

# **LOG PERIODIC PATCH ANTENNA DESIGN FOR 1GHZ - 5GHZ FREQUENCY BAND**

**A Project Report Phase – II**

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

by

PRAVEEN VISHAL R (39130357)



**DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING  
SCHOOL OF ELECTRICAL AND ELECTRONICS**

## **SATHYABAMA**

**INSTITUTE OF SCIENCE AND TECHNOLOGY  
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC**

**JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

**APRIL - 2023**



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## BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **PRAVEEN VISHAL R (39130357)** who carried out the project entitled "**LOG PERIODIC PATCH ANTENNA DESIGN FOR 1GHZ - 5GHZFREQUENCY BAND**" under our supervision from November 2022 to April 2023.

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Submitted for Viva voce Examination held on 19.04.2023

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## **DECLARATION**

I **PRAVEEN VISHAL R (39130357)** hereby declare that the “**LOG PERIODIC PATCH ANTENNA DESIGN FOR 1GHZ - 5GHZ FREQUENCY BAND**” is under the guidance of DR.SUGADEV,M.E.,Ph.D.,is submitted in partial fulfilment of the award Bachelor of Engineering degree in Electronics and Communication Engineering.

**DATE: 15.04.2023**

**PLACE: Chennai**



**SIGNATURE OF THE CANDIDATE**

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## ABSTRACT

A patch antenna is a type of antenna with a low profile, which can be mounted on a surface. It consists of a planar rectangular, circular, triangular, or any geometrical sheet or patch of metal, mounted over a larger sheet of metal called ground plane. They are the original type of microstrip antenna described by Howell in 1972 the two metal sheets together form a resonant piece of microstrip transmission lines with a length of approximately one-half wavelength of the radio waves. The radiation mechanism arises from fringing fields along the radiating edges. The radiation at the edges causes the antenna to act slightly larger electrically than its physical dimensions, so in order for the antenna to be resonant a length of microstrip transmission line slightly shorter than one-half the wavelength at the frequency is used. The patch antenna is mainly practical at microwave frequencies, at which wavelengths are short enough that the patches are conveniently small. It is widely used in portable wireless devices because of the ease of fabricating it on printed board circuit patch antennas on the same substrate called microstrip antenna can be used to make high gain array and phase array in which the beam can be electronically steered. A log-periodic antenna is an antenna that can operate on a wide frequency band and has the ability to provide directivity and gain. It has radiation and impedance characteristics that are repeated as a logarithmic function of excitation frequency. These antennas are fractal antenna. Log-periodic antennas were initially developed at the University of Illinois in 1955. They are capable of operating over a frequency range of 2:1. They are mainly used at the high frequency band of the spectrum. They are also used at very high frequency and UHF frequency bands as TV antennas. The length and spacing of elements in a log-periodic antenna increase logarithmically from one end of the dipole to the other.

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# CHAPTER1

## INTRODUCTION

### 1.1 HISTORY OF ANTENNAS

Antenna acquired a new significance as a connecting link between a radio system and outside world. The first radio antennas were built by Heinrich Hertz, a professor at the Technical Institute in Karlsruhe, Germany. In 1886, he assembled apparatus as a complete radio system operating at meter wavelengths with an end loaded dipole as a transmitting antenna and a resonant square-loop antenna as a receiver. He also experimented with a parabolic reflector antenna. Although Hertz was the pioneer and father of radio, his invention remained a laboratory curiosity until 20 years old Guglielmo Marconi of Bologna, Italy, added tuning circuits, big antennas and ground systems for longer wavelengths, and was able to signal over longer distances. For the next fifty years antenna technology was based on radiating elements configured out of wires and generally supported by wooden poles. These “wire” antennas were the mainstay of the radio pioneers, including: Guglielmo Marconi, Edwin Howard Armstrong, and Lee de Forest. Each of these “engineers” has been called the father of Radio. Dr. Lee Forest conducted his first long distance wireless broadcasts, one hundred years ago, from the Illinois Institute of Technology. The first generation antennas were narrowband (small range of the order of a few percent around the designed operating frequency) and were often arrayed to increase directivity. Development of the array culminated in the work of Hidetsu Yagi and Shintaro Uda (1926). During this period broadband antennas were also developed. These have a performance that is periodic in a logarithmic fashion, and have come to be known as “log-periodic” antenna.

### 1.2 NEEDS OF ANTENNAS

Wireless communications are impossible without antennas. An antenna is considered as a region of transition between a transmission line and space.

These characteristic features of antenna are listed below:

- Light weight

- Effective and Efficient Operation
- Meeting Various Wireless Applications
- Broadband Frequency coverage
- Inexpensive
- Easy to design and manufacture
- Robust
- Broad frequency

## **1.3 TYPES OF ANTENNAS**

The antenna can be classified in several ways. The classification depends on the frequency band of operation, physical structure and electrical/electromagnetic design. This antenna and the supporting technology are called adaptive or smart antennas and may be used for higher frequency bands in future.

A few commonly used antennas are described in the following sections

- Microstrip Antenna
- Reflector Antenna
- Travelling Wave Antenna
- Aperture Antenna

### **1.3.1 Microstrip Antenna**

Microstrip antennas are often used where thickness and conformability to the host surface are the key requirements. Patch antennas are assigned different names such as printed antennas, microstrip antennas or simply microstrip antennas. Since patch antennas can be directly printed on to a circuit board these are becoming increasingly popular within the mobile phone market. They are low cost, have a square, rectangular, circular, and triangular or elliptical shape. The most common geometries, such as rectangular and circular, are widely employed.

### **1.3.1 Reflector Antenna**

Reflector antennas are widely used to modify the radiation pattern of a radiating element. For example, the backward radiation from an antenna may be

eliminated with a plain sheet reflector of large dimension. Several types of reflectors are active cornerreflector, passive corner reflector, and parabolic reflector, elliptical reflector, hyperbolic reflector, circular reflector, thin reflector. To reduce diffraction the reflector should have a rolled edge with radius of curvature at least  $\lambda/4$  at the longest wavelength of operation.

### **1.3.2 Travelling Wave Antenna**

Travelling wave or non resonant or periodic antennas are those antennas in which there is no standing wave travel in these antennas. The main advantage of travelling wave antenna is large bandwidth.

### **1.3.3 Aperture Antenna**

The aperture is defined as the area, oriented perpendicular to the direction of an incoming radio wave, which would intercept the same amount of power from that wave as is produced by the antenna receiving it. Aperture antennas are most common at microwave frequencies. They may be taken form of a waveguide or a horn whose aperture may be square, rectangular, circular, and elliptical or any configuration. Aperture antennas are verypractical for space application because they can flush mounted on the spacecraft or aircraft. Their opening can be covered with a dielectric material to protect them from environment conditions. This type of mounting does not disturb the aerodynamic profile of the craft.

## **1.4 ANTENNA PARAMETERS**

The radiation pattern and radiation resistance of an antenna is the same when it transmits and when it receives, if no non-reciprocal devices are used. So, same antenna can be used for Transmission and Reception of Electromagnetic Waves. Antenna is a passive device, it does not amplify the signals, and it only directs the signal energy in a particular direction in reference with isotropic antenna.

### **1.4 Polarization**

Polarization of EM fields describes the time variations of the time harmonic field vectors at a given points. In other words, it describes the direction of the field

vectors change in time. Polarization is a time harmonic field characterizes.

#### **1.4.1 Effective Aperture**

The Effective Antenna aperture polarization is the ratio of the available power at the terminal of the antenna to the power flux density of a plane wave incident upon the antenna which matched of the antenna as shown in eqn. 1.1

$$A_e = D\lambda^2/4\pi \quad (1.1)$$

#### **1.4.2 Directive Gain of Antenna**

The gain is also called as directive gain when the antenna radiates power in a particular direction relative to the average power radiated by the Antenna. An antenna has large aperture has more gain.

#### **1.4.3 Directivity**

Directivity of an antenna is the ratio of the radiation intensity in a particular direction and the radiation intensity averaged over all directions as given in eqn. 1.2

$$D = 4\pi/\lambda^2 A_e \quad (1.2)$$

#### **1.4.4 Antenna Beam Width**

It is the angle, measured in a horizontal plane, between the directions at which the intensity of an electromagnetic beam. Large gain of antenna means smaller beam width.

