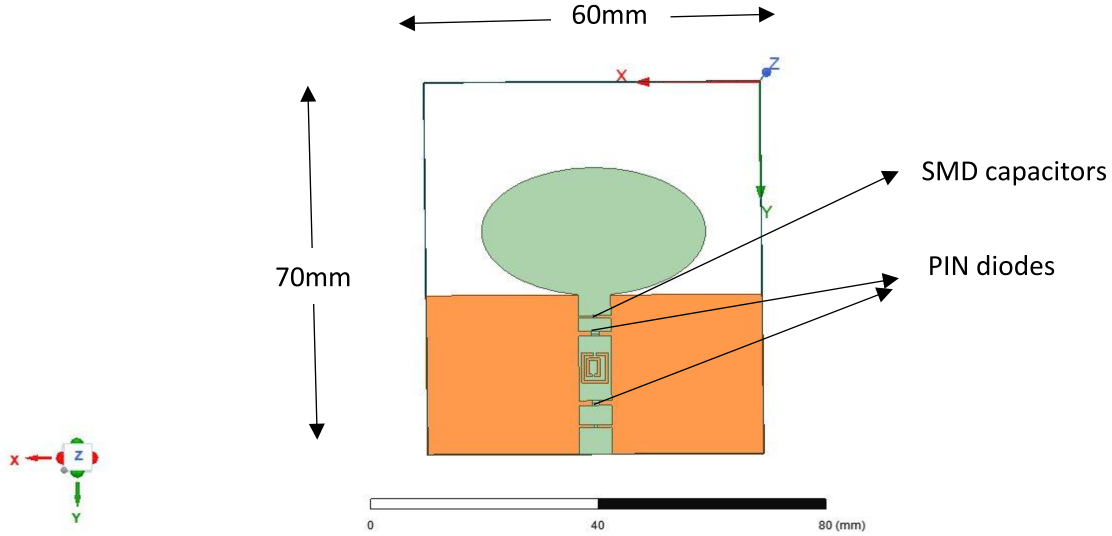


Figure 6.7: Reconfigurable filtenna

6.5 SIMULATION RESULTS (ON condition-2.4GHz)

The frequency for 5G sub-6GHz applications may be obtained, as was stated in the preceding section, by altering the fundamental characteristics of the suggested antenna. A parametric research is carried out to look into the properties of the suggested antenna in order to attain optimal performance. High Frequency Structure Simulator (HFSS) is used to simulate this antenna.

6.5.1 Return loss

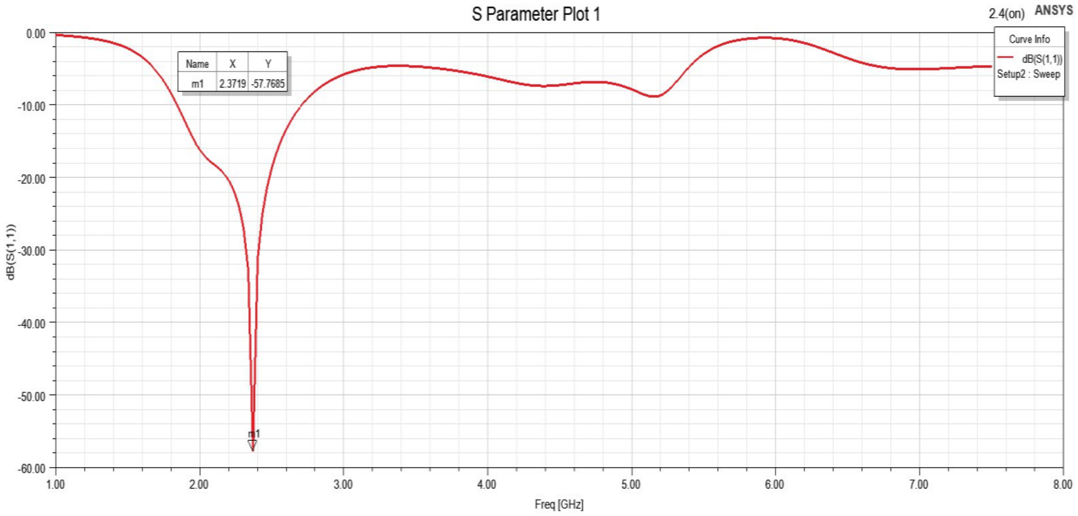


Figure 6.8 : Return loss(S11) Vs Frequency(ON-condition)

Figure 6.8 the graph shows information about the return loss w.r.t frequency, which depicts that it resonates at 2.3719GHz with S11 value of -57.7685dB.

6.5.2 Radiation pattern

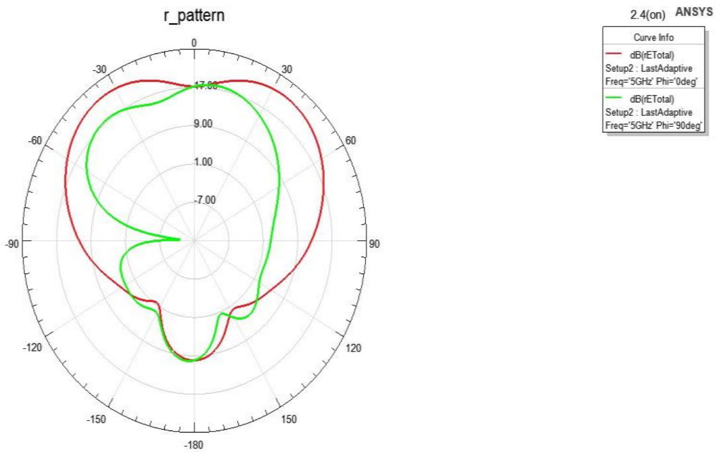


Figure 6.9 : Radiation pattern of Reconfigurable filtenna(ON-condition)

Figure 6.9 shows the radiation pattern with respect to the frequency at phi-0° and phi-90°.

6.5.3 3D Gain Plot:

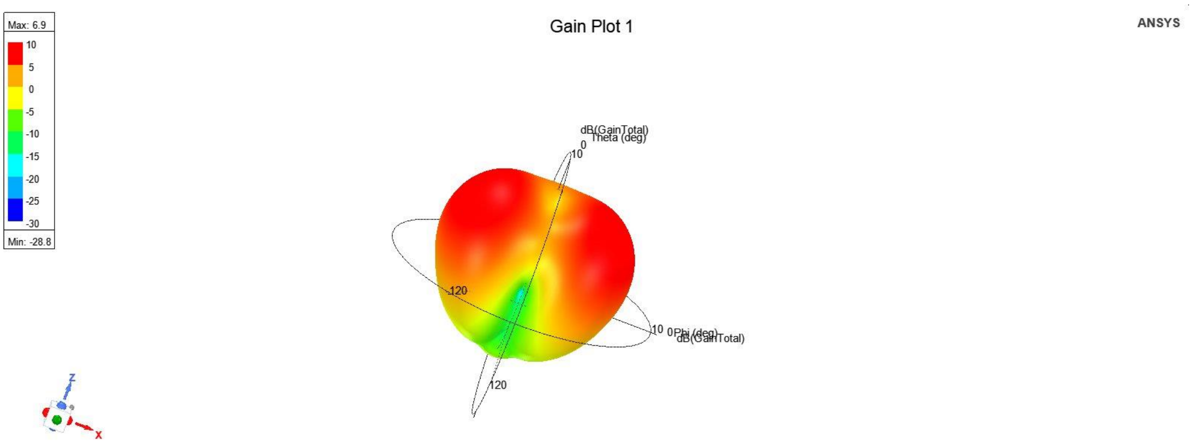


Figure 6.10 : 3D Gain plot of Reconfigurable filtenna(ON-condition)

Figure 6.10 shows 3D Gain plot of the antenna and here the Gain is about 10 dB is observed.

