

A High Directive Pointed Shaped Patch Antenna for IEEE P802.11 ax standard applications

Submitted in partial fulfilment of the requirements of the award of
Bachelor of Engineering Degree in Electronics and Communication Engineering

By

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SATHYABAMA

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

Accredited with grade “A” by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **BELBIN LIJJO J (37130051)** and **RAHUL V (37130334)** who carried out the project entitled "**A HIGH DIRECTIVE POINTED SHAPED PATCH ANTENNA FOR IEEE P802.11 ax STANDARD APPLICATIONS**" under our supervision from September 2019 to April 2020.

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DECLARATION

We, **BELBIN LIJJO J (37130051)** and **RAHUL V (37130334)** hereby declare that the Project Report entitled "**A HIGH DIRECTIVE POINTED SHAPED PATCH ANTENNA FOR IEEE P802.11 ax STANDARD APPLICATIONS**" done by us under the guidance of **Dr.M.Sugadev.** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

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Abstract

It is important to design the micro-strip patch antenna to fulfill the ever increasing need for wireless communication systems and the main aim of this paper is to simulate an arrow shaped patch antenna to operate in fifth generation wireless communication by designing in transmission line mode and it is entrenched with square substrate by using the FR4 material with dielectric constant of 4.4 and the presented antenna is resonated exactly at 3.5 GHz frequency which comes under *IEEE standard P802.11 ax & ITU n77*. The corresponding S parameter of presented antenna is -25 dB and achieving it in compact size, so the dimension of the antenna is 35.6 X 35.6 mm² with maximum gain of 4.5 dB. The proposed transceiver prototype has been designed and analyzed using HFSS software which gives accurate simulated values in all antenna parameters.

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CHAPTER 1

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, add 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

- Small Size
- 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. These antennas 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.

1.3.2 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 corner reflector, 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.

1.3.3 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.

1.3.4 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 very practical 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.

1.4.1 Radiation Pattern

The radiation pattern is the graphical and mathematical representation of radiation properties of an antenna as a function of space coordinate.

1.4.2 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.

1.4.3 Effective Aperture

The Effective Antenna aperture 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 polarization matched of the antenna as shown in eqn. 1.1

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

1.4.4 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.

1.4.5 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

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

1.4.6 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.

1.4.7 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.

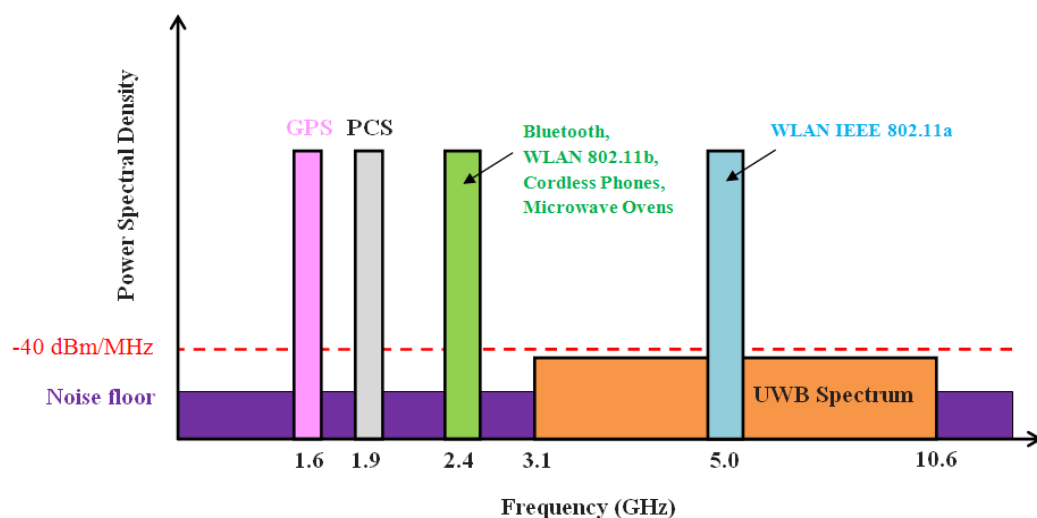


Fig 1.1 General Communication Band systems

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), microwave techniques, and 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 the 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-ported 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.

1.8.2 Directional Antenna

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.

1.8.3 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.

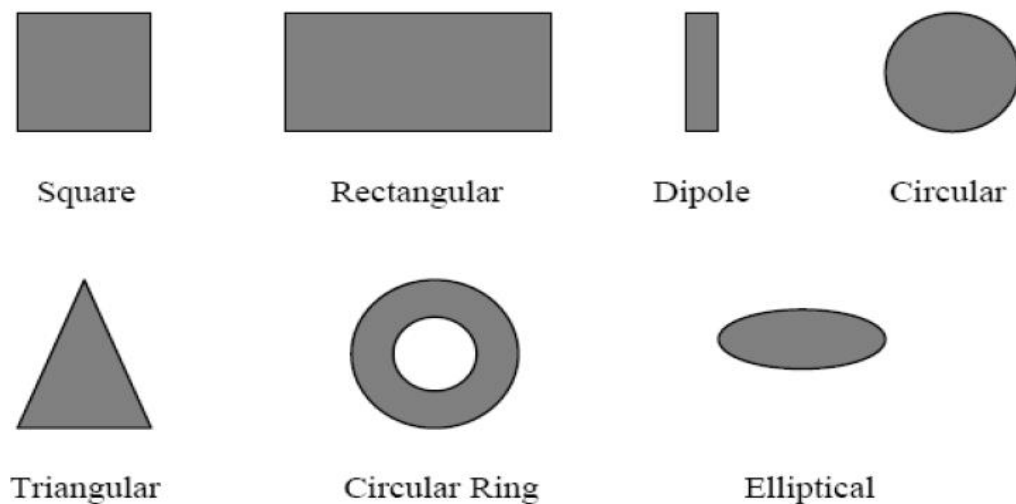


Fig 1.2 Different shapes of patches

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 (ϵ_{reff}) must be obtained in order to account for the fringing and the wave propagation in the line.

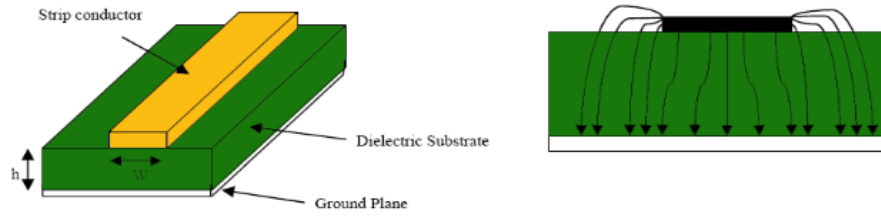


Fig. 1.3 Microstrip line and Electrical field line

The value of ϵ_{reff} is slightly less than ϵ_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 ϵ_{reff} is given by Balanis as:

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{w} \right]^{-1/2}$$

(1.1)

Where

ϵ_{reff}	=	Effective dielectric constant
ϵ_r	=	Dielectric constant of substrate
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.

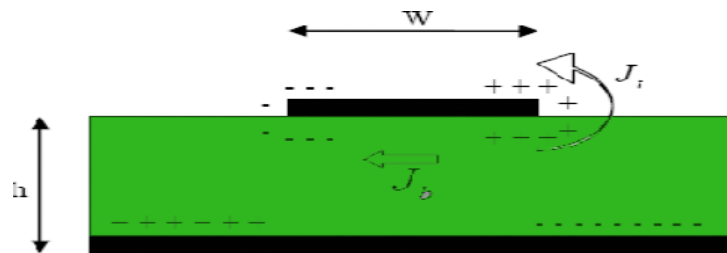


Fig. 1.4 Cavity Model

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, 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 δ_{eff} which is given as,

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

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

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

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

$$Q_d = \frac{\omega_r W_r}{P_d} \quad (1.5)$$

Where ω_r is the angular resonant frequency

W_r is the total energy stored in the patch at resonance.

P_d is the dielectric loss.

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

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

$$Q_c = \frac{\omega_r W_r}{P_c} = \frac{h}{\Delta} \quad (1.6)$$

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

$$Q_r = \frac{\omega_r W_r}{P_r} \quad (1.7)$$

Where P_r is the power radiated from patch.

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

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 because frequency is inversely proportional to wavelength. In the upcoming literature the shape of the patch is taken into an account and its role in function of antenna.

A micro-strip patch antenna is made up of radiating plate which is called as patch and this patch may be in different shapes such as in square, rectangular, circular and triangular. This patch in the antenna is going to acts as the radiating element and the material used in patch and ground are same either copper or gold.

The antenna can be in 3D structure so this is referred as planar antenna. This radiating element (patch) in antenna radiates the energy from the current as electromagnetic waves and the proposed antenna patch is designed in arrow shape with good performance rate in real time. 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 presented arrow shaped patch antenna is resonated exactly at 3.5 GHz frequency due to its L shaped near to the feed line which cut in 90° in both side of the feed. 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. The radiation characteristics of an regular triangular micro-strip antenna have been reported in 1998 and in recent 30° - 60° - 90° shaped triangular patch antenna is reported in cavity model. Most of the literature study is focused only on square, rectangular and also circular shape patch but this paper shows the best proof and study in arrow patch antenna .The impedance of this presented arrow shaped patch antenna is matched by designing it in strip line feeding yes the feed line of the patch antenna plays prominent role in impedance matching of the particular device.

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 ever increasing 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 size of 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 6x6 array 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 14.63GHz there is no gain, by changing the feeding location and by adding triangle and rectangle shapes to 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 operation.