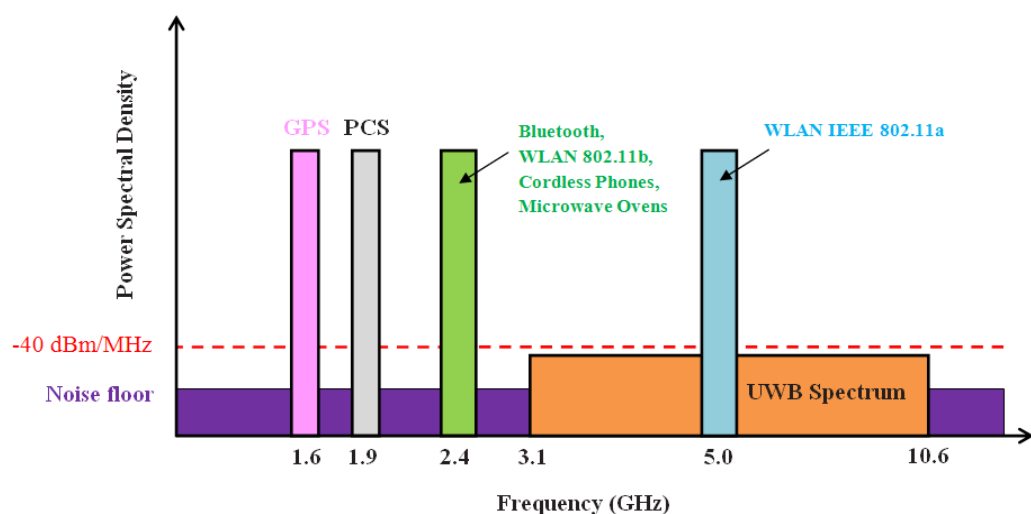
### 1.4.5 Antenna Side Lobes

Antenna is not able to radiate all energy in single perfect direction. Some of the energy can be radiated in other direction, often there are small peaks in the radiated energy in different directions. This peak is referred as side lobes.

## 1.5 APPLICATIONS

Microstrip antennas are increasingly gaining popularity for use in wireless application due to their low-profile structure. Therefore they are extremely compact for embedded antennas in handheld wireless device such as cell phones and pagers. The telemetry and communication antennas on missiles need to be thin and conformal Microstrip antennas. They also have been used in satellite communication area and widespread applications in microwave and millimeter wave systems successfully. These have been employed airborne and spacecraft systems because of their low profile and conformal nature.

**Fig 1.1 General Communication Band systems**



## 1.6 MICROSTRIP ANTENNA

The Microstrip antenna was proposed by G.A.Deschamps in 1853. The proposed concept of Microstrip antenna to transmit radio frequency signals could not gain much ground till 1970's. Its practicability remained hampered due to various

inherent defects. Further, the development of the printed circuit board (PCB), many kind of low-attenuating media materials made the use of Microstrip antennas more practical. Microstrip antennas are often used where thickness conformability to the surface of mount or platform are the key requirements. The prime limitation of this type of antenna is the bandwidth, which is lesser than 5% for the most single-substrate designs. However, a second substrate can be added to create a dual band design or a broadband design with a bandwidth of up to 35%. The Microstrip antenna has two most commonly used geometries, such as rectangular and circular, are widely employed. Square patches are used to generate a pencil beam, rectangular patches for a fan beam in the view of their straight forward fabrication, and circular patch can be used in the calculation of current distribution in the circular patch MSA. The size of a Microstrip antenna is inversely proportional to its frequency. At frequencies lower than AM radio at 1MHz, the Microstrip patch antenna size will be increased. For a Microstrip antenna designed to receive an FM radio at 100MHz, its length would be of the order of 1 meter which is still very large for any type of substrate. At X-band, the Microstrip antenna size will be of the order of one centimeter which is easy to realize soft-board technology.

The Microstrip is constructed on a thin dielectric sheet using a printed circuit board and etching techniques. The dual copper-layered is commonly used because it allows the Microstrip antenna to cover the shape of the monitoring surface. The patch is generally made of conducting material such as copper or gold. The radiating patch and the field line usually photo etched on the dielectric substrate. The EM waves firing off the top of the patch into substrate and radiated out into the air after reflecting off the ground plane.

## **1.7 ARRAY OF MICROSTRIP ANTENNA**

It is possible to construct complex arrays of patch/Microstrip antennas by employing the printed-circuit techniques on a dielectric substrate. Such array may have high gain, customizable beam and return loss properties and other unique features at low cost. Depending on the directivity requirement, such array may contain from few to a very large number of elements. Use of such array with large number of elements is quite common in radar applications for electronic scanning. One of the major drawbacks of such arrays is mutual coupling. These techniques are used to reduce the coupling between surrounding

patch elements and metal walls. It effectively prevent surface mode from being excited in a substrate, thus allowing the substrate thickness to be increased without serious effects.

## **1.8 CHARACTERISTICS OF MICROSTRIP PATCH ANTENNAS**

A Microstrip patch antenna consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side as shown in figure 2.2. The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and the feed lines are usually photo etched on the dielectric substrate. Arrays of antennas can be photo etched on the substrate along with their feeding networks. Microstrip circuits make a wide variety of antennas possible through the use of the simple photo etching techniques. Microstrip patch antennas are attractive due to their conformal properties. So far they have been mostly fabricated on substrates such as FR4 and duroid which typically exhibit dielectric constants no greater than 10. However, high permittivity materials ( $>10$ ) have the property of increasing electric field intensity in their volume and this can prove useful in antenna design.

A Microstrip antenna is a resonator type antenna. It is usually designed for single mode operation that radiates mainly linear polarization. For a circular polarization radiation, a patch must support orthogonal fields of equal magnitude but in-phase quadrature. This requirement can be accomplished by single patch with proper excitations or by an array of patches with an appropriate arrangement and phasing. Some more important characteristics for Microstrip antennas are given below

### **1.8.1 Isotropic Antenna**

An isotropic antenna is defined as “a hypothetical lossless antenna having equal radiation in all directions”. Although hypothetical and not physically realizable, an isotropic radiator is taken as a reference for expressing the directional properties of actual antennas.

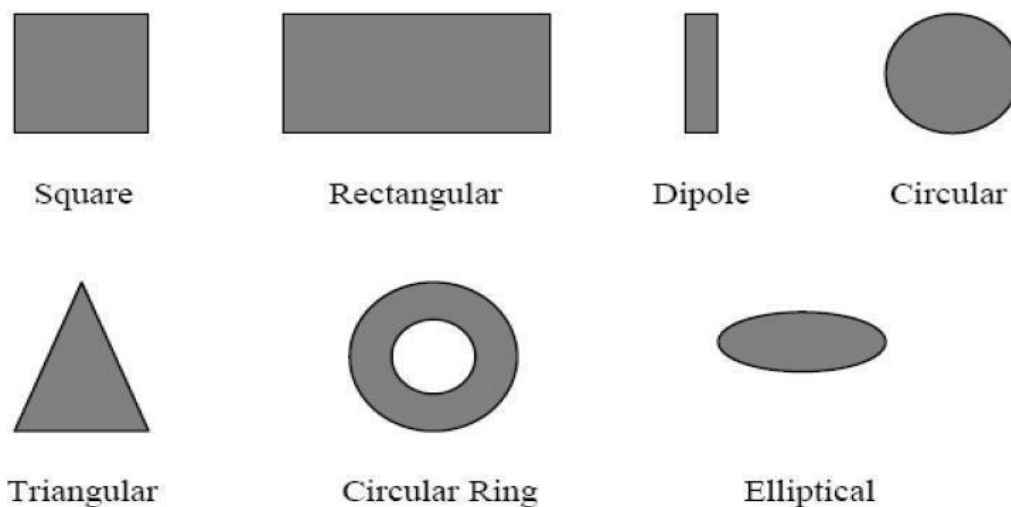
A directional antenna is defined as “having the property of radiating or receiving electromagnetic waves more effectively in particular directions than in others.” This term is usually applied to an antenna whose maximum directivity is significantly greater than that of a linear dipole antenna.

### 1.8.2 Omni directional Antenna

An omnidirectional antenna is an antenna having a radiation pattern which is nondirectional in a plane.

## 1.9 DIFFERENT SHAPES OF MICROSTRIP PATCH ANTENNA

The rectangular and circular patches are the basic and most commonly used Microstrip antennas. The different shapes of Microstrip patch antenna as shown in figure 1.2.