6.5.4 Realized Gain(ON-condition):

This combines the directivity and efficiency of the antenna. It illustrates for a transmitting antenna how successfully the antenna can radiate the energy given into space in a certain direction. In contrast, it shows how well a receiving antenna converts the electromagnetic waves it picks up into electrical power. When it is calculated with efficiency and directivity, it is referred to as power gain. D.

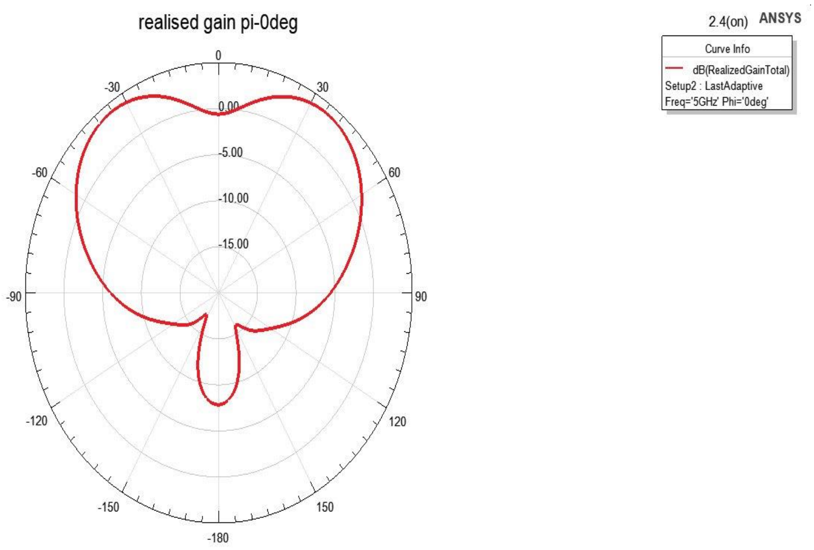


Figure 6.11(a):Realized Gain of Reconfigurable filtenna (Phi= 0deg)

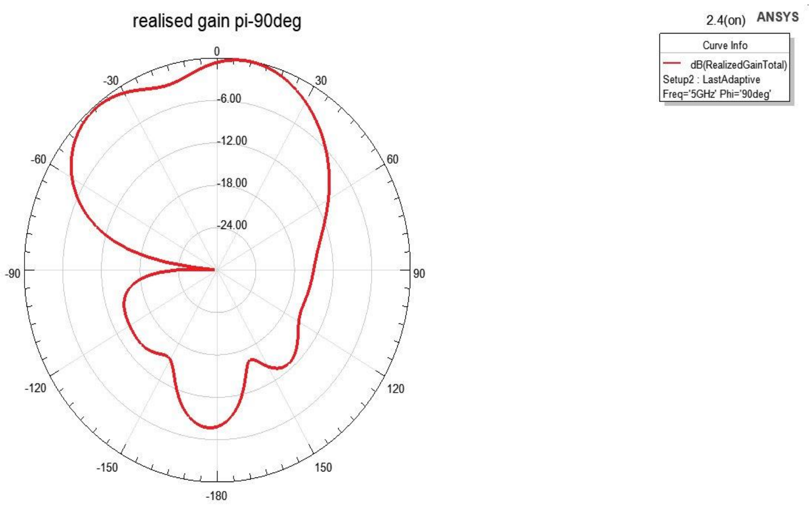


Figure 6.11(b):Realized Gain of Reconfigurable filtenna (Phi= 90deg)

6.5.5 Parametric sweep (ON condition)

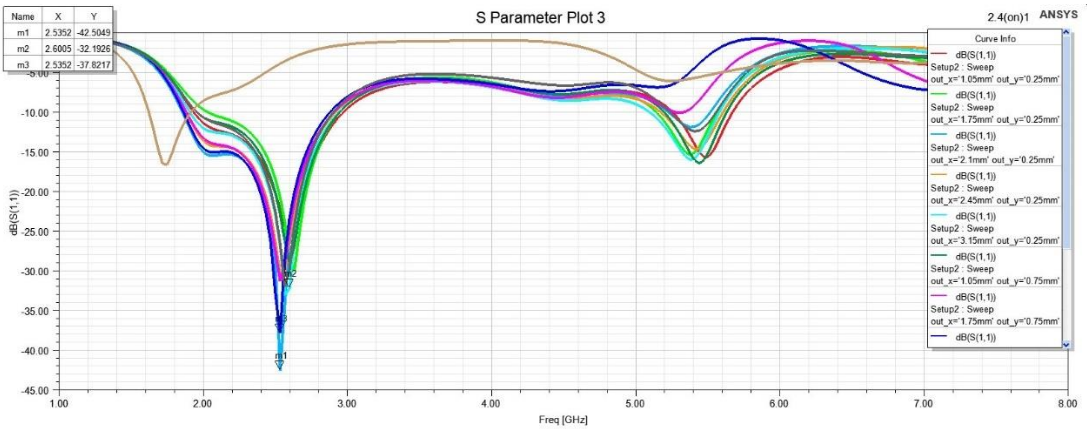


Figure 6.12: Reconfigurable filtenna (ON condition)

Here the above figure 6.12 represents the parametric analysis of Return loss Vs Frequency w.r.t SRR filter gaps by observing the above plot we notice the W-2.1mm we get the antenna operates at 2.5352 GHz.it is the case for both diodes are on case and here for these values we got Return loss about -42.5049B at 2.5352 GHz. In this three cases antenna is simulated and analysed by using HFSS software and Results are observed.

6.6 SIMULATION RESULTS (OFF condition-5.1GHz):

6.6.1 Return loss:

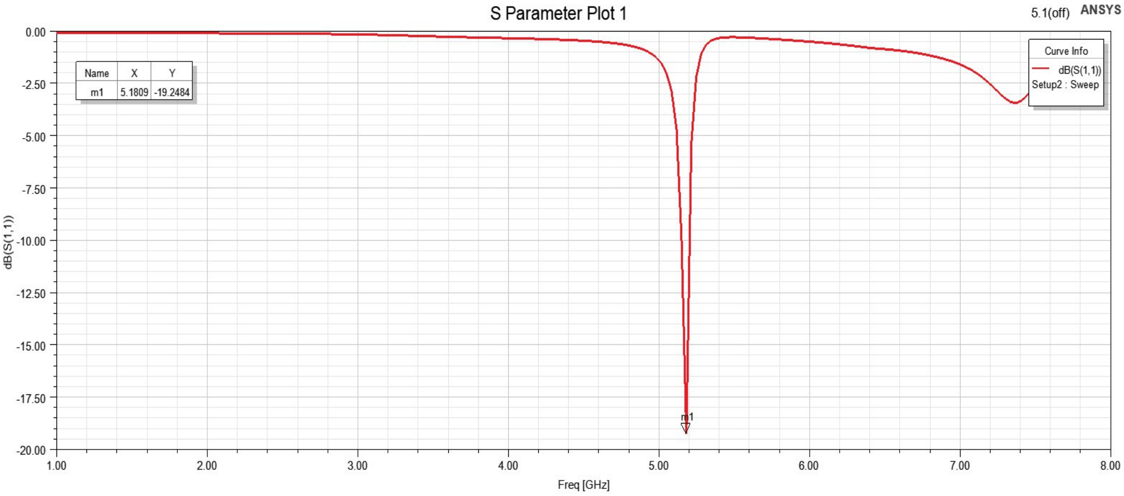


Figure 6.13 : Return loss(S11) Vs Frequency(OFF-condition)

Figure 6.13 the graph shows information about the return loss w.r.t frequency, which depicts that it resonates at 5.1809GHz with S11 value of -19.2484dB.