Touko Tcheutou Stephane Borel (2019) explained about the design of rectangular patch array antenna for satellite communication. Small sized patch array antenna is

used widely in satellite communication because of its advantages when compared to conventional antennas. A linear 2x2 array antenna is designed with exactly resonators in 12GHz with a bandwidth of 693.2MHz with thickness of 1.6mm. The efficiency of the antenna designed is equal to 83% since the gain and directivity obtained are 8.98db and 10.83db respectively. This antenna is designed in High Frequency Structure Simulator software for satellite communication, X band application and Ku band application. One of the significant advantages of array antenna is that direction of maximum radiation can be used for beam scanning. 40 x 30 mm² are the dimensions of the array antenna designed for satellite communication.

The antenna is designed in HFSS software in FR4 epoxy as a substrate Material with dimensions of 42 x 30 x 1.6 mm³. 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 $L=W=33.7\text{mm}$ 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 shaped defected 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. $40\text{mm} \times 50\text{mm} \times 10\text{mm}$ are the parameters of the designed array antenna.

A compact triple slotted Rectangular Microstrip Patch Antenna with Metamaterial ground for 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 by Different RMPA architectures to realize an antenna to operate in sub-6 GHz for 5G communications. The modified RPA with a Triple Slotted in patch without altering the dimension resonates at 3.5GHz with good return loss performance of -30.77 dB and gain of 5 dB . The dimension of compact TSRMPA with MTM ground is $30.2 \times 36.4\text{ mm}^2$. 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° to 48° 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° 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 8×2 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 95%. U slot parameters are used to achieve wide bandwidth and the coaxial fed rectangular patch antenna is printed on Rogers RT/Duroid substrate with thickness of 3.175mm and permittivity of 2.2. The Length and width of the antenna is 67 x 74mm.

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 triple band 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 from 5GHz to 6.25GHz fall on C Band. The 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 a broad 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 at 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 resonating frequencies of 2.48GHz, 5.72GHz and 6.26GHz and the 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 microstrip line. The improved gain of the antenna is

14.75dBi with frequency range of 4.93 GHz – 5.05 GHz. 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 SUBSTRATE MATERIAL

FR4 epoxy glass substrates are the material of choice for most PCB applications. The material is very low cost and has excellent mechanical properties, making it ideal for a wide range of electronic component applications. As more and more microwave systems aimed at consumer

markets are developed, there is a considerable interest in minimising the cost of these systems. Substantial cost savings could be realised by using FR4 in place of costly PTFE based substrates for microwave circuits and antennas. This paper describes a programme of work which has been undertaken at ERA Technology, as part of its Membership Research Programme, to evaluate the characteristics of this material at microwave frequencies between 1 GHz and 15 GHz. It is concluded that the use of FR4 is unlikely to be viable for antenna feeding structures due to its high losses. However, for high density microwave circuits where path lengths are short and for broadband antenna elements, where losses and absolute dielectric constant values are less critical, the material could be used in place of more conventional microwave substrate materials, offering significant cost savings. To provide the high-speed network environment in order to cope with a large volume of data, a multilayer PCB that can transfer digital signals at high speed in the high frequency domain is needed. The FR-4 substrate is applicable to network equipment with low dielectric loss and low permittivity.

3.5 SMA CONNECTOR

The SMA connector is a semi-precision sub-miniature RF and microwave connector that is extensively used, especially for RF connections within electronic systems for frequencies up to 18 GHz and sometimes more.

The SMA connector comes in a variety of formats, male, female, straight, right-angled, bulkhead fitting and many more enabling it to meet most requirements. Its sub-miniature size also enables it to be used, even within relatively small items of electronic equipment.

Although now well established, the SMA connector is likely to see its use extended as many new RF systems see their operating frequencies extending well into the microwave region.

SMA connectors are designed to have a constant 50-ohm impedance across the connector. The SMA connectors were originally designed and specified for operation up to 18 GHz, although some versions have top frequencies of 12.4

GHz, some less and some are specified up to 24 or 26.5 GHz. The higher frequency top limits may need to operate with a higher return loss. The SMA connector uses a 1/4-inch diameter, 36-thread-per-inch threaded barrel.

Different Connectors:



Fig 3.1 SMA Connector

3.6 VECTOR NETWORK ANALYSER:

A Vector Network Analyzer contains both a source, used to generate a known stimulus signal, and a set of receivers, used to determine changes to this stimulus caused by the device-under-test or DUT.

The stimulus signal is injected into the DUT and the Vector Network Analyzer measures both the signal that's reflected from the input side, as well as the signal that passes through to the output side of the DUT. The Vector Network Analyzer receivers measure the resulting signals and compare them to the known stimulus signal. The measured results are then processed by either an internal or external PC and sent to a display.

Vector Network Analyzer's perform two types of measurements – transmission and reflection. Transmission measurements pass the Vector Network Analyzer stimulus signal through the device under test, which is then measured by the Vector Network Analyzer receivers on the other side. The most common transmission S-parameter measurements are S₂₁ and S₁₂ (S_{xy} for greater than 2-ports). Swept power measurements are a form of transmission measurement. Some other examples of transmission measurements include gain, insertion loss/phase, electrical length/delay and group delay. Comparatively, reflection measurements measure the part of the VNA stimulus signal that is incident upon the DUT, but does not pass through it.



Fig 3.2 Vector network analyser

3.7 SOFTWARE:

Ansys HFSS is a 3D electromagnetic (EM) simulation software for designing and simulating high-frequency electronic products such as antennas, antenna arrays, RF or microwave components, high-speed interconnects, filters, connectors, IC packages and printed circuit boards. Engineers worldwide use Ansys HFSS to design high-frequency, high-speed electronics found in communications systems, radar systems, advanced driver assistance systems (ADAS), satellites, internet-of-things (IoT) products and other high-speed RF and digital devices.

HFSS (High Frequency Structure Simulator) employs versatile solvers and an intuitive GUI to give you unparalleled performance plus deep insight into all your 3D EM problems. Through integration with Ansys thermal, structural and fluid dynamics tools, HFSS provides a powerful and complete Metaphysics analysis of electronic products, ensuring their thermal and structural reliability. HFSS is synonymous with gold standard accuracy and reliability for tackling 3D EM challenges by virtue of its automatic adaptive meshing technique and sophisticated solvers, which can be accelerated through high performance computing (HPC) technology.

The proposed wearable microstrip patch antenna is simulated using the ANSYS EM suite version 20 which is described above in detail and in the next part the simulated WMSPA is place and given some detailisation on the design and done analysis in the proposed design.

3.8 ANTENNA DESIGN

In the modern era communication the wireless type of communication is taken into a picture as the name spec “wireless” so the info is communicated with help of radio frequency (RF) and at present this scenario plays the prominent role. In the modern wireless communication the RF equipment plays the key role so the most important RF equipment is patch antenna which is going to act as the transceiver. Now in this letter MSPA is taken into the picture so it is mandatory to discuss some points on the MSPA. Any how this MSPA is invented between the 1950's-1970's this patch antenna is emerged in recent years only and also attracted the attention of the researchers & research scholars towards it side. The one reason in initial stages all people have seen only its drawback and only in recent years they have studied the advantage of it and come to know that in future it will rule the communication field as it is playing the prominent role & ruling the modern wireless communication. Have to undergo various optimization & techniques to be implemented to achieve the certain goal in MSPA. From various techniques here in this letter only array technique in MSPA is taken into the picture because the presented simulated antenna is implemented with the array technique and achieved the better performance by resonating at 3.5 GHz (Sub-6 GHz) frequency application. In common the term array is the group or combination in the simulated design the combination of radiating patch built on the single FR4 dielectric material so the simulated MSPA is termed as linear 3x3 array MSPA with the help of this technique beam steering in MSPA can be done by steering beam of the radiating signal from the combination so the directivity of the MSPA is increased by suppressing the interference and avoiding the signal overlapping. Next important criteria to be taken in to the picture is application, in this letter the presented simulated Array MSPA plays the prominent role in Sub-6 GHz frequency band which covers the Fifth generation LTE band for the modern wireless communication. The international standard for the resonated frequency of the presented Array MSPA is IEEE standard P802.11 ax & ITUn77. A year before there is only one promising spectrum for the 5G wireless communication that is mm waves in recent days the other promising

spectrum is added that is the Sub-6 GHz frequency band so hereby the presented Square Patch Linear 3X3 Array MSPA is for 5G wireless Application.