***Fig 1.2 Different shapes of patches***

### 1.10 METHODS OF ANALYSIS

The preferred models for the analysis of Microstrip patch antennas are the transmission line model, cavity model, and full wave model (which include primarily integral equations/Moment Method). The transmission line model is the simplest of all and it gives good physical insight but it is less accurate. The cavity model is more accurate and gives good physical insight but is complex in nature. The full wave models are extremely

accurate, versatile and can treat single elements, finite and infinite arrays, stacked elements, arbitrary shaped elements and coupling. These give less insight as compared to the two models mentioned above and are far more complex in nature.

### 1.10.1 Transmission line model

This model represents the Microstrip antenna by two slots of width  $W$  and height  $h$ , separated by a transmission line of length  $L$ . The Microstrip is essentially a non-homogeneous line of two dielectrics, typically the substrate and air. Hence, as seen from figure 2.8, most of the electric field lines reside in the substrate and parts of some lines in air. As a result, this transmission line cannot support pure transverse-electric-magnetic (TEM) mode of transmission, since the phase velocities would be different in the air and the substrate. Instead, the dominant mode of propagation would be the quasi-TEM mode. Hence, an effective dielectric constant ( $\epsilon_{eff}$ ) must be obtained in order to account for the fringing and the wave propagation in the line.



**Fig. 1.3 Microstrip line and Electrical field line**

The value of  $\epsilon_{eff}$  is slightly less than  $\epsilon_r$  because the fringing fields around the periphery of the patch are not confined in the dielectric substrate but are also spread in the air as shown in Figure 1.7 above. The expression for  $\epsilon_{eff}$  is given by Balanis as:

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[ \frac{h}{W} \right]^{-1/2}$$

Where,  $\epsilon_{eff}$  = Effective dielectric constant

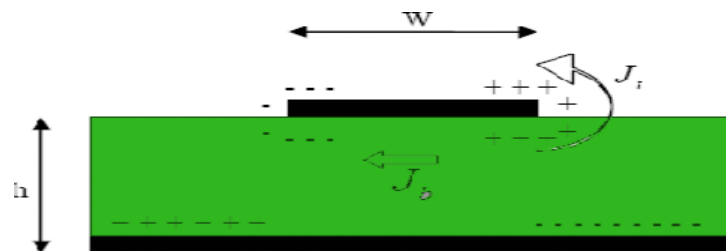
H= Height of dielectric substrate

W= Width of the patch

### 1.10.2 Cavity Model

Although the transmission line model discussed in the previous section is easy to use, it has some inherent disadvantages. Specifically, it is useful for patches of rectangular design and it ignores field variations along the radiating edges. These disadvantages can be overcome by using the cavity model. A brief overview of this model is given below. In this model, the interior region of the dielectric substrate is modeled as a cavity bounded by electric walls on the top and bottom. The basis for this assumption is the following observations for thin substrates ( $h \ll \lambda$ ).

- Since the substrate is thin, the fields in the interior region do not vary much in the z direction, i.e. normal to the patch.
- The electric field is z directed only, and the magnetic field has only the transverse components  $H_x$  and  $H_y$  in the region bounded by the patch metallization and the ground plane.



**Fig. 1.4 Cavity Model**

Consider figure 1.8 shown above. When the Microstrip patch is provided power, a charge distribution is seen on the upper and lower surfaces of the patch and at the bottom of the ground plane. This charge distribution is controlled by two mechanisms—an attractive mechanism and a repulsive mechanism as discussed by Richards. The attractive mechanism describes between the opposite charges on the bottom side of the patch and the ground plane, which helps in keeping the charge

concentration intact at the bottom of the patch. The repulsive mechanism describes between the like charges on the bottom surface of the patch.

## CHAPTER 2

### LITERATURE SURVEY

#### 2.1 RELATED WORK

Design and Optimization of a microstrip patch antenna for increased bandwidth has been discussed by Archana Agrawal (2013). The need for wireless communication is everincreasing and it is important to design broadband antennas which can be used to cover a wide range of frequencies. A possible way of increasing the bandwidth is to increase the sizeof the dielectric and another way for small sized antennas are by the use of U slot and L probe stacked microstrip patch antenna. By adding additional resonators either directly or indirectly coupled to the patch antenna and combinedly with the use of EBG structures can be used to improve radiation pattern, enhanced gain, minimized side and back lobes. A 6x6array antenna with EBG structure has been discussed with size as 12mm x 17mm x 1.6 mm.A wide bandwidth of 4.15 to 5.27 GHz is achieved and frequency resonated at 4.17GHz with -38.6db reflection Coefficient. The wide band is achieved by using EBG structures.

Design and analysis of circular shaped microstrip patch antenna at 14.6 GHz has been studied by Furkan Atalah (2018). The substrate material used to design the antenna is FR4 epoxy having permittivity of 4.4 and the size of the antenna is 20.00 x 31.06 mm with a thickness of 1mm. Even when the return loss achieved by the antenna is -35db in 14.63GHzthere is no gain, by changing the feeding location and by adding triangle and rectangle shapesto the lower resonator the input reflection coefficient at 14.6GHz is changed to -15.69db return loss with gain of 6.1db. By looking on shapes among rectangular, circular, triangular and annular patches circular patch is the second most popular shape that can be easily optimized and analyzed to get improved impedance values, radiation pattern and frequency of operarion.

The antenna is designed in HFSS software in FR4 epoxy as a substrate Material with dimensions of 42 x 30 x 1.6 mm<sup>3</sup>. The design of a dual slotted h shaped microstrip antenna for SAR Estimation has been discussed by Manasi S. Kanitkar (2020). The design of microstrip patch antennas is different for impedance matching and resonant frequency. Resonant frequency can change by changing the length of the patch whereas by changing the width impedance matching can be changed. Various parameters are analyzed for understanding the performance of antenna like radiation pattern, VSWR, return loss, gain, directivity, radiation pattern and so on and the value of SAR is measured to know whether the antenna is hazardous to human health or not. To radiate maximum power impedance matching is a most important factor and here full port impedance of 50Ω is used. The dual slot h shaped antenna resonates exactly in 2.2GHz with a return loss of -22.7db and the obtained VSWR value is 1.2 with gain of 3.65dBi. The obtained specific absorption rate value is 0.39W/Kg is much less from the allowable limit by TEC as 1.6W/Kg.

The design of multiband Microstrip Antenna for communication system has been proposed by Antara Ghosal (2018). The analysis of slotted microstrip patch antenna in square shape is designed and the slots are introduced in the single structure for multiband operations. The antenna is designed in HFSS software using transmission line model equation and MATLAB is used to find the result parameters. The antenna resonates in multiband frequencies of 3.3, 3.9, 4.4 and 8.8 GHz which has the size of L=W=33.7mm and thickness of about 1.6mm. These multiband are having a return loss less than -10db and the gain of the antenna in all the bands are in negative and the efficiency of the antenna is very less. The multiband is obtained by adding slots in the simple patch antenna.

A compact array antenna for LTE 1.8GHz Electric power wireless communication has been proposed by Jainzong He (2017). To require the needs of electric power wireless communication LTE technology adopts orthogonal frequency division multiplexing (OFDM) and Multiple input and multiple output (MIMO), it can be used in the development of intelligent power grid. To improve the stability of the signal from transmitted and received by the power system with the improved gain and channel capacity, based on OFDM and MIMO Technologies MIMO array

antenna can be applied to the terminals. Dumbbell shapeddefected ground structure has been used to reduce the channel and noise interference between the ports of the MIMO antenna. To prove the surface waves between the array elements are observing the electromagnetic distribution in the near field can be done by adding EBG structure between two arrays. 40mm x 50mm x 10mm are the parameters of thedesigned array antenna.

A compact triple slotted Rectangular Microstrip Patch Antenna with Metamaterial groundfor Sub-6 GHz/5G communication is simulated and fabricated by Vinoth M (2020), The antenna design is optimized in steps to achieve a compact antenna with high performance byDifferent RMPA architectures to realize an antenna to operate in sub-6 GHz for 5Gcommunications. The modified RPA with a Triple Slotted in patch without altering the dimension resonates at 3.5 GHz with good return loss performance of -30.77 dB and gain of5 dB. The dimension of compact TSRMPA with MTM ground is 30.2 x 36.4 mm<sup>2</sup> . These antennas are investigated using High Frequency Structural Simulator (HFSS) software. Finally, good concurrence between simulated and tested result is presented to prove the functioning of proposed antenna design.