6.6.2 Radiation pattern:

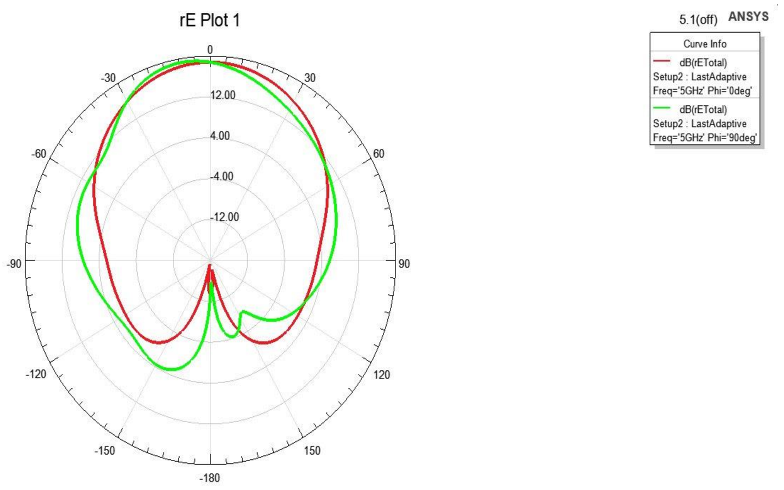


Figure 6.14 : Radiation pattern of Reconfigurable filtenna(OFF-condition)

6.6.3 VSWR:

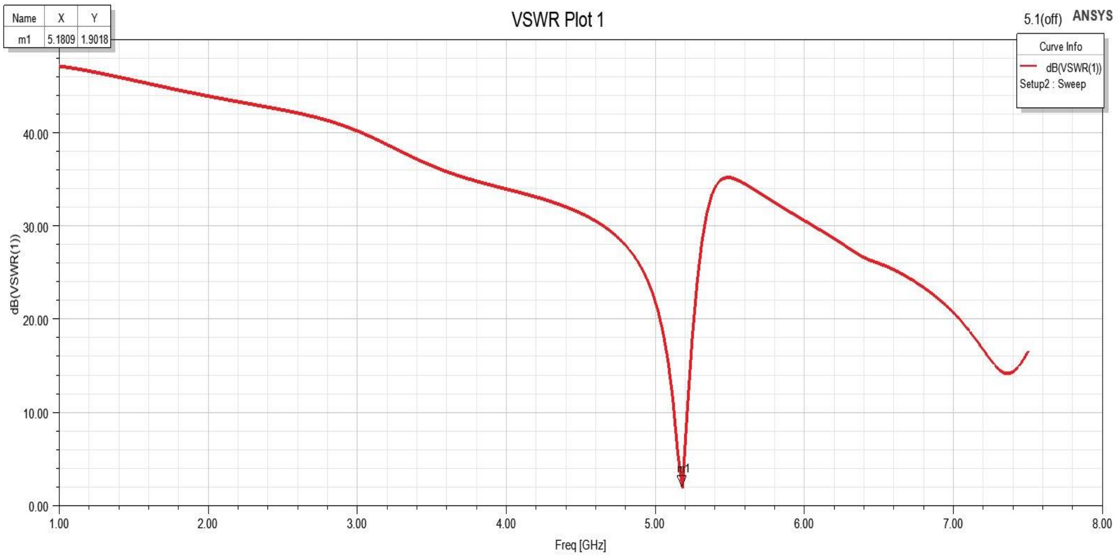


Figure 6.15 : VSWR Vs Frequency of Reconfigurable filtenna(OFF-condition)

Figure 6.15 variation of VSWR w.r.t frequency was presented.at frequency 5.1809GHz VSWR value was found to be 1.9018 which is well below the cut off value means that a good impedance matching is mismatched between feed and antenna.

6.6.4 3D Gain plot:

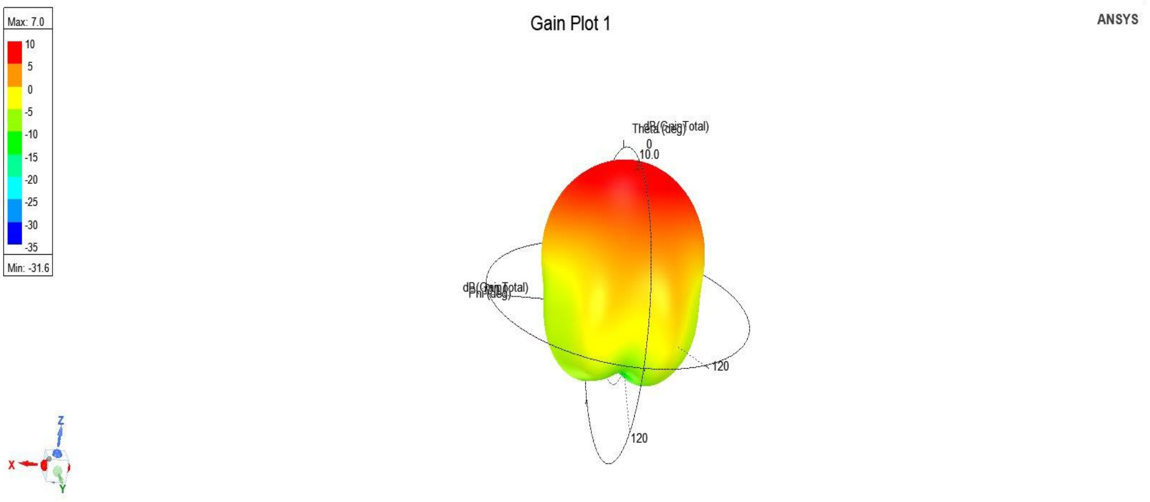


Figure 6.16: 3D Gain plot of Reconfigurable filtenna(OFF-condition)

6.6.5 Realized Gain(OFF-Condition):

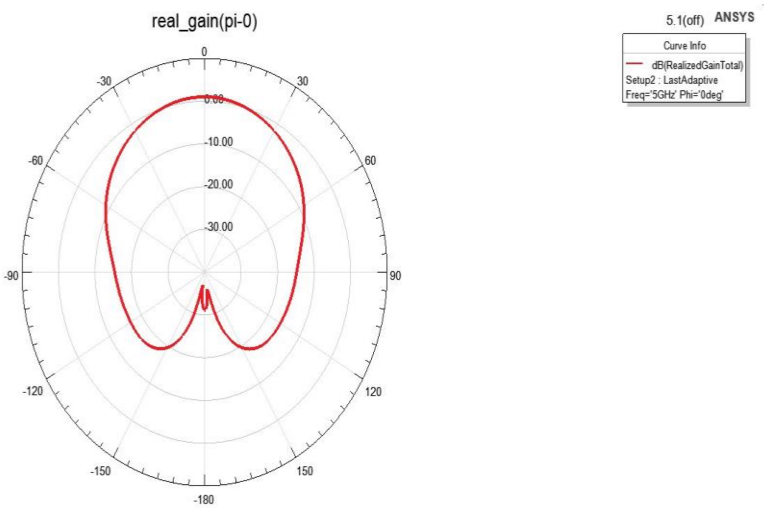


Figure 6.17(a):Realized Gain of Reconfigurable filtenna (Phi=’0deg’)

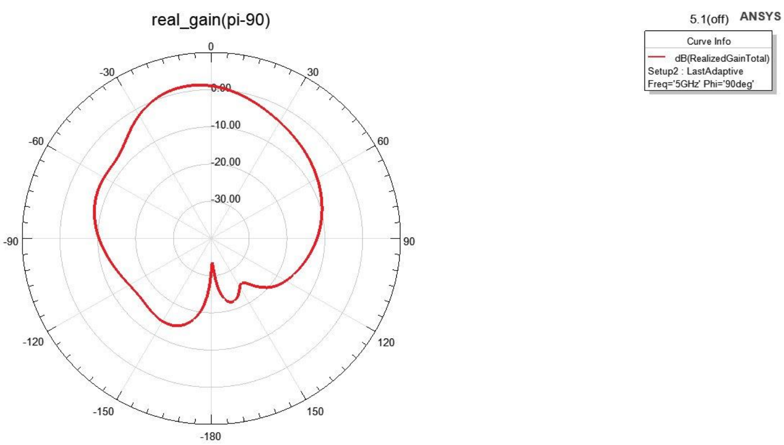


Figure 6.17(b):Realized Gain of Reconfigurable filtenna (Phi='90deg')