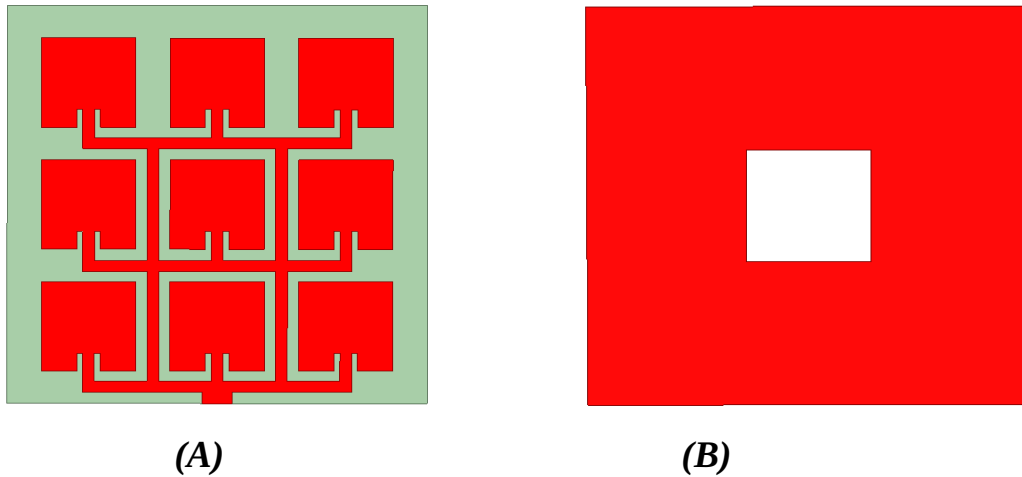


Figure 3.3 Represent the array antenna (A) Patch (B) Ground

On entering into the design analysis part of the antenna mainly considered the modes of design and feed of the patch antenna. In micro-strip patch antenna there are two modes of design the first one is transmission mode of design and second one is cavity resonator mode of design in patch antenna. Most of the antennas are designed only in transmission line mode design of antenna because it gives the high accuracy. The main advantages of the transmission line mode antenna design is can easily achieve narrow bandwidth with very high efficiency both in transmission and working in real time and power consumption of the transmission mode of antenna is very low because by achieving narrow bandwidth in wide bandwidth more amount of power is required so in this proposed antennas power consumption rate is low because proposed antenna is designed in transmission line mode. In transmission line mode only full duplex antenna is used so this proposed antenna is acts as the transceiver with obtaining output value in high accuracy.

In micro-strip patch antenna feed plays a prominent role, so it is designed carefully. This feed is used to match impedance of the antenna and helps to radiate the signal from the antenna. The return loss of antenna is controlled by proper impedance matching of feed line and patch. There are four different types of feeding techniques can be used in the micro-strip patch antenna design such as co-axial probe feed, inset feed, aperture coupling, proximity coupling. On compared to this four types

inset feeding technique is preferred because it is easy to fabricate, so there will be no issues or loss in the real time working of the antenna, Impedance of patch varies with feeding location and various antenna performance parameters can be controlled by proper feeding technique and its location.

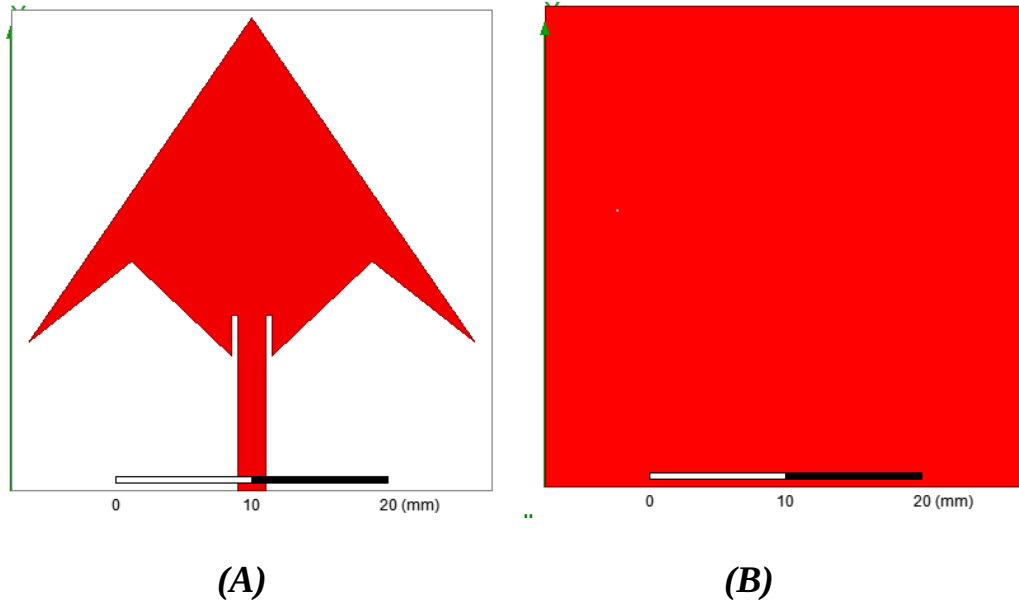


Figure 3.4 Represent the proposed antenna (A) Patch (B) Ground

The figure 1 represents the proposed design of arrow patch antenna it is built using the substrate material called FR4 epoxy with dielectric constant of 4.4. In this proposed antenna design the shape of the radiating element is triangular and achieved with the high gain. The frequency of this antenna resonates at the 3.5 GHz so the application of this proposed triangular shaped antenna is 5G and operating in Sub-6-GHz band with high performance efficiency in real time. The novel triangular shaped patch antenna is analyzed in full ground using the HFSS software which shows the high accurate results in simulation. This obtained value shows the great accuracy where it is discussed in upcoming literature sections. From the figure 1 it shows that strip line feed is used to match the impedance for the presented triangular shaped antenna and also shows the two L shaped cut at 90° which play's a prominent role in exact frequency resonance at 3.5 GHz of proposed antenna.

CHAPTER 4

RESULT AND ANALYSIS

In this section various parameters of proposed triangular shaped patch antenna is discussed & analyzed by simulating it with the help of HFSS software so this literature section will gives the detail analysis in results with very high accuracy.

4.1 RETURN LOSS

The return loss of designed antenna should remain at negative values, so the designed antenna has low range of signal reflection. The proposed Array antenna and triangular shaped designed antenna is showing active response in frequencies centered at 3.5 GHz with corresponding return loss of -18.5dB in array structure and -25.2 dB in triangular shaped structure. The obtained return loss values proposed antenna is falls in negative so the designed triangular shaped patch antenna has low range of signal reflection in transmission.