Timoty A. Hill (2018) proposed a 28GHz Taylor feed network for side lobe reduction in Phased array antennas. An antenna is designed to be exactly resonating in 28GHz 8-element beam steerable. The achieved beam steering is from  $0^\circ$  to  $48^\circ$  using meanders and the taper reduced the side lobe by 2.84dB to -15.2dB. The antenna is built with a set of Taylor n-bar feed for phased array with line width greater than 0.2mm in all parts of the feed. Based on the directivity of the antenna which is obtained as 13.6 dBi and the overall efficiency of the antenna is 66% with the Taylor bore sight feed PCB and at the maximum steering angle of  $48^\circ$  the scan loss obtained is 2.9dB. The SLL reduction will increase the signal to interference noise ratio in 5G millimetre wave links.

K. Kaboutari (2019) proposed a design of microstrip patch array antenna with cosecant squared radiation pattern profile. An  $8 \times 2$  array antenna which comprises eight pairs of radiating that are arranged in a symmetrical structure and are connected to a single feed line. The proposed array antenna has an impedance bandwidth of 1.93GHz ranging from 9.97GHz to 11.90GHz with return loss less than or equal to -10db and achieving a gain of 14.95dBi. The compact array antenna which has been designed for radar applications at X-band frequency has an overall dimensions of  $106 \times 34 \times 0.813 \text{ mm}^3$  and fabricated in Rogers RO4003 dielectric substrate.

A Compact Multiple slot Microstrip antenna for modern mobile communication has been proposed by M.Sugadev (2016). A triple band patch antenna is designed by etching slots in the radiating patch in the shapes of L and M to get the resonating frequencies at 3.6GHz, 5.6GHz and 7.9GHz. Transmission line of 50 Ohm Impedance is used to design in Fr4 epoxy resin material with return loss less than -10db and VSWR below 2 in all the three frequency bands and the gain 0.826dB.

Quad Band U-Slot Microstrip Antenna for C,X and Ku Band Wireless Applications has been proposed by M.Sugadev (2105). A Quad band Microstrip patch antenna to target frequencies spanning over C,X and Ku Band by making a U slot in the patch by obtaining a return loss below -22db and Voltage standing wave ratio below 1.5 at all resonating frequencies of 5.8GHz, 8.25GHz, 9.85GHz and 13.95GHz. The bandwidth achieved in all resonating frequencies are found to be 5.2 – 5.5GHz, 7.7-

8.5GHz, 9.75-10GHz and 13.75 – 14.10GHz and the efficiency of the antenna is an UWB Metamaterial Antenna for WLAN Application has been discussed by U. Surender(2015). The antenna structure has an inverted T slotted on the radiating layer is and designed to operate in range from 3.1GHz to 10.6GHz and it has exactly resonated in 5.5GHz for WLAN Application. Metamaterials antennas are used to enhance the performance of antenna in miniaturized sizes. The antenna is designed in FR4 dielectric medium with a height of 1.6mm and having a length and width of 25mm and 21mm. The return loss obtained is - 28dB in 5.5 GHz with a max gain of 3.6dB.

M. Sugadev (2017) explained about the antenna design with corporate feed based metamaterial antenna for wireless application. Coplanar waveguide fed antennas provide impedance matching for border frequency range. Along with CPW feed the design uses two annular rings for radiating layer and also uses split ring resonator elements for achieving metamaterial property. The antenna resonates in 2.8GHz and 4.8GHz with a maximum gain of 5.53dB and with an impedance bandwidth of 450MHz. The CPW method of feeding is used to provide good impedance matching and omnidirectional patterns.

A triple-band antenna array for next generation wireless and satellite based applications has been proposed by Asghar A. Razzaqi (2014). The antenna is designed and simulated using Agilent ADS Momentum using FR4 substrate with a thickness of 1.66mm. The tripleband of 1x2 and 1x4 microstrip patch antenna array are designed for next generation wireless and satellite application by achieving a triple band in 3.6GHz, 5.2GHz and 6.7GHz and the main patch of the antenna is designed for 3.6GHz. The 1x2 array achieved gain of 7.75, 7.7 and 9.4 in dBi with bandwidths of 1.67%, 1.06% and 1.65% and for 1x4 array are 10.2, 8.2 and 10 are the gains in dBi with bandwidth of 1.67%, 1.45% and 1.05%. This antenna array can be used for advanced antenna beam steering systems.

Nikita Saxena (2018) explained about the design and analysis of multiband antenna for S and C band. The antenna is designed and analysed to obtain the multiband characteristics at 2.379GHz, 2.45GHz, 3.75GHz , 4.46GHz, 5GHz and

6.25GHz. The frequencies from 2GHz to 4GHz fall on S Band of radar frequency and antenna is designed in RT Duroid as a substrate with permittivity of 2.2 and four L shaped slots were cut from the surface of the patch to increase the surface current of the patch and gain of the antenna which is designed in CST Software and the S11 parameter obtained in all the six frequencies are below -10dB.

M. Sugadev (2017) explained about the antenna design with corporate feed based metamaterial antenna for wireless application. Coplanar waveguide fed antennas provide impedance matching for border frequency range. Along with CPW feed the design uses two annular rings for radiating layer and also uses split ring resonator elements for achieving metamaterial property. The antenna resonates in 2.8GHz and 4.8GHz with a maximum gain of 5.53dB and with an impedance bandwidth of 450MHz. The CPW method of feeding is used to provide good impedance matching and omnidirectional patterns.

Frequency and pattern reconfigurable rectangular patch antenna using single PIN diode has been explained by Anuradha A. Palsokar (2020). The antenna works in two different modes and resonates at 2.47GHz, 3.8GHz and 5.36GHz and to reduce the complexity of the biasing network single PIN diodes are used. The switching element is operated by a DC voltage and when the switch is in on state the inner rectangular patch is connected with the outer rectangular patch and in off state they both are disconnected. The antenna has a size of 66mm x 58mm and the size of the patch is 36mm x 25.2mm with a full port impedance of 50 Ohm.

A Compact multiband antenna for wireless and satellite communication by Pristin K Mathew (2014). The antenna consists of an array of rectangular slits with miniaturized wideband triple band frequency to operate at Industrial Scientific and Medical band, Wireless and satellite communication bands. Among the methods like transmission line model, cavity model the antenna is designed in transmission line model with an overall size of 12mm x 16mm with frequency centered at 5.5GHz in FR4 as substrate material and thickness of 1.6mm. Coaxially probe technique of radius 0.25mm is used for feeding the entire antenna is designed in CADFEKO

software. The designed antenna return loss less than -10db in all the three bandwidth achieved are 50MHz, 290MHz and 310MHz respectively with VSWR value less than 2 in all three bands.

Electromagnetic Band Gap structures in an microstrip patch antenna improves the performance of rf and microwave devices. By using the properties of surface wave suppression and artificial magnetic conductor it acts as a metamaterial. The development of EBG structures is more compactable with wide range of wireless communication system and the development of Electromagnetic Band Gap structures in microstrip patch antenna design is discussed by Md. Shahidul Alam (2013). To improve the performance of an antenna or any other microwave devices unipolar EBG structures can be used. EBG structures are also used to reduce the power loss through substrate of a conventional antenna. Most Commonly EBG Structures produces smoother radiation profile, lower back radiation, high gain and efficiency. Unipolar EBGs are framed by interconnecting unit cell on the top layer to match a high impedance surface. LC network is formed for specific frequency by EBG surface impedance.

A Miniaturized Antenna with high gain is very much required for satellite communication. To improve the gain by reducing the size of the antenna has been discussed by Zekui Zhang (2017). The Efficiency of the antenna obtained is 85.6% is due to fed by coupled microstripline. The improved gain of the antenna is 14.75dBi with frequency range of 4.93 GHz – 5.05GHz. The improved gain has been produced by the array structure of the antenna.