6.6.6 Parametric sweep (OFF condition)

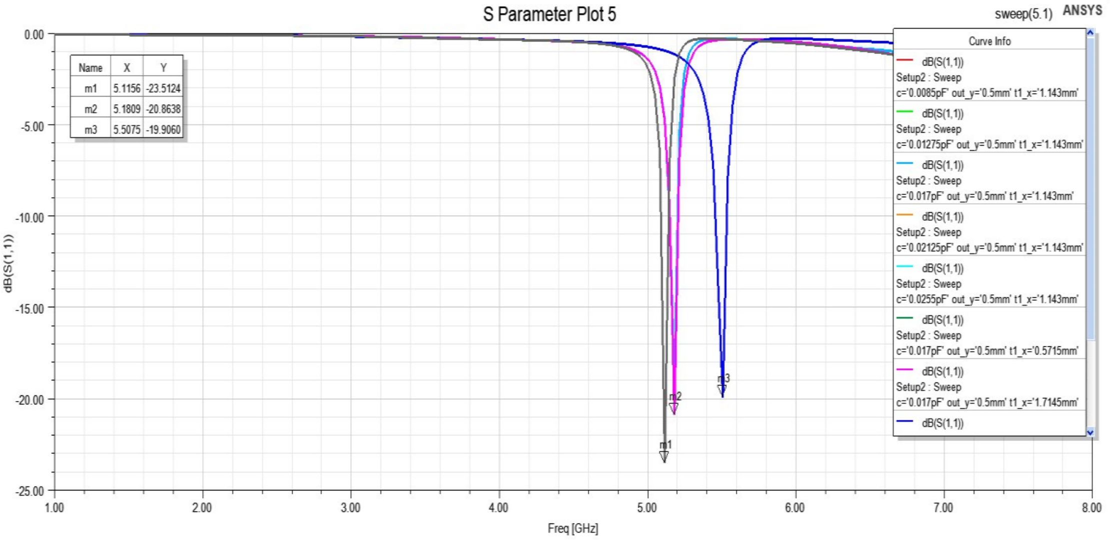


Figure 6.18: Reconfigurable filtenna (OFF condition)

Here the above figure 6.18 represents the parametric analysis of Return loss Vs Frequency w.r.t SRR filter gaps by observing the above plot we notice the W-0.5mm we get the antenna is operated at 5.1156GHz.it is the case for both diodes are on case and here for these values we got Return loss about -23.5124B at 5.1156GHz. In this three cases antenna is simulated and analysed by using HFSS software and Results are observed.

Table 6.3: Summery of the results

Parameters	Value
Return loss	-19.2484dB
VSWR	1.9018
Gain	10dB

6.7. RECONFIGURABLE ELLIPTICAL FILTENNA

DESIGN MODEL (90 deg):

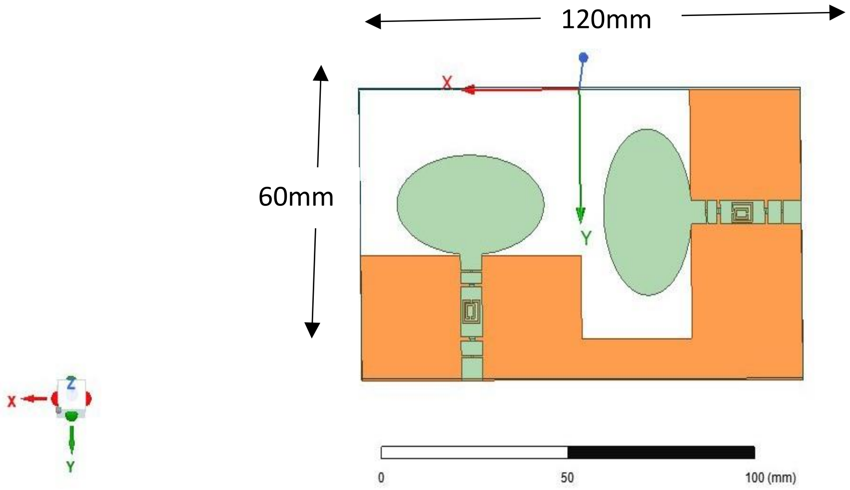


Figure:6.19 Reconfigurable elliptical filtenna (90 deg)

6.7.1 RETURN LOSS (ON Condition)

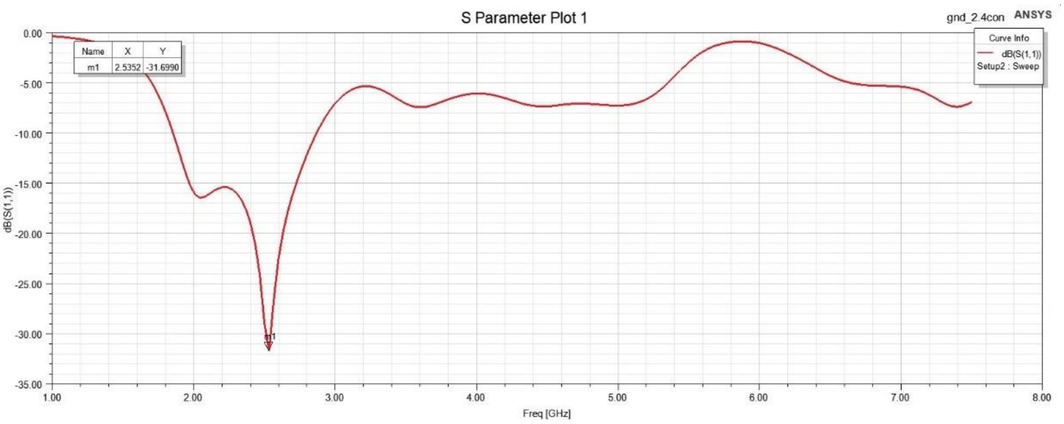


Figure 6.19(a) : Return loss(S11) Vs Frequency(ON-condition)

Figure 6.19(a) the graph represents information about the return loss w.r.t frequency, which depicts that it resonates at 2.5352GHz with S11 value of -31.6990dB with a band.

6.7.2 RETURN LOSS (OFF Condition)

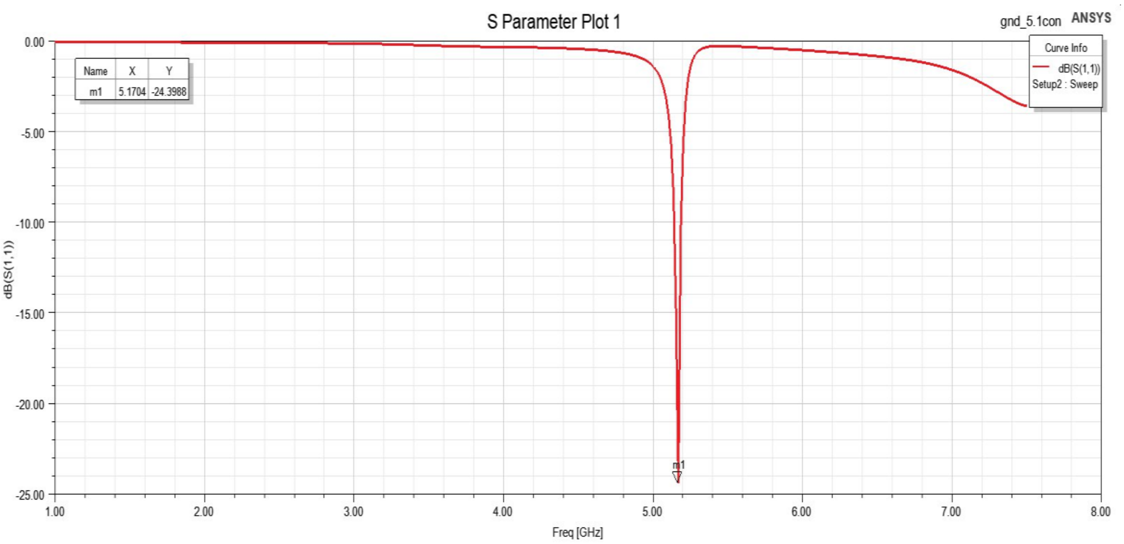


Figure 6.19(b): Return loss(S11) Vs Frequency(OFF-condition)

Figure 6.19(b) the graph represents information about the return loss w.r.t frequency, which depicts that it resonates at 5.17014GHz with S11 value of -24.3988dB .