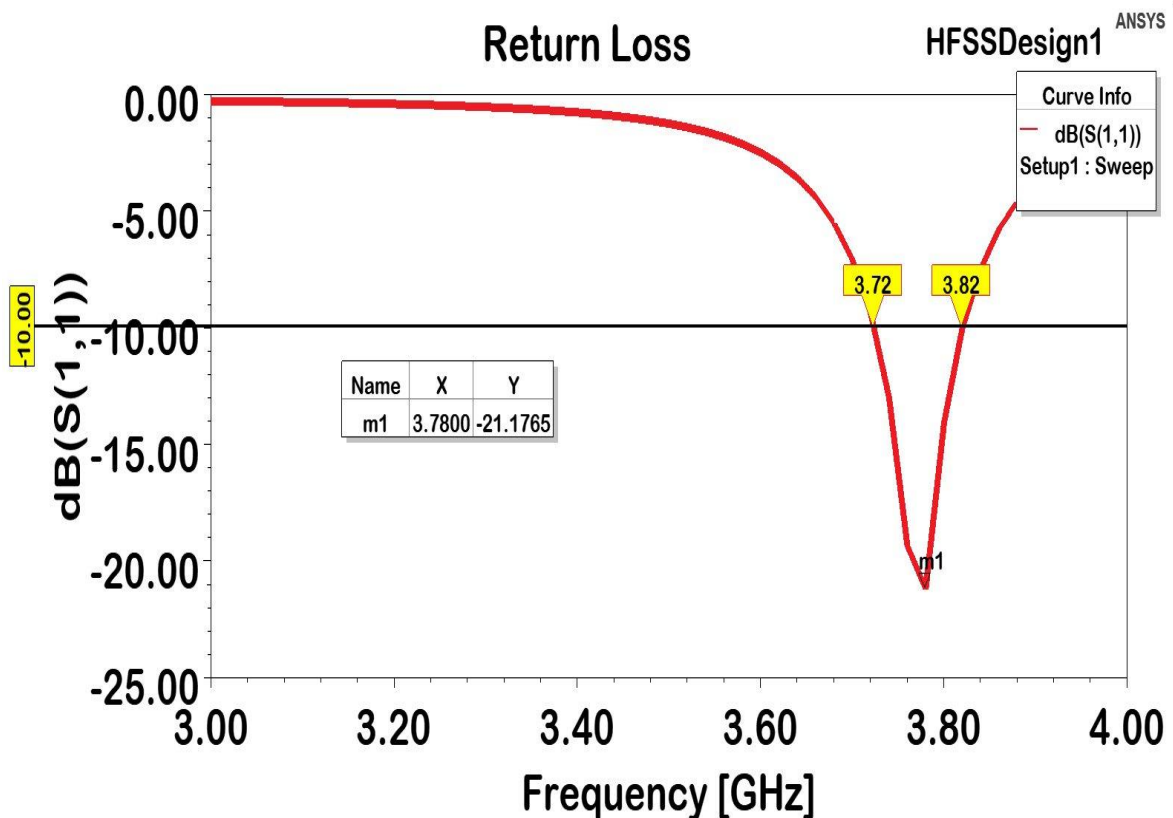


Figure 4.1 Return loss of array structure

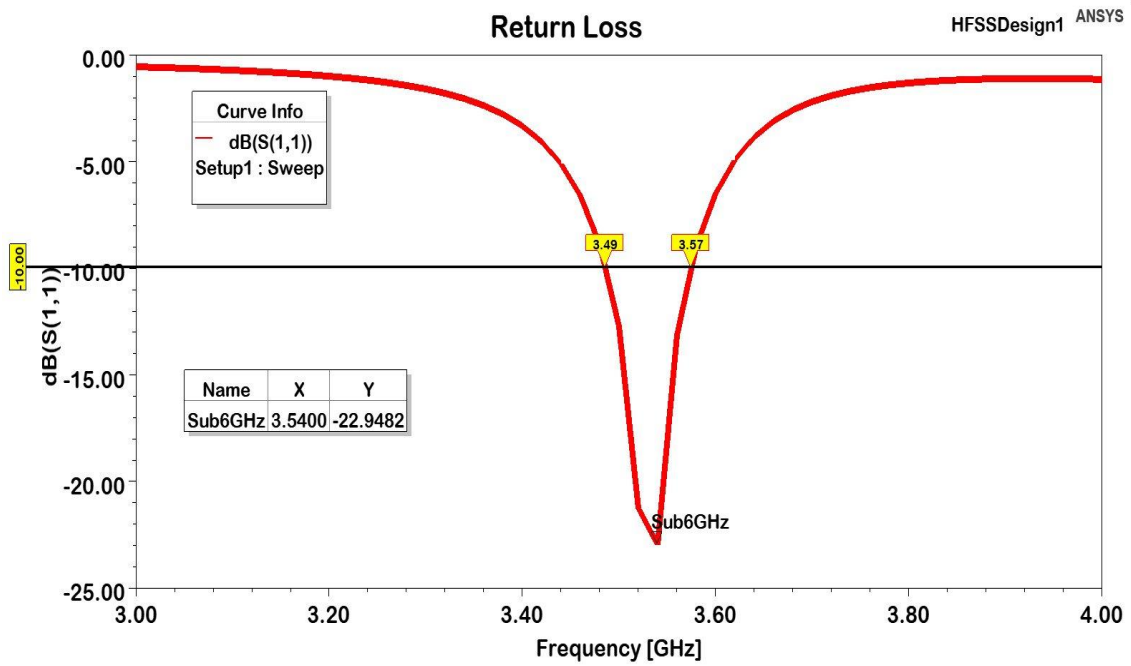


Figure 4.2 Return loss of triangular shaped structure

4.2 VSWR

The VSWR of the designed array antenna and triangular shaped patch antenna lies near to unity so it proves that given input signal is completely radiated by the antenna without any reflection and it The observed VSWR value describes that proposed antenna is impedance matched to the transmission line.

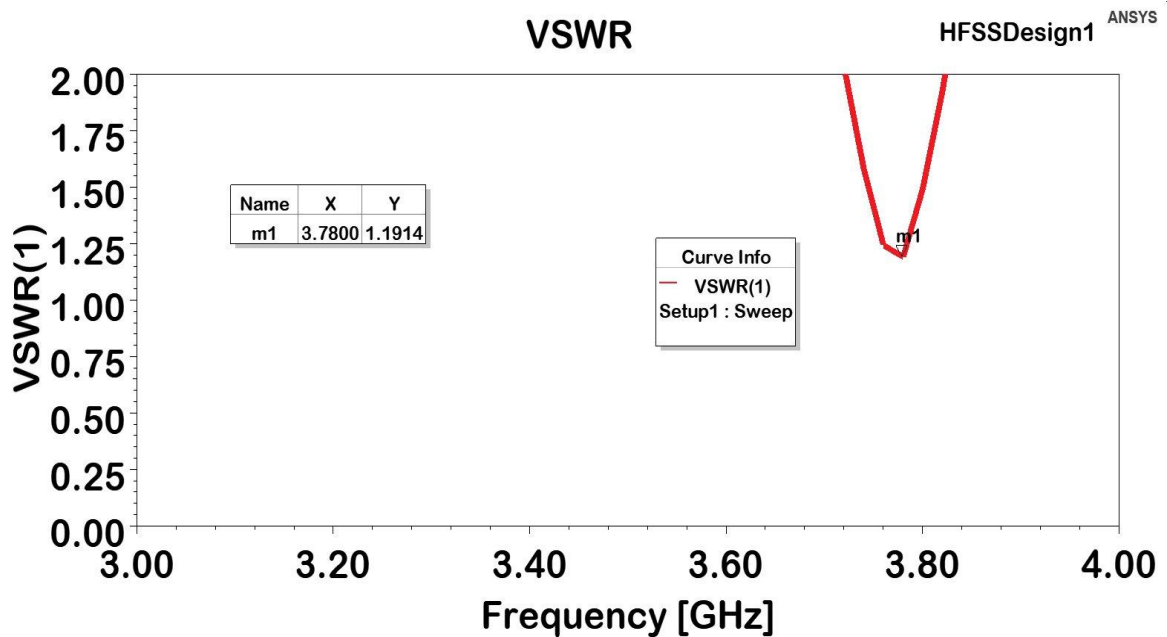


Figure 5.3 VSWR of array structure

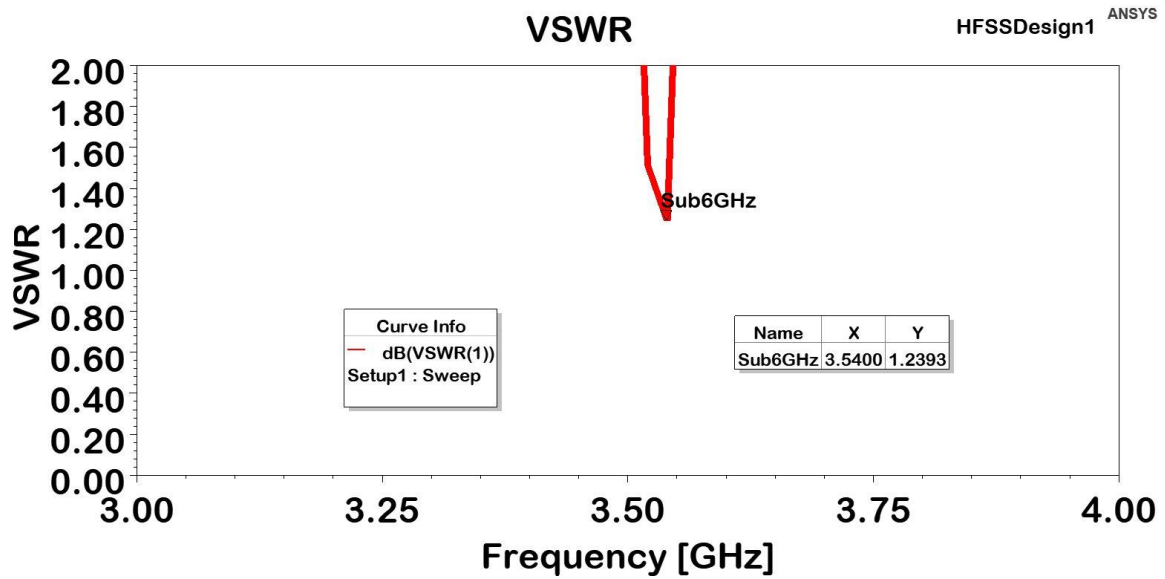


Figure 4.4 VSWR of triangular shape antenna

4.3 IMPEDENCE PLOT

The impedance plot is a tool for visualizing the impedance of a transmission line antenna system as a function of frequency. It simultaneously display various parameters including impedances (Z-parameters), admittances (y-parameters), reflection coefficients and it act as a tool for visualizing the impedance of a transmission line antenna system as a function of frequency. The Y parameters, Z parameters, reflection coefficient proposed design is plotted in the smith chart and analyzed.