## **CHAPTER 3**

### **PROPOSED METHODOLOGY**

#### **3.1 PROPOSED SYSTEM**

When compared to other shapes in arrow shape patch high gain and directivity achieved easily due to its sharp edge in front end of the antenna and the proposed antenna also shows the high gain and directivity in real time this is mainly due to its arrow shape. This transceiver structure exhibits narrow band response due to the quality factor (Q) of the pointed patch antenna is high and in communication narrow band is preferred to achieve the high efficiency in transmission.

#### **3.2 ADVANTAGES**

- Bandwidth is High
- Gain is High
- Efficiency is 85%
- simple design structure
- SAR is zero

#### **3.3. HARDWARE REQUIRED**

- Substrate Material (FR4 Epoxy material)
- SMA connector (50 Ohm impedance)
- Copper (for patch and ground)
- Vector Network Analyzer.

### 3.4 CALCULATION

which causes pushing of some charges from the bottom, to the top of the patch. As a result of this charge movement, currents flow at the top and bottom surface of the patch. In this model, the interior region of patch is modeled as a cavity bounded by electric walls on the top and bottom, and magnetic wall all along the periphery. The fields in the interior region do not vary because the substrate is very thin. The cavity model assumes that the height to width ratio (i.e. height of substrate and width of the patch) is very small and as a result of this the attractive mechanism dominates and causes most of the charge concentration and the current to be below the patch surface. Much less current would flow on the top surface of the patch and as the height to width ratio further decreases, the current on the top surface of the patch would be almost equal to zero, which would not allow the creation of any tangential magnetic field components to the patch edges. Hence, the four sidewalls could be modeled as perfectly magnetic conducting surfaces.

This implies that the magnetic fields and the electric field distribution beneath the patch would not be disturbed. However, in practice, a finite width to height ratio would be there and this would not make the tangential magnetic fields to be completely zero.

Since the walls of the cavity, as well as the material within it are lossless, the cavity would not radiate and its input impedance would be purely reactive. Hence, in order to account for radiation and a loss mechanism, one must introduce a radiation resistance  $R_F$  and a loss resistance  $R_L$ . The quality factor is defined in terms of the ratio of the energy stored in the resonator to the energy supplied by a generator where the stored energy is constant with time. Higher  $Q$  indicates a lower rate of energy loss relative to the stored energy of the resonator. It is given by

$$Q = \frac{f_r}{\Delta f} \quad (1.2)$$

A lossy cavity would now represent an antenna and the loss is taken into account by the effective loss tangent  $d_{eff}$  which is given as,

$$d = 1/Q_T \quad (1.3)$$

$Q_T$  is the total antenna quality factor and has been expressed in the form

$$Q_T = Q_d + Q_c + Q_r \quad (1.4)$$

$Q_d$  Represents the quality factor of the dielectric and it is given as

$$Q_d$$

Where  $\omega_r$  is the angular resonant frequency

$W_T$  is the total energy stored in the patch at resonance.

$P_d$  is the dielectric loss.

$\tan d$  is the loss tangent of the dielectric.

$Q_c$  Represents the quality factor of the conductor and it is given as

$$Q_c = \frac{\omega_r W_T}{P_c} = \frac{h}{D} \quad (1.6)$$

$Q_r$  Represents the quality factor for radiation and it is given as

$$Q_r$$

Where  $P_r$  is the power radiated from patch.

$$\text{Hence } d_{eff} = \frac{h}{W_r W_r} \tan \delta + \frac{P_r}{\Delta} \quad (1.8)$$

The above equation describes the total effective loss tangent for Microstrip patch antenna.

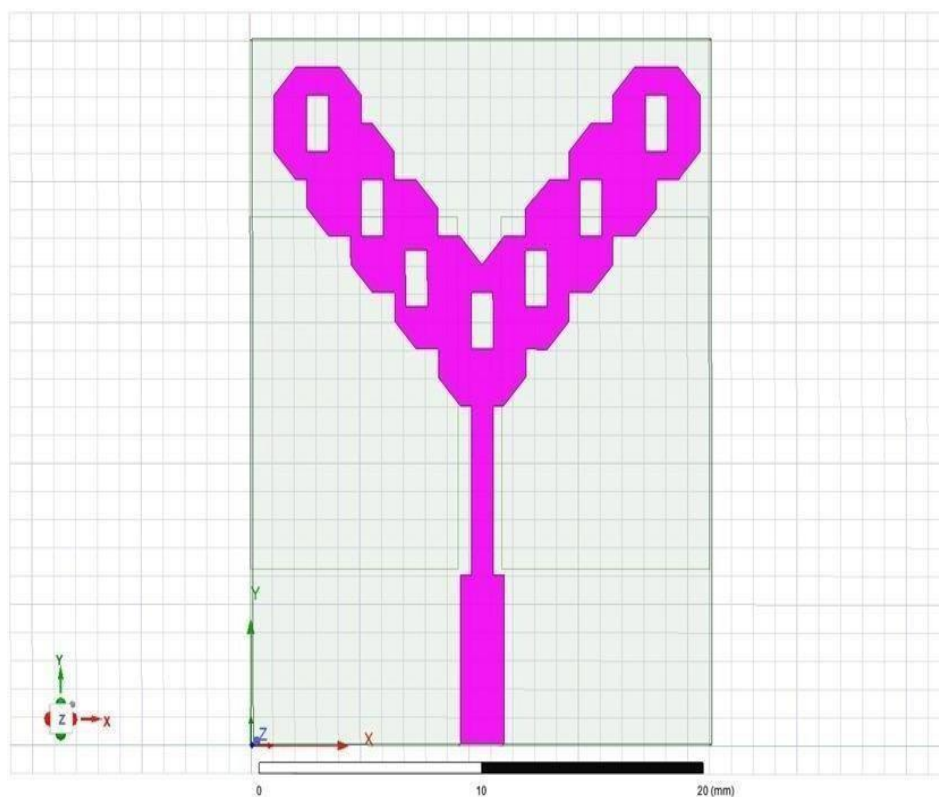
The micro-strip patch antenna plays a prominent role in communication systems in recent years because of these transceiver is the largest component in wireless communication systems now-a-days this wireless has become popular due to its ease of installation and without this transceiver help the communication is not possible. Among various types of antennas the micro-strip patch antenna took into an account in past few years due to its low profile structures and other advantages like it can be designed in different shapes with achieving very high efficiency with narrow bandwidth because in wireless communication narrow band is preferred not wide bandwidth. In this micro-strip patch antenna the substrate materials also plays the major role in transceiver operation in real time so in this letter focuses on material comparison by making comparative simulated results to show the importance of substrate material. In the next literature 5G application is taken into an account with operating in sub-6GHz band.

From the most of the other literature study of fifth generation (5G) applications only Millimeter waves is focused and designed the antenna and fabricated but on compared to mm waves the Sub-6GHz is preferred in recent years for the Sub-6GHz the operating frequency bandwidth falls between 3.4 to 3.6 GHz. In September 2015 the (ITU-R) International Telecommunication Union- Radio communications Standardization sector announced the service recommendation for the 5G mobile networks under the ITU std n77 for the IEEE std P 802.11 ax applications. Not like in past evaluation (i.e) in previous evaluation only the data rates is boosted and considered as advancement. Three categories are taken into an account in fifth generation they are enhanced mobile broadband (eMBB), massive machine type communication and ultra reliability & low latency communication. This paper mainly aims on mobile communication in fifth generation applications and the proposed

antenna resonates at sub-6GHz frequency for the IEEE std P 802.11 ax

applications, when compared to prior generation this coverage range is less .

### 3.5 ANTENNA DESIGN



*Fig.3.1*

The preferred models for the analysis of Microstrip patch antennas are the transmission line model, cavity model, and full wave model (which include primarily integral equations/Moment Method). The transmission line model is the simplest of all and it gives good physical insight but it is less accurate. The cavity model is more accurate and gives good physical insight but is complex in nature. A Microstrip antenna is a resonator type antenna. It is usually designed for single mode operation that radiates mainly linear polarization. For a circular polarization radiation, a patch must support orthogonal fields of equal magnitude but in-phase quadrature. This requirement can be accomplished by single patch with proper excitations or by an array of patches with an appropriate arrangement and phasing.

## CHAPTER 4

### SIMULATED AND RESULTS

#### 4.1 S PARAMETER

Return loss is the loss of power in the signal returned/ reflected by mismatch with the terminating load or with a device inserted in the line. Unit of return loss is decibels (dB).