4.7.3 S21(ON Condition)

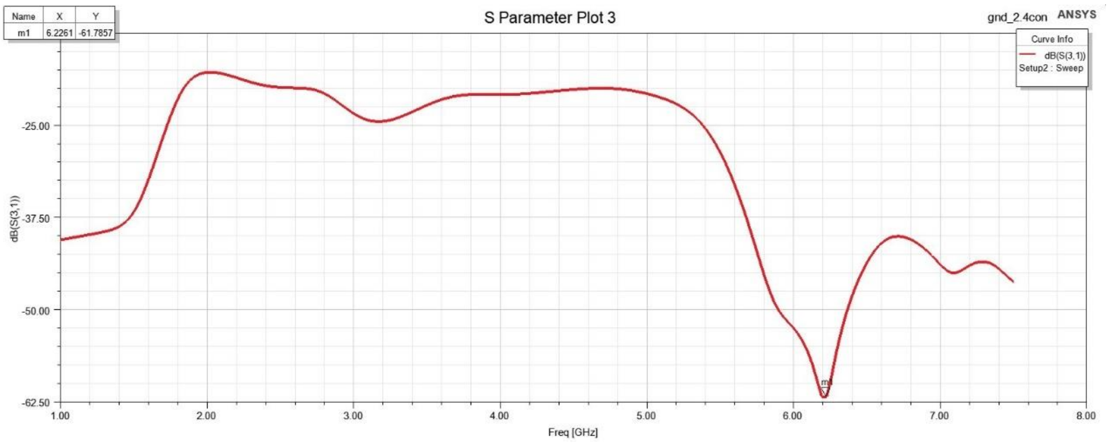


Figure 6.19(c): (S21) Vs Frequency(ON-condition)

4.7.4 S21(OFF condition)

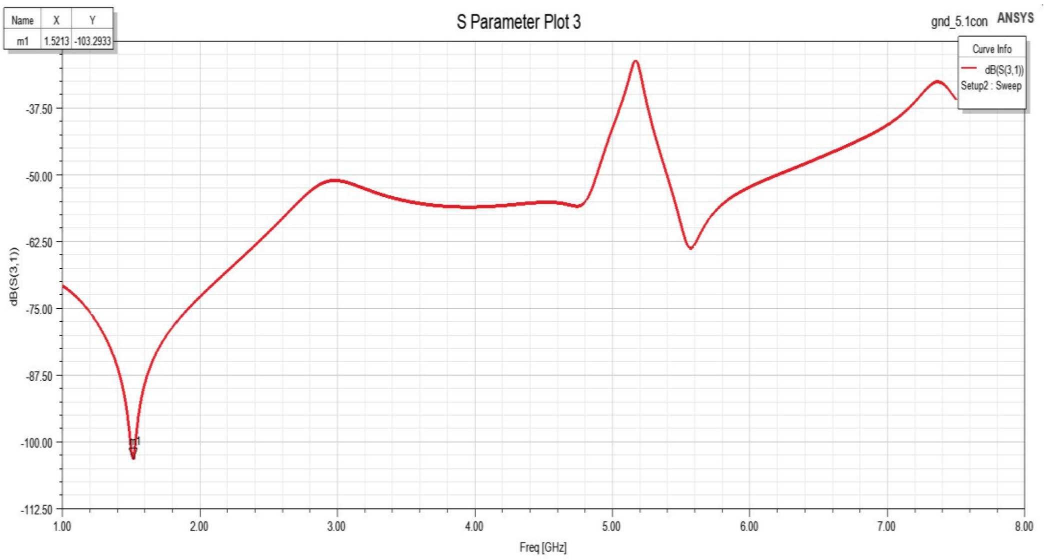


Figure 19(d): (S21) Vs Frequency(OFF-condition)

6.8 DESIGN MODEL (180 deg):

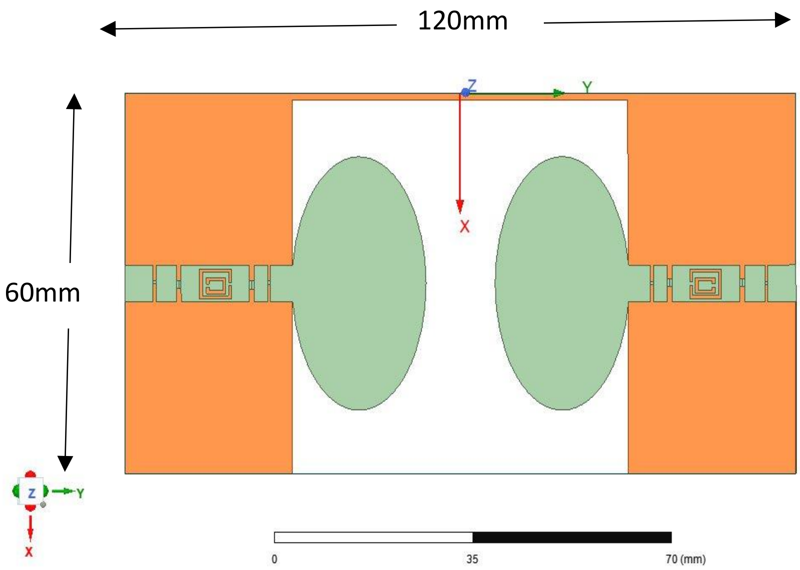


Figure:20 Reconfigurable elliptical filtenna (180 deg)

6.8.1 RETURN LOSS (ON Condition)

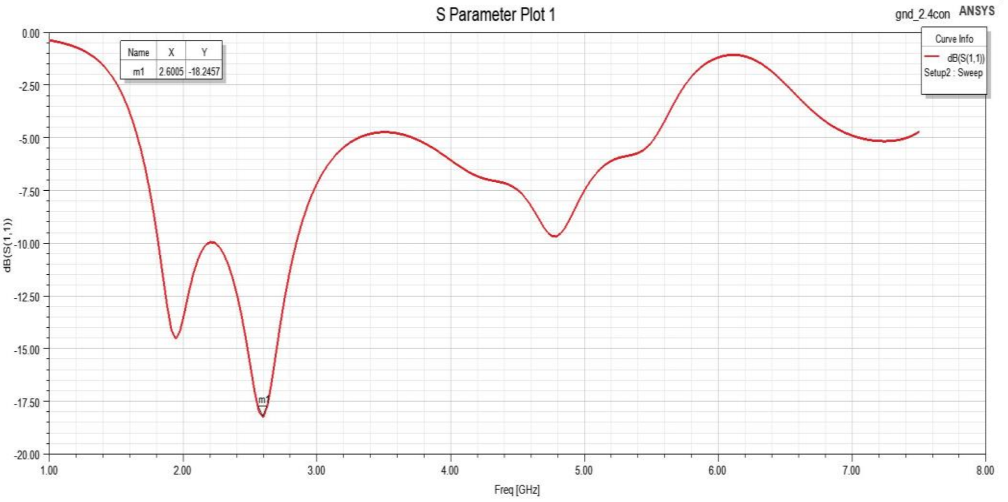


Figure 20(a) : Return loss(S11) Vs Frequency(ON-condition)

Figure 20(a) the graph represents information about the return loss w.r.t frequency, which depicts that it resonates at 2.6005GHz with S11 value of -18.2457dB.