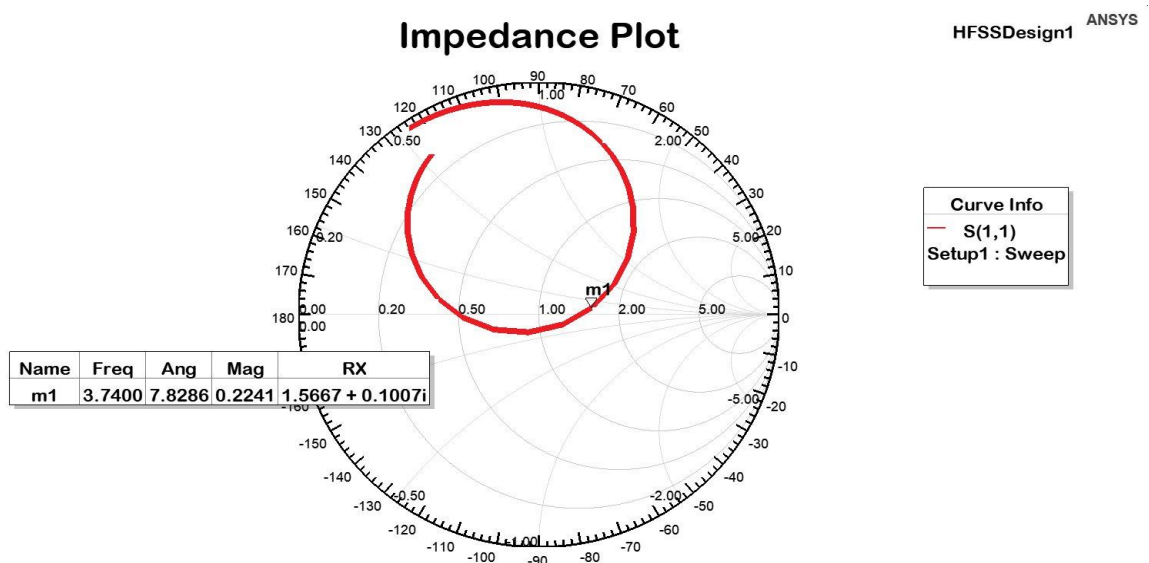


Figure 4.5 Impedance plot of array antenna

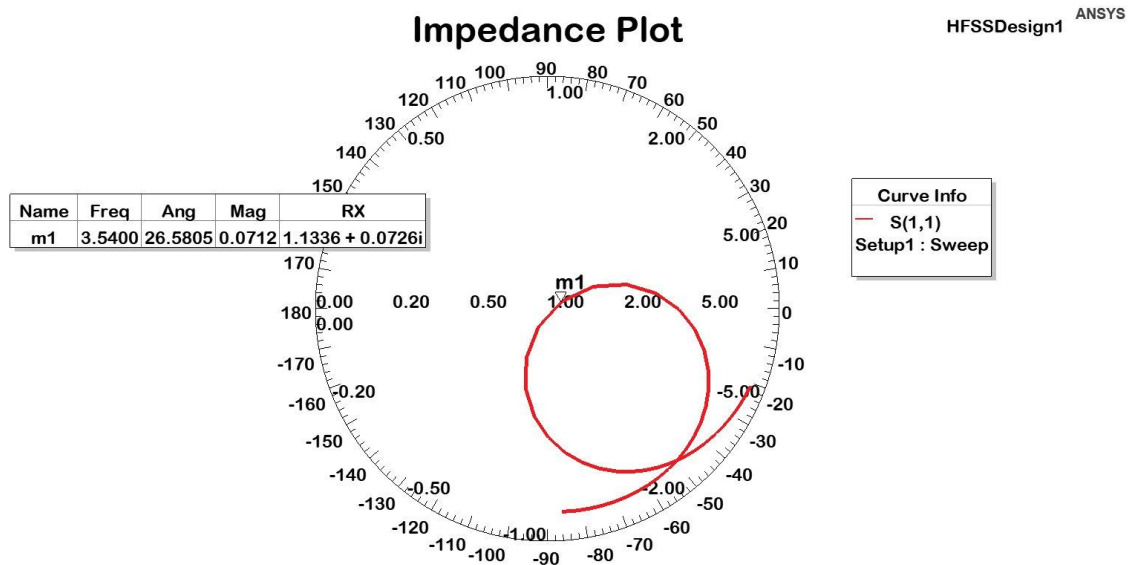
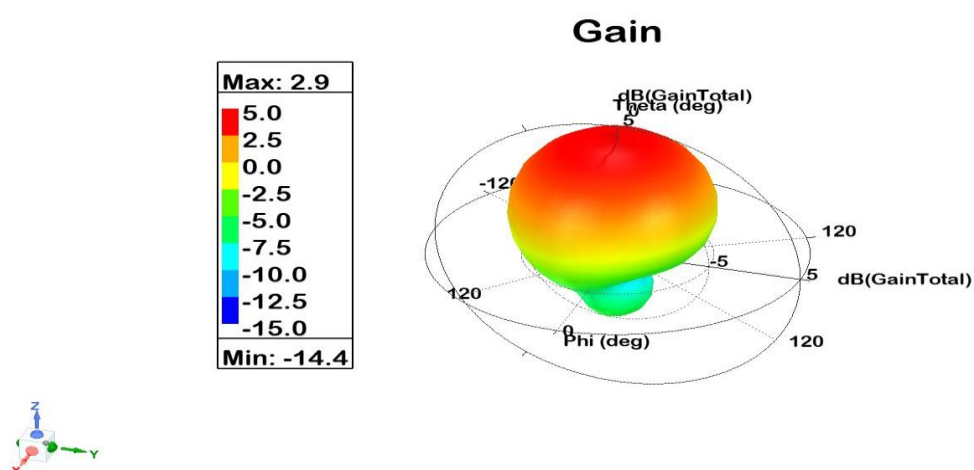


Figure 4.6 Impedance plot of triangular shape antenna

4.4 GAIN AND DIRECTIVITY

The gain and directivity of proposed antenna is represented in 3D polar plot using the HFSS software and analyzed the obtain values. The obtain gain of the proposed transceiver of array antenna structure is 4.6dB and for triangular pointer structure is 3.9dB and the gain pattern is called as the plot of gain at function direction. The directivity is the measure of the radiation of an antenna in degree in one direction and directivity of proposed array antenna is 6.1dB and for triangular pointer structure is 4.7dB.



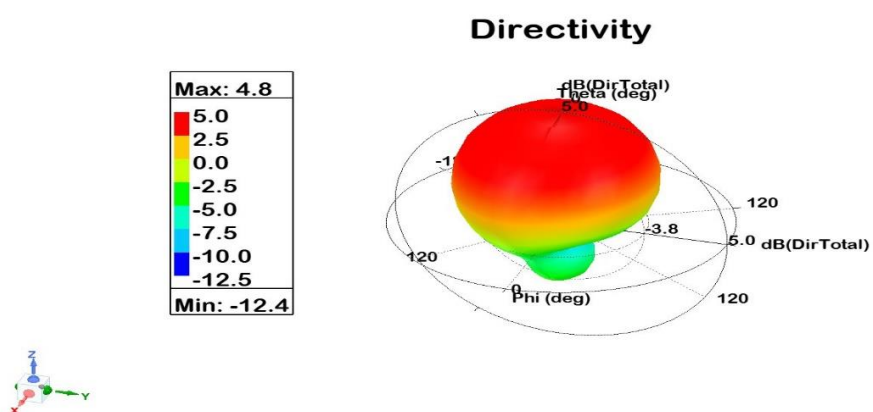


Figure 4.7 Gain and Directivity plot of array antenna

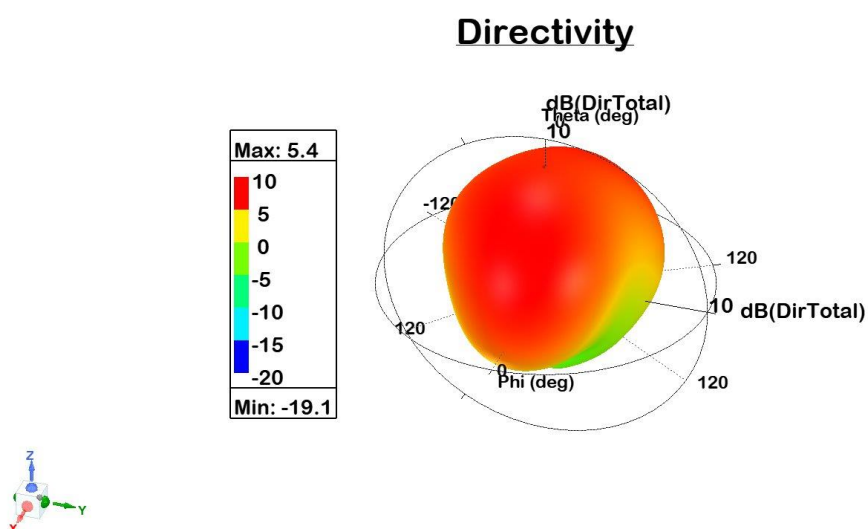
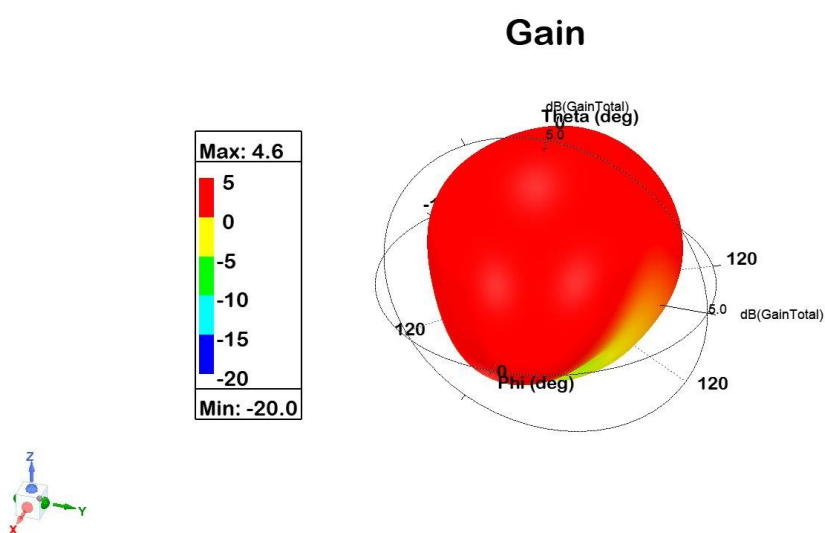


Figure 4.8 Gain and Directivity plot of triangular pointer structure

4.5 RADIATION PATTERN

The power radiated by an antenna is said to be radiation pattern. The strength of the radio waves of the antenna at different directions is illustrated with the help of radiation pattern by analyzing the antennas azimuth and elevation angle. The figure 5(a) and 5(b) represents the radiation pattern for the 3.5 GHz frequency application, such as 5G mobile communication in zero, ninety, one twenty and three sixty degrees and analyzed by the HFSS software. From the analysis of obtained radiation pattern it produces linear polarization in 0 and 180 degree so the signal of the proposed antenna is travelled both in parallel and perpendicular to the surface of the antenna.