An antenna's Return Loss is a figure that indicates the proportion of radio waves arriving at the antenna input that are rejected as a ratio against those that are accepted. It is specified in decibels (dB) relative to a short circuit.

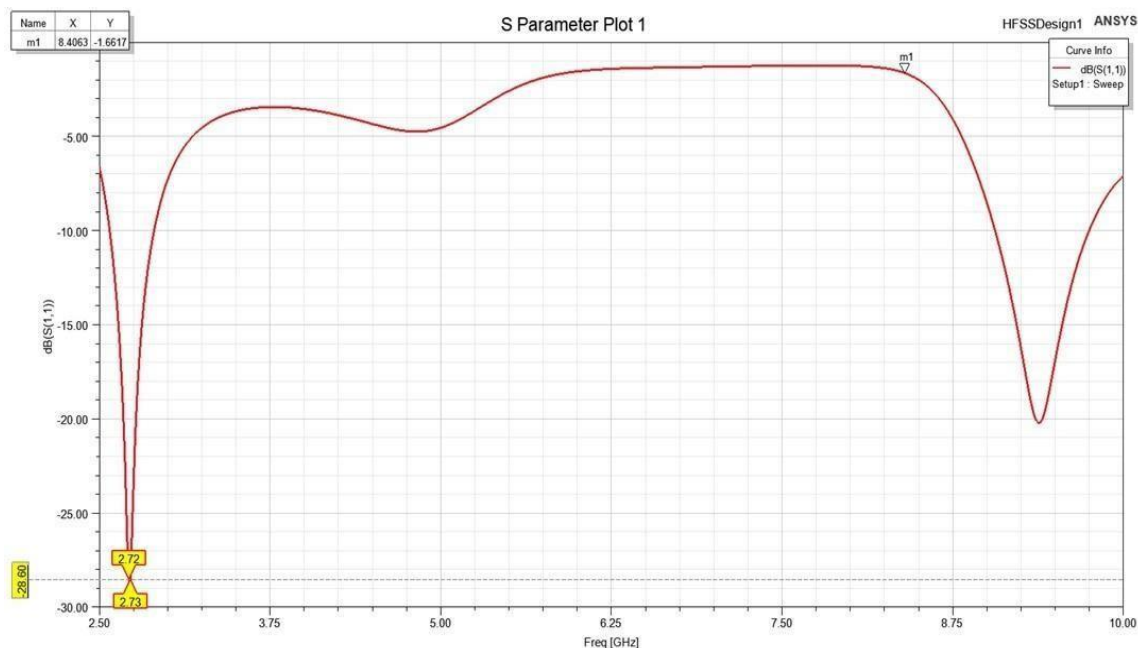
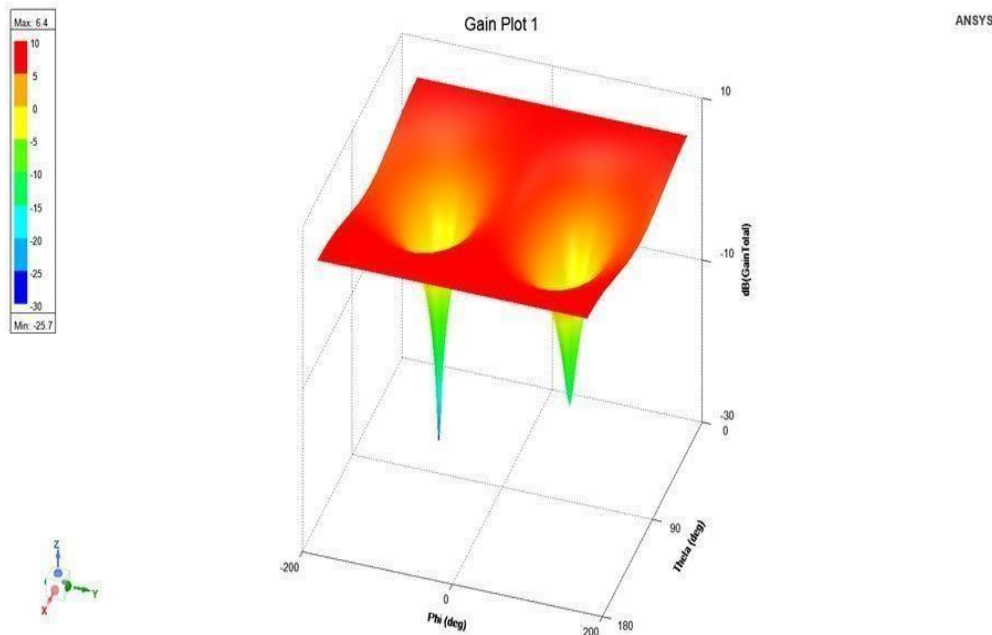


Fig 4.1

An antenna's Return Loss is a figure that indicates the proportion of radio waves arriving at the antenna input that are rejected as a ratio against those that are accepted. It is specified in decibels (dB) relative to a short circuit.

## 4.2 GAIN PLOT



*Fig.4.2*

The gain of an antenna is a measure of the ability of the antenna to focus the energy of the radiated signal in a particular direction. The gain of an antenna is measured in decibels (dB) relative to an isotropic radiator (i.e., an ideal antenna that radiates uniformly in all directions). A high gain antenna radiates more energy in a specific direction, while a low gain antenna radiates energy more uniformly in all directions. In a gain plot, the antenna gain is plotted as a function of radiation angle or direction. The radiation pattern of the antenna can be visualized by observing the shape of the gain plot. The radiation pattern shows how the antenna radiates energy in different directions. There are several types of gain plots, such as polar plots, rectangular plots, and Smith charts. Polar plots show the gain of an antenna in different directions, while rectangular plots show the gain of an antenna as a function of frequency. Smith charts are used to analyze the impedance of an antenna.

## 4.3 rE PLOT

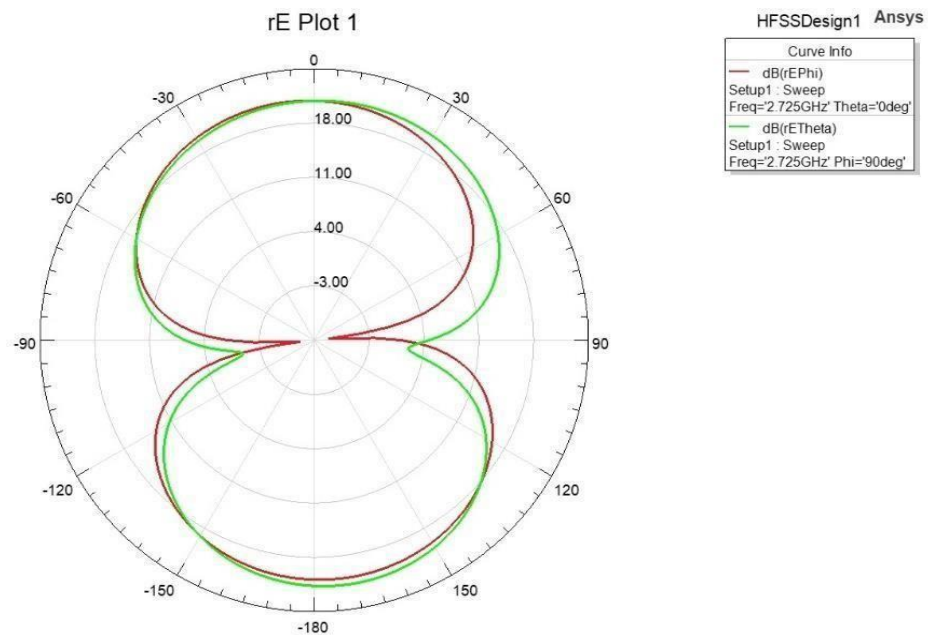


Fig.4.3

In antenna engineering, the "ER plot" refers to the Elevation Radiation Pattern plot, which is a graphical representation of the radiation pattern of an antenna in the vertical plane.