6.8.2 RETURN LOSS (OFF Condition)

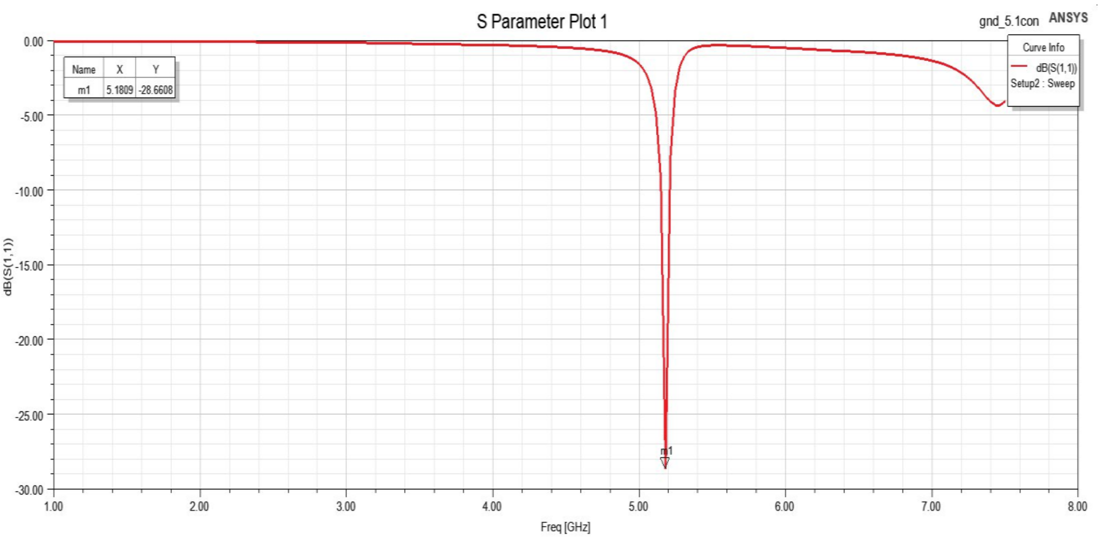


Figure 20(b): Return loss(S11) Vs Frequency(OFF-condition)

Figure 20(b) the graph shows information about the return loss w.r.t frequency, which depicts that it resonates at 5.1809GHz with S11 value of -28.6608dB.

6.8.3 S21 (ON condition)

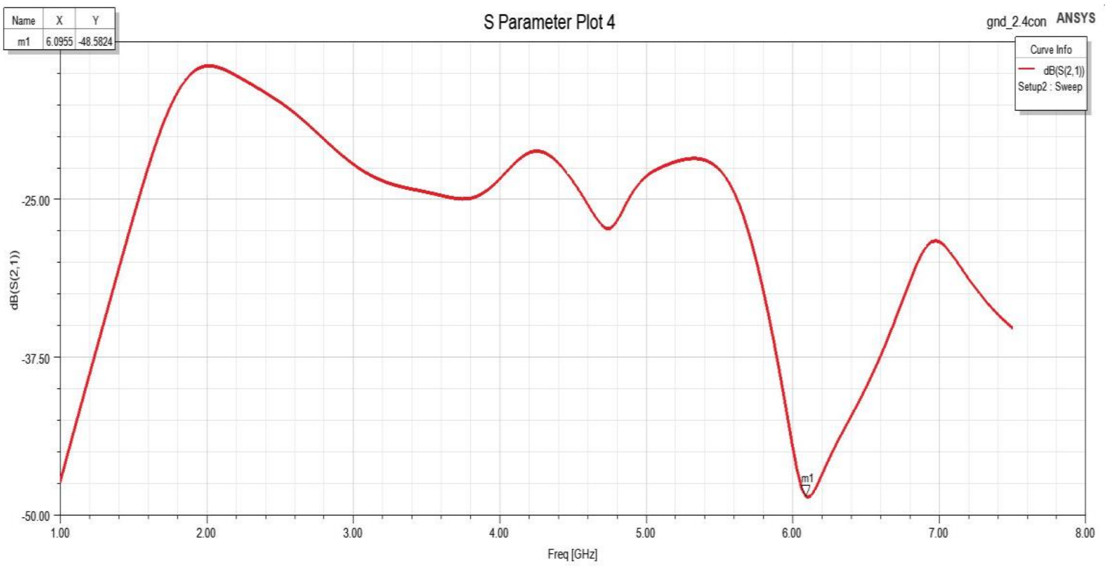


Figure 20(c): (S21) Vs Frequency(ON-condition)

6.8.4 S21 (OFF condition)

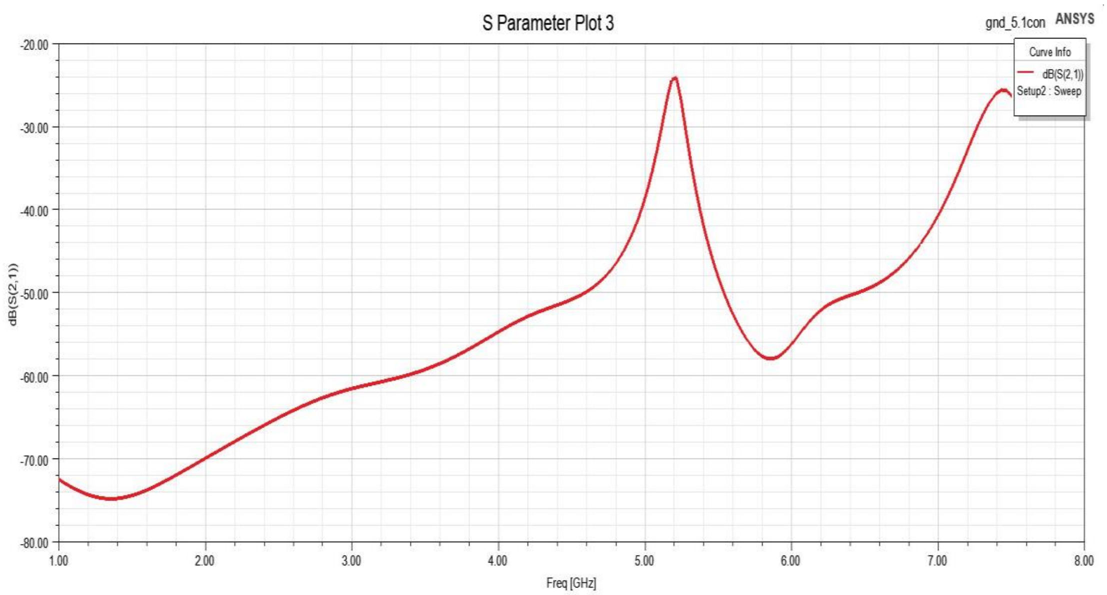


Figure 20(d): (S21) Vs Frequency(OFF-condition)