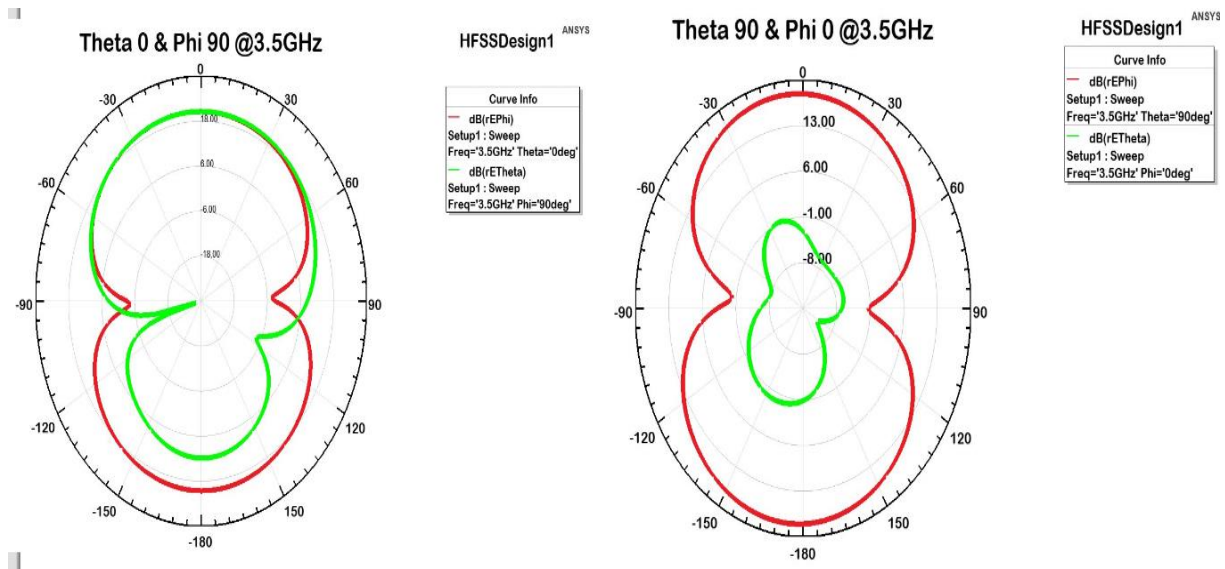


Figure 4.9 Radiation pattern of array antenna

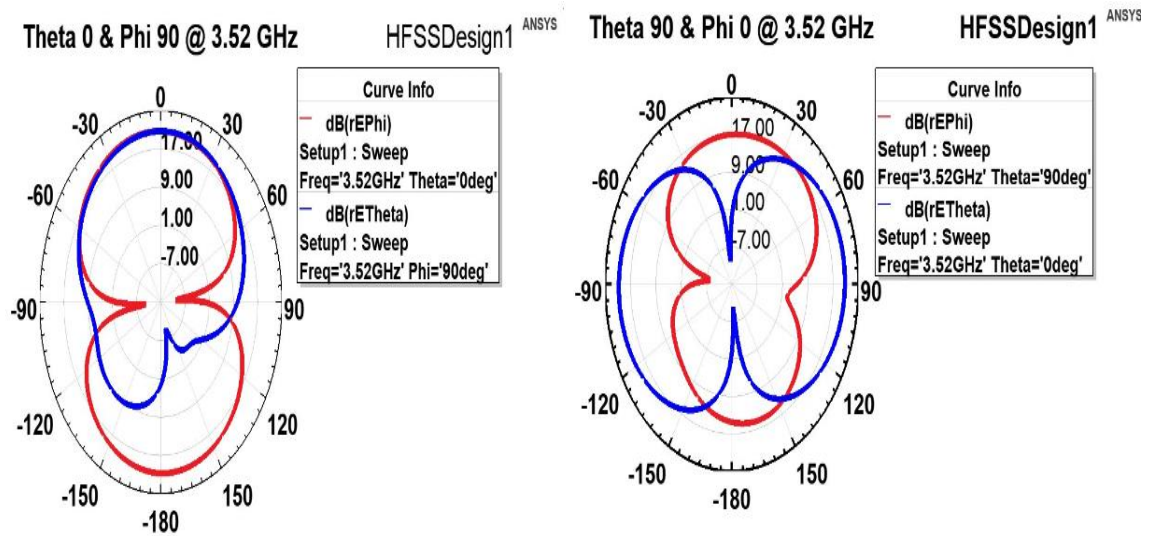


Figure 4.10 Radiation pattern of Triangular shape antenna

4.6 ACCEPTED POWER

The accepted power is defined as the power which is given to the antenna or input power. This below graph is analyzed by comparing the accepted power of array antenna and pointer shape antenna in specified direction. This parameter is important in scenario where interference or coverage to be reduced in reverse direction.

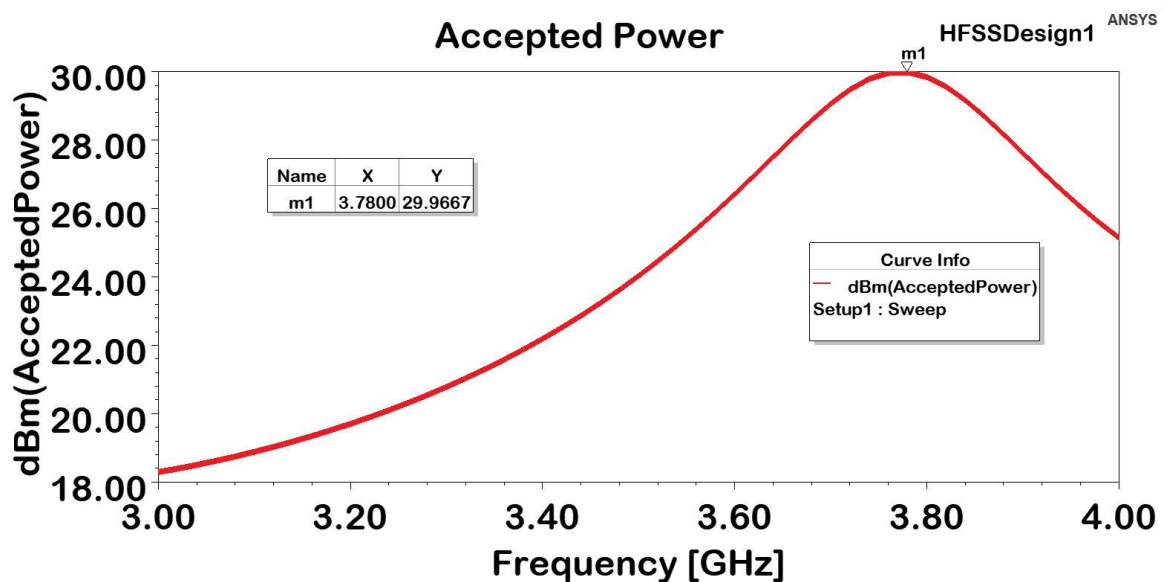


Figure 4.11 Accepted power of array antenna

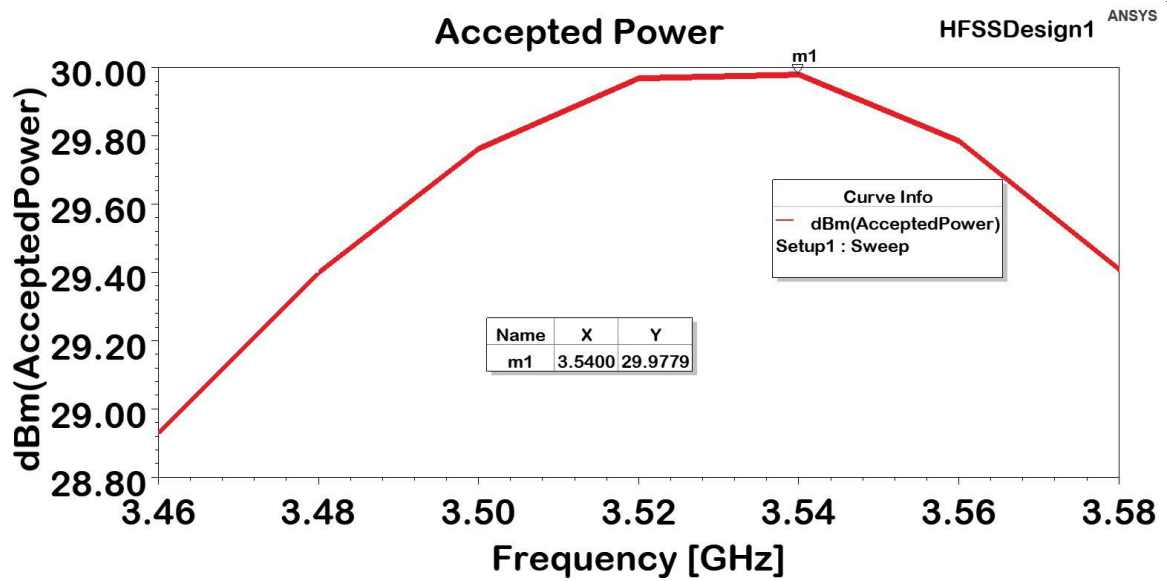


Figure 4.12 Accepted power of Pointer shape antenna

4.7 RADIATED POWER

The radiated power is defined as the power which is radiated from the antenna or output power. This below graph is analyzed by comparing the radiated power of array antenna and pointer shape antenna in specified direction. This parameter is important in analysing how much power is radiated compared to accepted power.