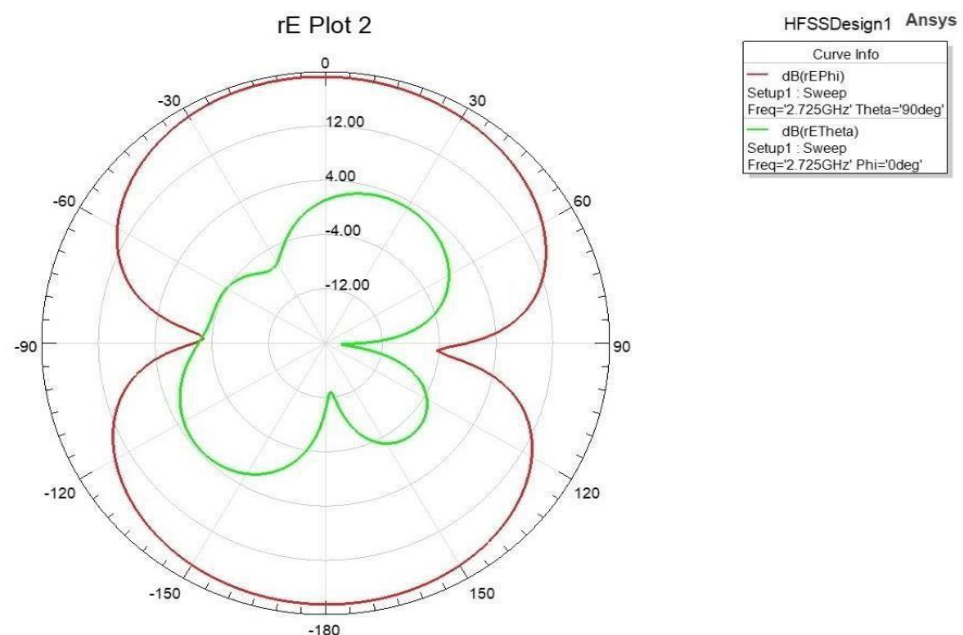


Fig 4.4

The Elevation Radiation Pattern plot shows how the radiation intensity of an antenna varies with elevation angle, which is the angle between the antenna's main beam and the horizontal plane.

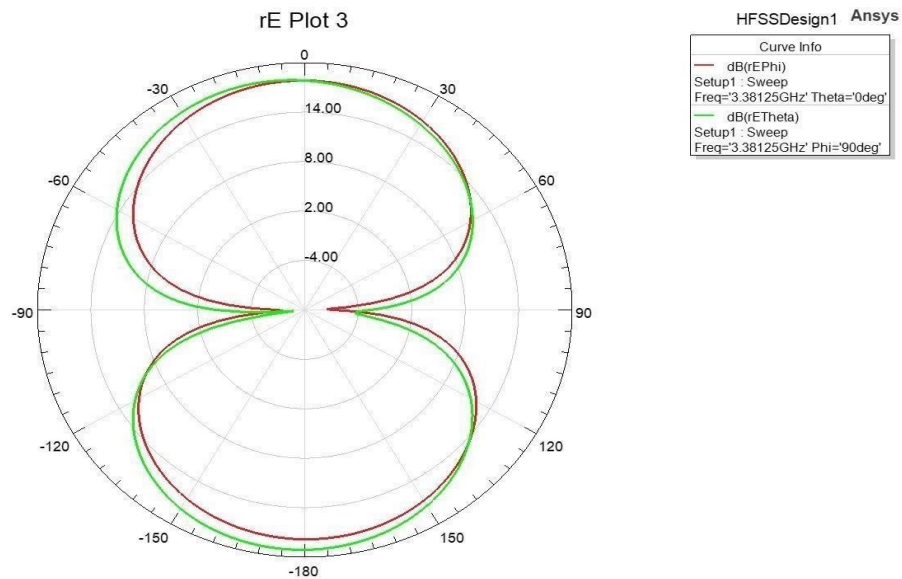


Fig 4.5

The plot is typically displayed in polar coordinates, with the elevation angle on the y-axis and the radiation intensity on the x-axis. The radiation intensity is often shown in decibels relative to the maximum radiation intensity in the direction of maximum gain.

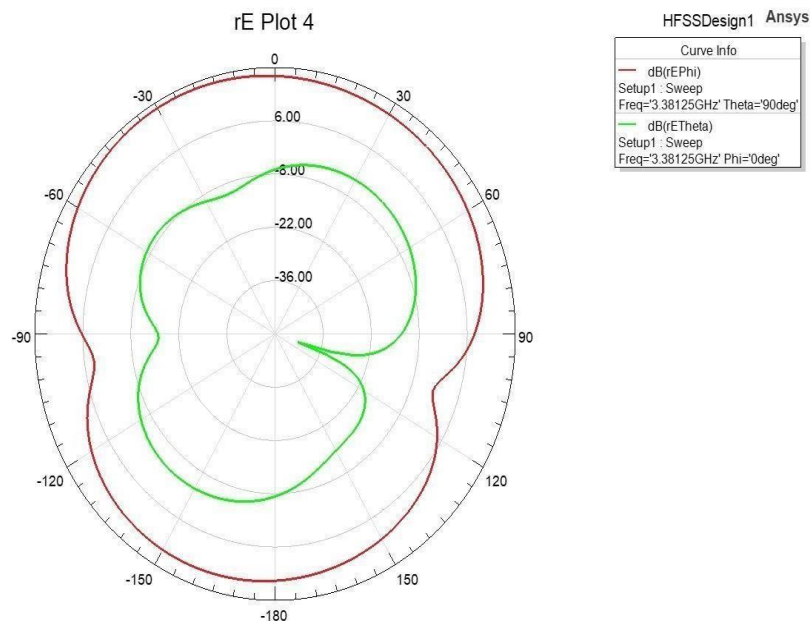
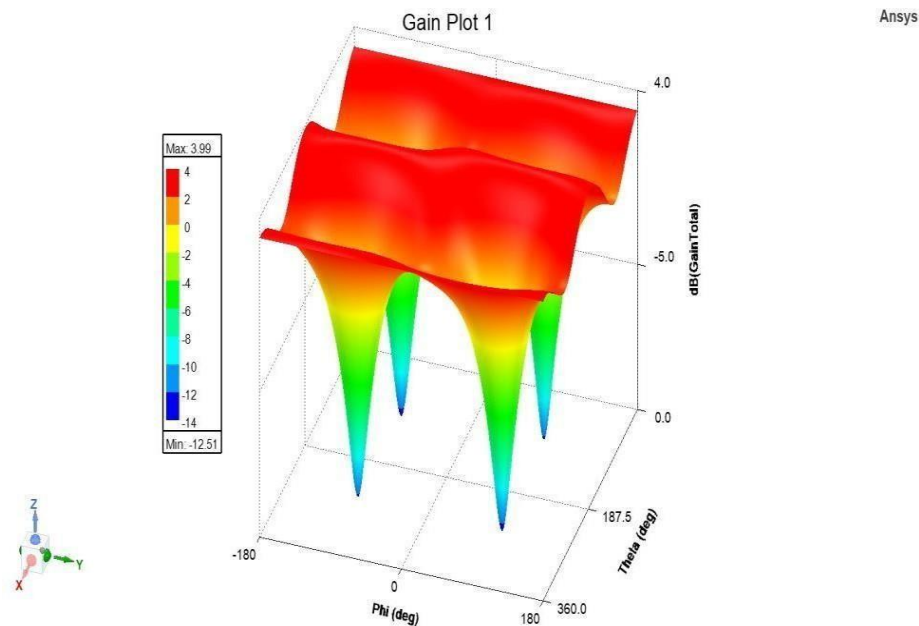


Fig 4.6

The ER plot is an important tool for analyzing and designing antenna systems, particularly for applications such as satellite communication and terrestrial radio communication, where it is important to know how the antenna will radiate energy in the vertical direction. The shape of the ER plot is determined by the antenna's design parameters, such as the size and shape of the radiating element and the feed mechanism used to excite the antenna.