6.9 DESIGN MODEL (4-PORT):

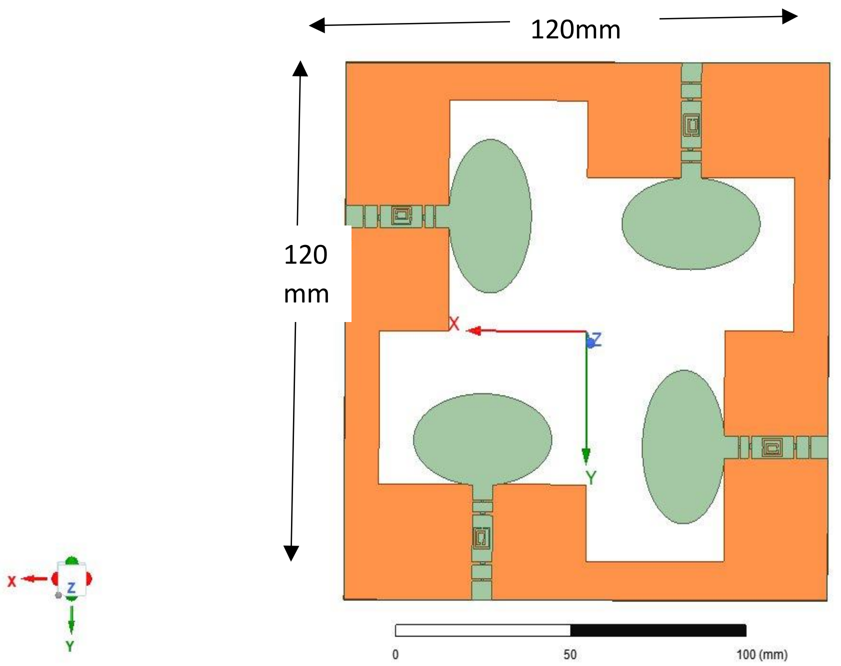


Figure:21 Reconfigurable elliptical 4-port filtenna

6.9.1 RETURN LOSS (ON Condition)

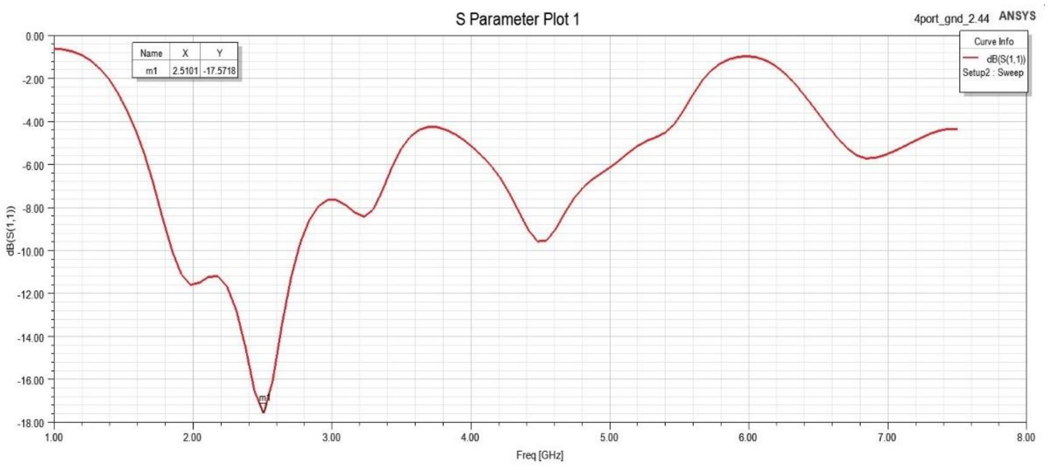


Figure 21(a) : Return loss(S11) Vs Frequency(ON-condition)

Figure 21(a) the graph represents information about the return loss w.r.t frequency, which depicts that it resonates at 2.5101GHz with S11 value of -17.5718dB.

6.9.2 RETURN LOSS (OFF Condition)

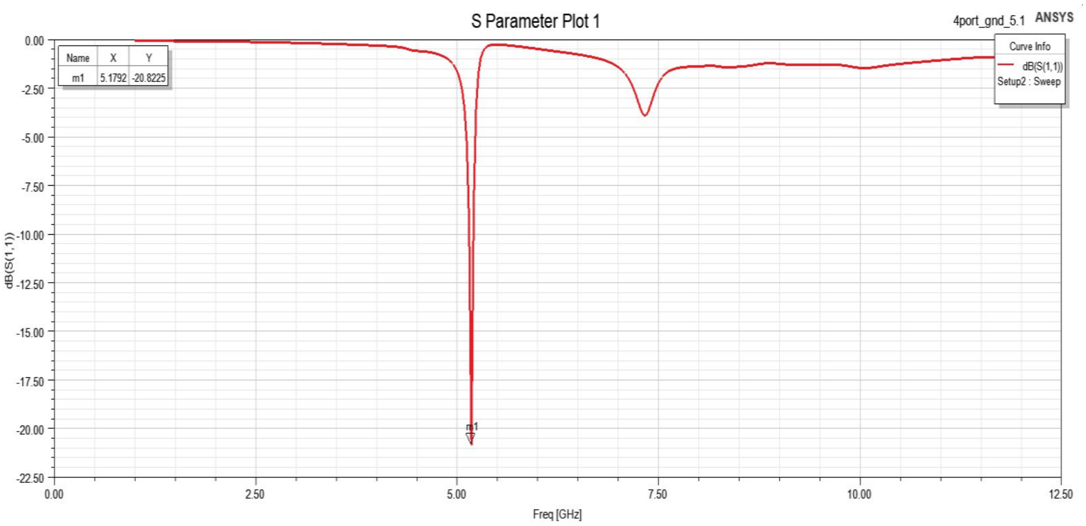


Figure 21(b) : Return loss(S11) Vs Frequency(OFF-condition)

Figure 21(b) the graph shows information about the return loss w.r.t frequency, which depicts that it resonates at 5.1792GHz with S11 value of -20.8225dB .

6.9.3 S21 (ON condition)

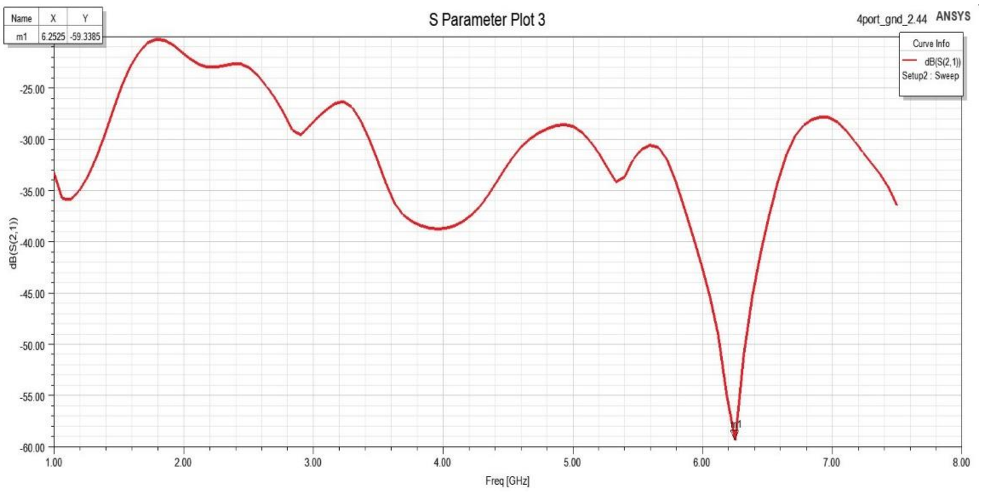


Figure 21(c) : (S21) Vs Frequency(ON-condition)

6.9.4 S21 (OFF condition)

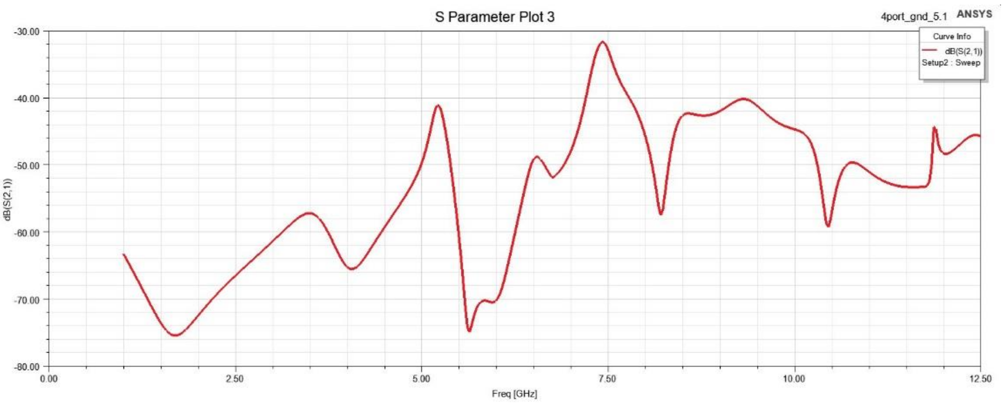


Figure 21(d) : (S21) Vs Frequency(ON-condition)