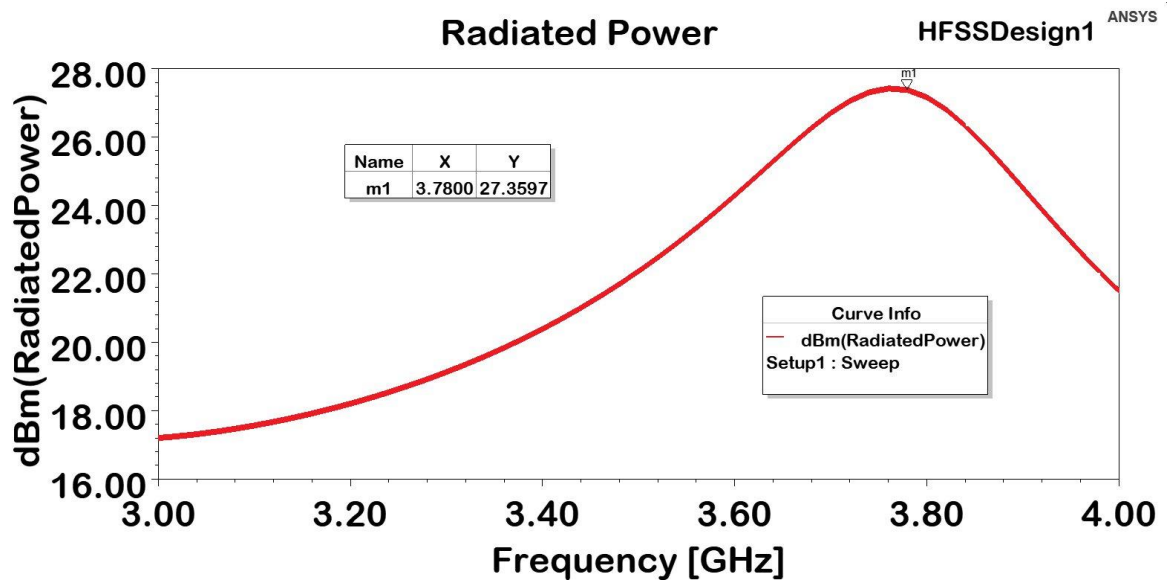


Figure 4.13 Radiated power of array antenna

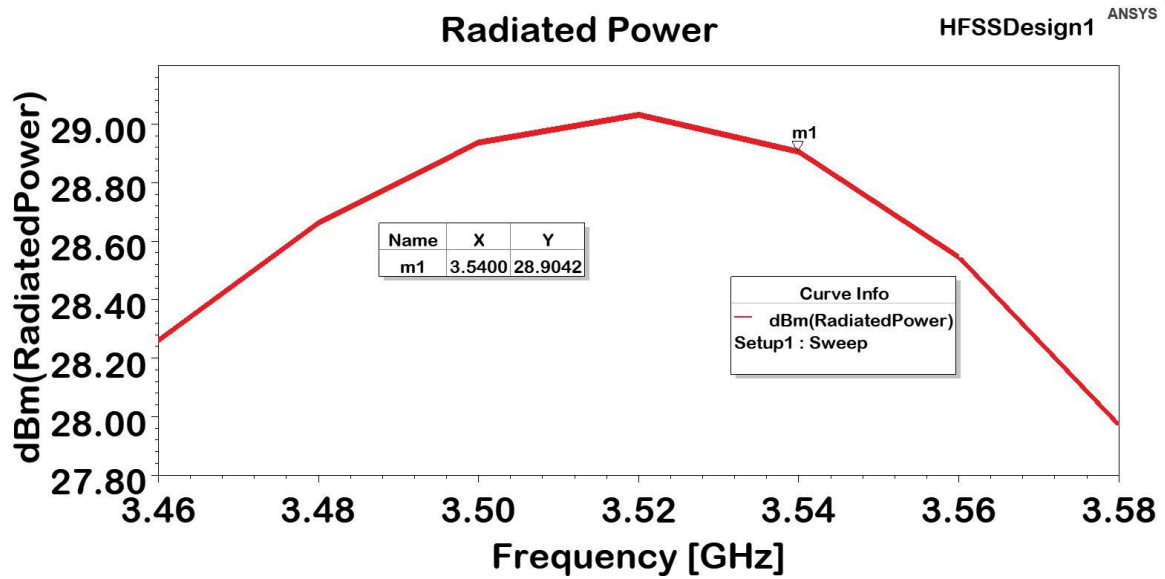


Figure 4.14 Radiated power of Pointer shape antenna

4.8 RADIATION INTENSITY

The radiation intensity is a far field parameter which can be obtained by simply multiplying the radiation power by the square distance and the radiation intensity is also called as the antenna power pattern. This below graph represents the power pattern for the proposed array antenna and arrow shaped patch transceiver.

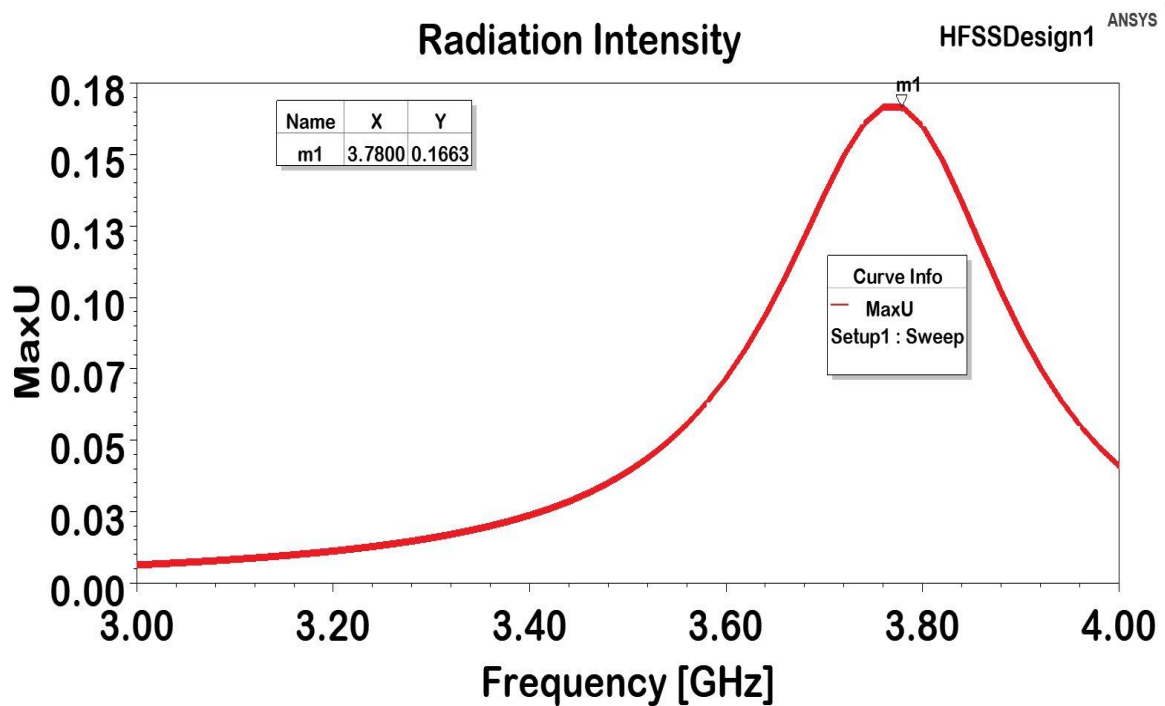


Figure 4.15 Radiation Intensity of array antenna

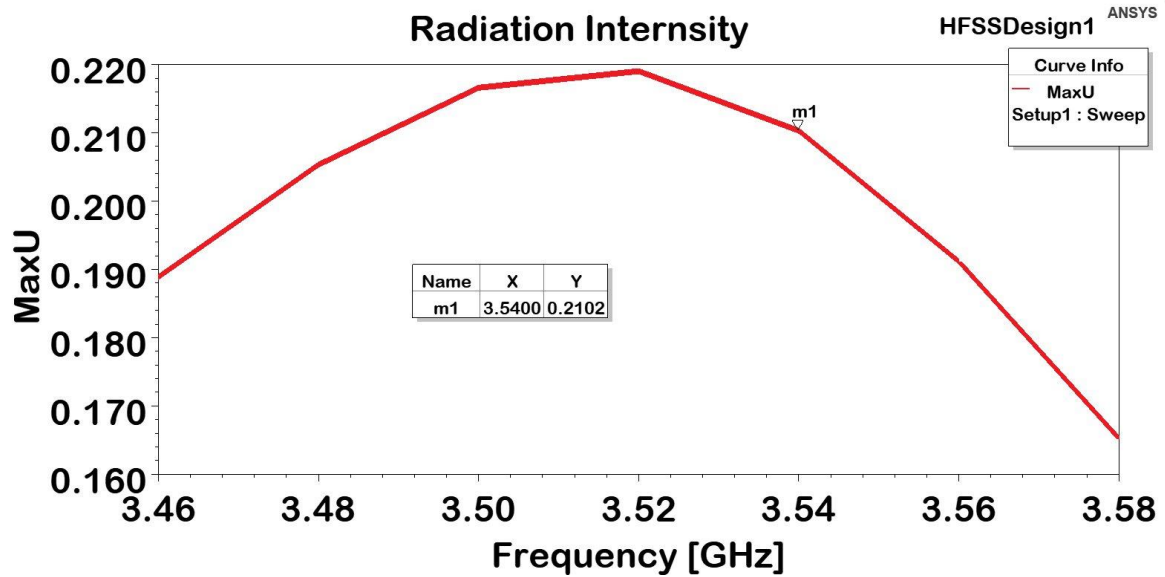


Figure 4.16 Radiation Intensity of Pointer shape antenna

4.9 SURFACE CURRENT AND SAR

As the proposed MSPA is going to be operated for 5G applications and it should have a minimum radiation and it should not be harmful to human body so parameter namely Specific Absorption Rate (SAR) for the proposed array antenna and triangular shaped antenna MSPA have to be analyzed the radiation of this MSPA is “zero” so there is no harm full radiation for the human beings. The next figure illustrates the simulated Surface Current Distribution for the proposed MSPA at reported frequencies in this letter. From the analysis of the obtained results the surface current in the proposed MSPA array structure and triangular shape is distributed evenly in the overall region.