#### 4.4 GAIN PLOT

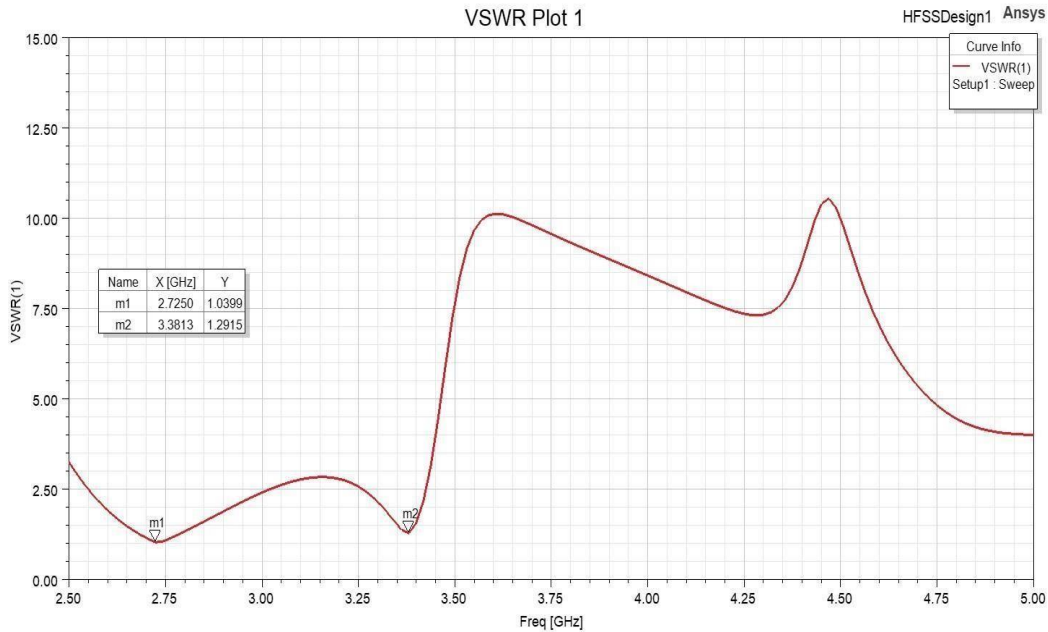


*Fig 4.7*

In antenna engineering, a gain plot is a graph that shows how the antenna's gain varies with frequency. The gain of an antenna refers to its ability to convert input power into radiated power in a particular direction. The gain of an antenna is usually expressed in decibels (dB) and is a measure of the antenna's directional efficiency. A gain plot typically consists of a graph with the frequency on the horizontal axis and the antenna gain (in dB) on the vertical axis. The gain plot can help engineers understand how the antenna will perform in different frequency bands and can be used to optimize the antenna design for a particular application. In general, the gain of an antenna increases with frequency up to a certain point, and then begins to decrease. This is due to a phenomenon called the antenna's "beamwidth," which is related to the size of the antenna and the wavelength of the signal it is transmitting or receiving. As the frequency increases, the wavelength decreases, which causes the beamwidth to narrow and the gain to increase. However, at very high frequencies, the antenna becomes too small relative to the wavelength, and the gain begins to decrease.

## 4.5 VSWR

Fig 4.8



VSWR stands for Voltage Standing Wave Ratio, which is a measure of the impedance mismatch between a transmission line or cable and an antenna or other load. VSWR is an important parameter in radio frequency (RF) engineering because it affects the amount of power that can be delivered to the load and the efficiency of the transmission system.

When an RF signal is transmitted from a source to a load through a transmission line, the impedance of the line and the load should match for maximum power transfer. If there is a mismatch between the line and the load, some of the signal is reflected back toward the source, creating standing waves along the transmission line. The ratio of the maximum voltage to the minimum voltage along the transmission line due to these standing waves is known as VSWR. VSWR is typically expressed as a ratio, such as 1.5:1 or 2:1, and it indicates how much power is reflected back to the source. A VSWR of 1:1 would indicate a perfect match between the transmission line and the load, while a VSWR of 2:1 would indicate that half of the transmitted power is being reflected back to the source.

In practice, VSWR is measured using a VSWR meter or network analyzer, which can measure both the forward and reflected power along the transmission line. By measuring the ratio of these two powers, the VSWR can be determined.

## CHAPTER 5

## **CONCLUSION**

Designing a log-periodic patch antenna for the 1GHz - 5GHz frequency band can be a challenging task, as the antenna must be able to operate efficiently over a wide range of frequencies. However, by carefully selecting the dimensions and layout of the antenna elements, it is possible to create an antenna with good impedance matching and radiation patterns across the desired frequency range.

The log-periodic patch antenna is a popular choice for broadband applications because of its ability to provide good impedance matching and directional performance over a wide frequency range. The antenna consists of a series of patch elements of varying sizes, arranged in a logarithmic pattern to provide continuous coverage over the desired frequency band.

In the design process, several parameters must be optimized, including the size and spacing of the patch elements, the feed network, and the substrate material. The design must also take into account the effects of edge diffraction and the proximity of the feed network to the patch elements.

Once the antenna design is complete, it can be tested using simulation software and/or physical measurements to verify its performance. The final design should provide good gain, low VSWR, and a stable radiation pattern across the desired frequency range.

In conclusion, designing a log-periodic patch antenna for the 1GHz - 5GHz frequency band requires careful attention to the dimensions, layout, and substrate properties of the antenna elements. With the proper design and optimization techniques, it is possible to create an antenna that provides good impedance matching and directional performance over a wide frequency range.

## **REFERENCES**

- [1] Archana Agrawal, Pramod Kumar Singhal and Ankit Jain, "Design and optimization of a microstrip patch antenna for increased bandwidth", International Journal of Microwave and Wireless Technologies, 2013, 5(4), 529-535,

doi:10.1017/S1759078713000160.

[2] Biswas M, Dam M (2018). "Closed-form model to determine the co-axial probe reactance of an equilateral triangular patch antenna". International Journal of Microwave and Wireless Technologies 1-13, <https://doi.org/10.1017/S1759078718000661>.

[3] Colaco, J., & Lohani, R. (2020). Design and Implementation of Microstrip Patch Antenna for 5G applications. 2020 5th International Conference on Communication and Electronics Systems (ICCES). doi:10.1109/icces48766.2020.9137921.

[4] Daniel Minoli and Benedict Occhiogrosso, "Practical Aspects for the Integration of 5G Networks and IoT Applications in Smart Cities Environments", Hindawi Wireless Communications and Mobile Computing Volume 2019, Article ID 5710834, 30 pages <https://doi.org/10.1155/2019/5710834>.

[5] Jaget Singh, "Inset Feed Microstrip Patch Antenna", International Journal of Computer Science and Mobile Computing, Vol.5 Issue.2, February- 2016, pg. 324-329.

[6] Greeshma K V, 5G – "Future of Mobile Internet", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Published by, [www.ijert.org](http://www.ijert.org), NSRCL-2015 Conference Proceedings, Volume 3, Issue 28.

[7] Madhusudhan K, Divya Nayak, Harshitha M, Maneesha S, Akash C C, "Comparison of Probe feed and Proximity coupled feed technique for Rhombus Shaped Antenna", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181 Published by, [www.ijert.org](http://www.ijert.org), ICRTT - 2018 Conference Proceedings, Volume 6, Issue 15.

[8] M. Meena and P. Kannan, "ANALYSIS OF MICROSTRIP PATCH ANTENNA FOR FOUR DIFFERENT SHAPES AND SUBSTRATES", ICTACT JOURNAL ON

MICROELECTRONICS, APRIL 2018, VOLUME: 04, ISSUE: 01, ISSN: 2395-1680 (ONLINE) ICTACT JOURNAL ON MICROELECTRONICS, APRIL 2018, VOLUME: 04, ISSUE: 01, DOI: 10.21917/ijme.2018.0092.

[9] M.Sugadev, Dr.E.Logashanmugam, "A compact multiple slot microstrip antenna

for modern wireless communications, International conference on Control Instrumentation Communication and Computational Technologies, ICCICCT 2016, pp. 805- 808, December 2016.

[10] M.Sugadev and Logashanmugam E, “High Gain Multiband Stacked DRA for WiMax and WLAN Applications”, American Journal of Applied Sciences, Vol.14, No.8, August 2017, pp. 779-785.

[11] M.Sugadev, E.Logashanmugam, “ Corporate feed based Metamaterial antenna for wireless applications, Cluster Computing, Vol.21, 2018, pp.125-134.

[12] M. Vinoth, J. Belbin Lijjo, S. Allen, Dr. M. Sugadev, “Design and Analysis of Insert- fed Reconfigurable Antenna for 5g (sub-6ghz) applications”, Solid State Technology Volume: 63 Issue: 6 Publication Year: 2020, pp 5509-5519.

[13] M Vinoth\* , Dr. AL.Vallikannu, “A compact Inset Fed Microstrip Patch Antenna with Defected Ground Structure for Sub-6 GHz / 5G applications”, Solid State Technology Volume: 63 Issue: 5 Publication Year: 2020, pp 2468-2477.