6.9.5 S31 (ON condition)

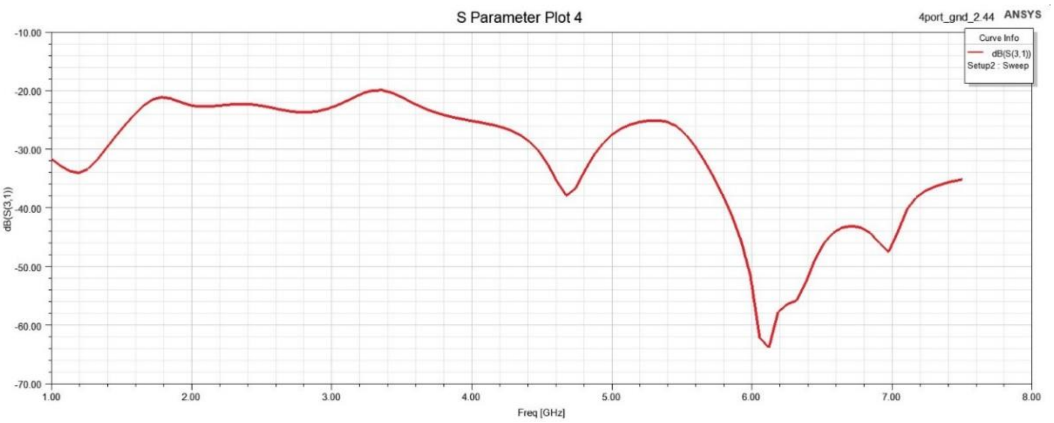


Figure 21(e) : (S31) Vs Frequency(ON-condition)

6.9.6 S31 (OFF condition)

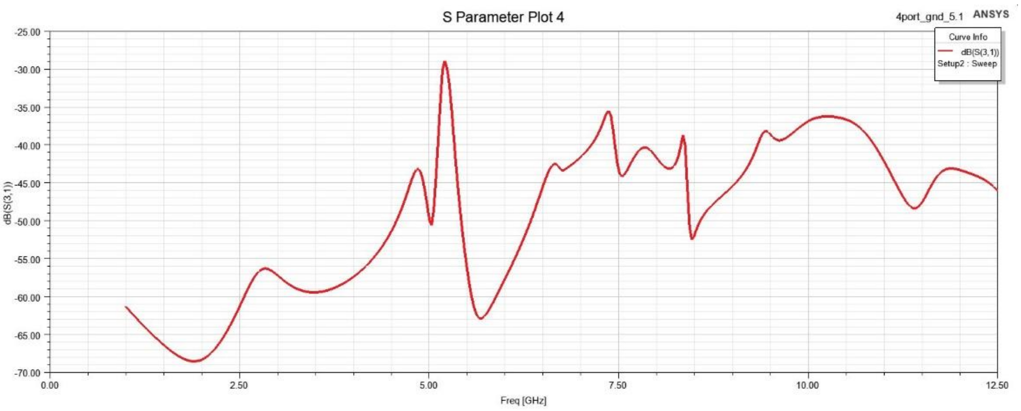


Figure 21(f) : (S31) Vs Frequency(OFF-condition)

6.9.7 S41 (ON condition)

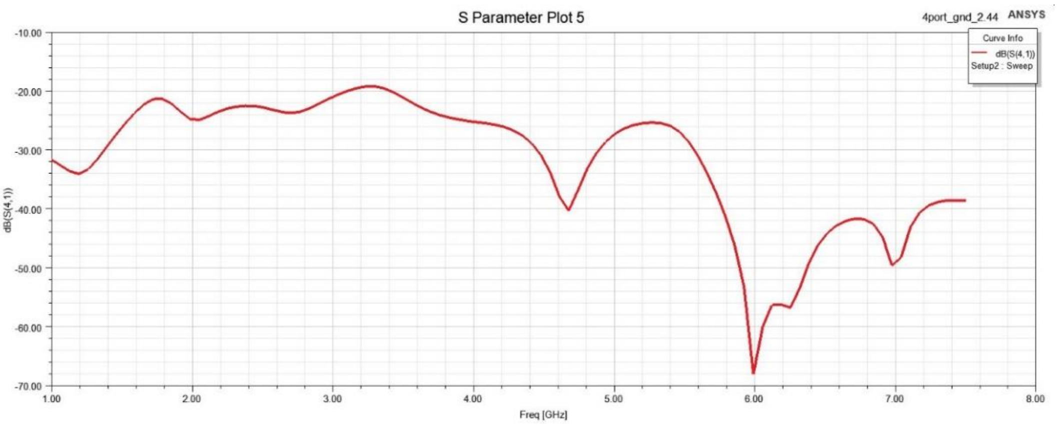


Figure 21(g) : (S41) Vs Frequency(ON-condition)

6.9.8 S41 (OFF condition)

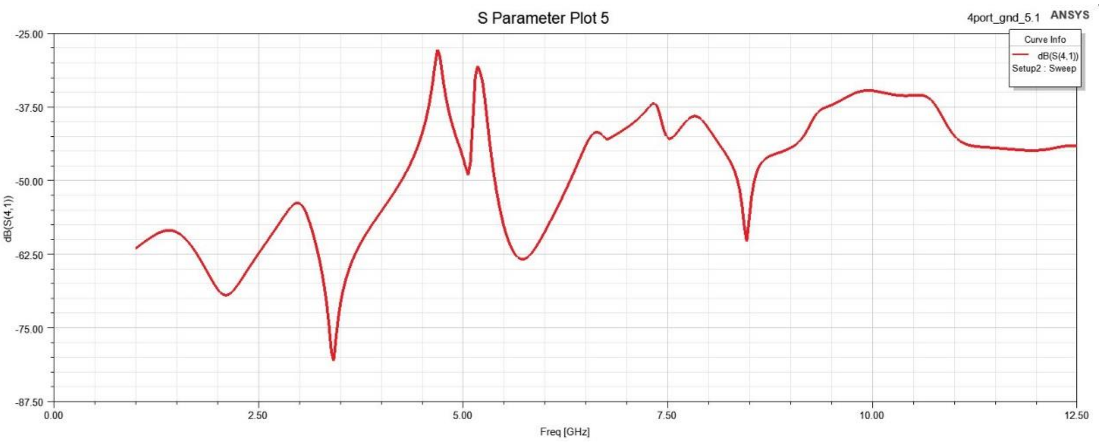


Figure 21(h) : (S41) Vs Frequency(OFF-condition)

CONCLUSIONS

Designing a small, single-feed, dual-frequency microstrip antenna with frequency and polarisation diversity is the goal of the thesis. Varactors and PIN diodes are employed as switching or tuning mechanisms. The antennas are built to function in the preferred frequency ranges, which are home to a wide range of wireless communication applications. The tuning frequency with a streamlined switching mechanism that is directly integrated into the radiating patch is a key design factor throughout the investigation. First, the design elements based on the antenna's geometrical characteristics were looked at. researches using simulations. Their dependency on the antenna dimensions may be seen in terms of their return loss, VSWR, and realised gain of the antenna at various resonances. The resonances are critically determined by dimensional factors. As a result, the annular slot loaded circular patch antenna is effective because it allows for easy tuning for various operating frequencies.First we had designed a normal T- slot Rectangular patch antenna which is made of Arlon diclad880 substrate having dielectric constant 4.4 and thickness of 2.2mm for operating at 2.4GHz and 5.1GHz. The Simulation results proved the antenna achieves a good return loss, VSWR, and realized gain. Further we replaced the Rectangular patch with Elliptical patch with SRR Filter which can be used in the applications which require reconfigurabilty. Here two pin diodes are used to control the state of antenna.The Simulation results shows that the antenna performs well in terms of Return Loss (S), VSWR, AR, and Gain The proposed Antenna works at 2.4 GHz & 5.1GHz Frequencies for Bluetooth and Wi-Fi/WLAN Applications.

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