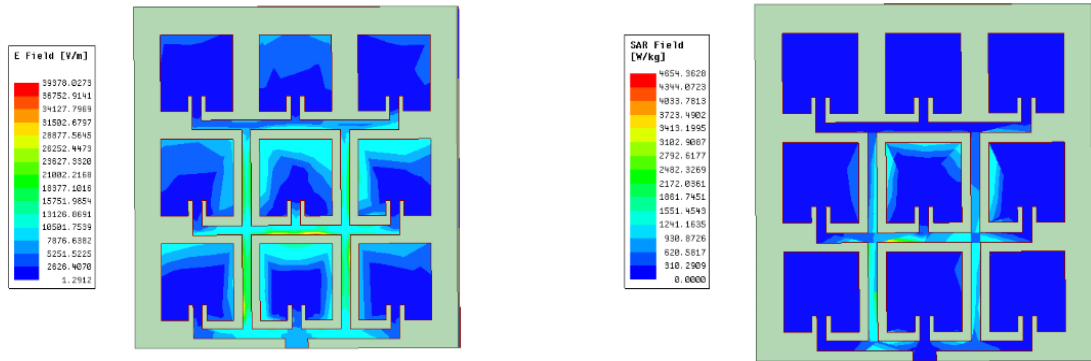


Figure 4.17 Surface current and SAR of array antenna

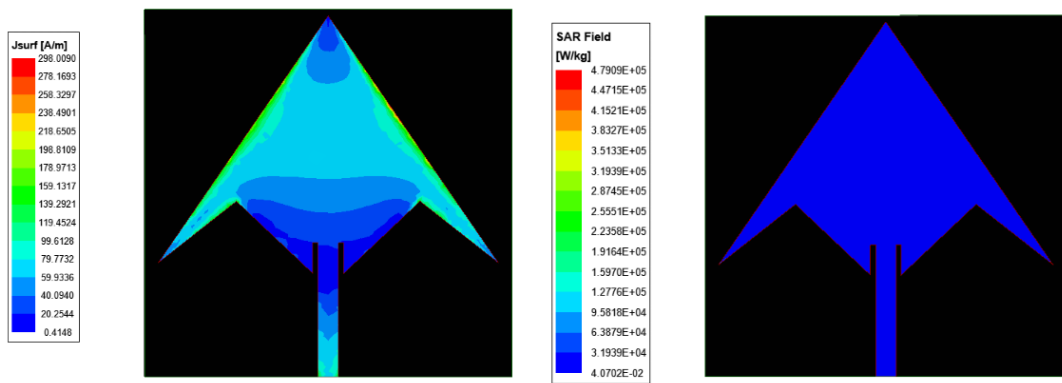


Figure 4.18 Surface current and SAR of Traingular antenna

4.10 COMPARED RESULTS OF DESIGN

Results	Array Structure	Arrow shaped
Return Loss	-21.17dB	-22.94dB
VSWR	1.19	1.23
Gain	2.9dB	4.6dB
Directivity	4.8dB	5.4dB
Efficiency	60.4%	85.1%

Figure 4.19 Comparison table for array and arrow design

4.11 FABRICATED ANTENNA DESIGN IMAGES

Array antenna and triangular shaped antenna have been designed and simulated. Compared to array antenna the efficiency, directivity and gain of triangular antenna have produced much increased value. so we fabricated the triangular shape antenna which is shown in the fig 4.18.

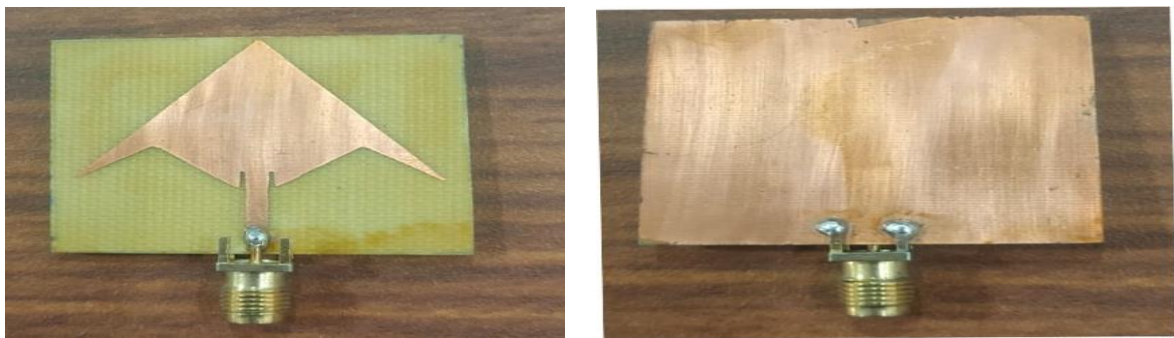
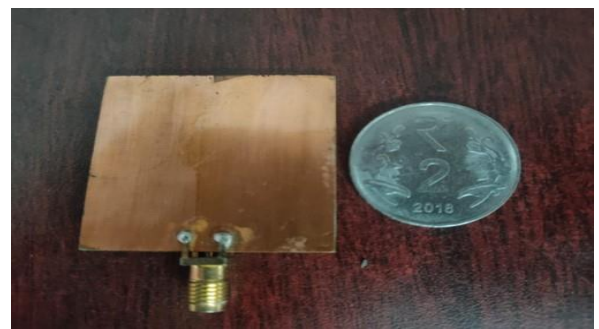
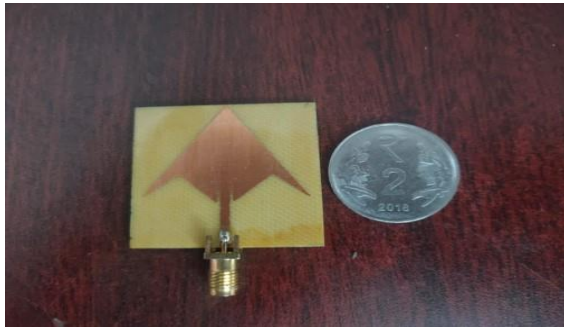


Figure 4.20 Front and back of the fabricated design



4.12 TESTED RESULT

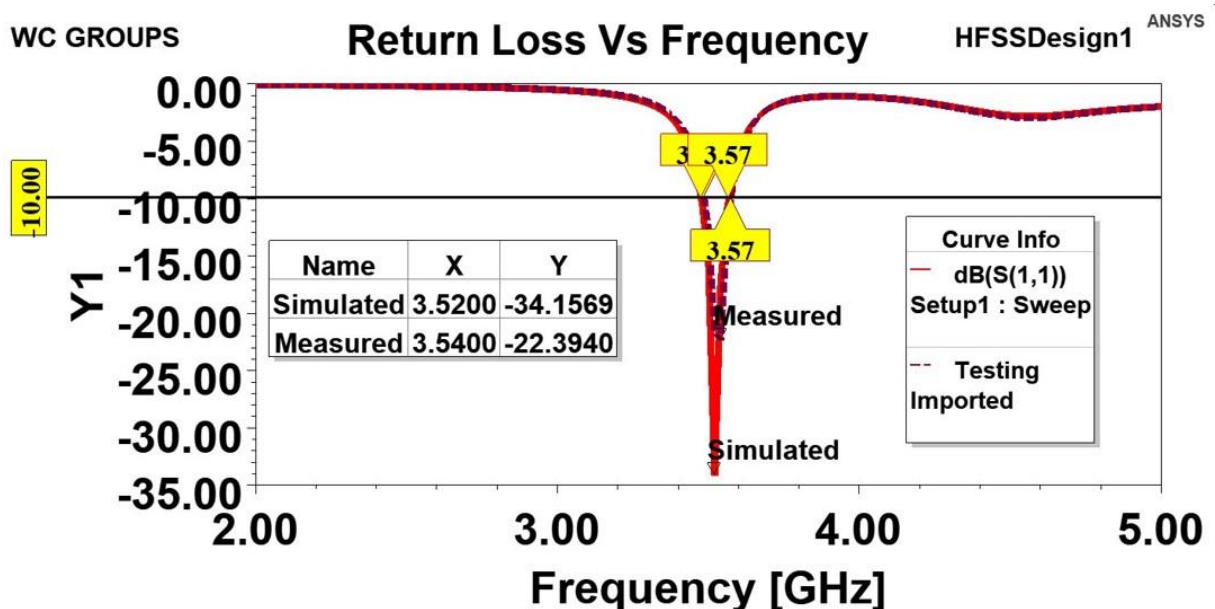


Figure 4.21 Tested result for frequency and return loss

By analysing the efficiency and overall performance of array structure and triangular structure, the efficiency of triangular shaped microstrip patch antenna is higher than array antenna with return loss of -34.1569db. So the triangular shaped antenna have been fabricated and analysed in vector network analyser and the return in testing is found to be -22.394db at 3.5GHz. There will be small change in return loss when it is compared to simulation and tested results. The resonated frequency in simulation is 3.52 GHz and the return loss is -34.1569 where the tested results are frequency is 3.54GHz and return loss is -22.394. The HFSS simulation software produces almost 95% similar results after testing.

CONCLUSION 5

The proposed micro-strip arrow shaped patch antenna was plotted using the substrate material such as FR4 with inset feeding technique and achieved to work in 5G applications in sub-6GHz band with low signal reflection. The performance parameters such as gain, directivity, S parameter, bandwidth were noted and analyzed using the HFSS simulation tool and took a detail study in the above literature. The proposed methodology revealed better performance rate from the analysis. The presented fabricated arrow shaped patch antenna will show's a great performance in real time with the very high efficiency of 95.9% in 5G applications operating in Sub-6GHz band.

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