

DESIGN AND ANALYSIS OF COMPACT SYMMETRICAL MULTIBAND ANTENNA FOR FUTURE WIRELESS APPLICATION

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

By

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SATHYABAMA

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

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

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of AJAY. N (37130010), CLIFFORD JESUDOSS. A. R (37130091) who carried out the project entitled “**Design and Analysis of Compact Symmetrical Multiband Antenna for Future Wireless Application**” under our supervision from

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We, **AJAY. N (37130010)** and **CLIFFORD JESUDOSS. A. R (37130091)** hereby declare that the Project Report entitled “**DESIGN AND ANALYSIS OF COMAPCT SYMMETRICAL MULTIBAND ANTENNA FOR FUTURE WIRELESS APPLICATION**” done by us under the guidance of **Dr. S. KARTHIKEYAN** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

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ABSTRACT

This paper describes the design of an integrated antenna multiband application that can be used for future wireless applications. The antenna has 6 operating frequencies between the frequency range of 1 – 15 GHz as 3.46, 4.12, 6.56, 7.6, 9, 9.72. The substrate material is FR – 4 epoxy material which has a dielectric constant of 4.4. The antenna designed can be used in all wireless applications such as radar, WLAN, Wi-Fi, etc. The antenna is designed as low cost, low profile, and easy fabrication. The antenna is designed using ANSYS HFSS software, which provides a high degree of accuracy. The antenna is designed in fractal shape to maximize the effective length. Various parameters, for example, the gain, directivity, efficiency, VSWR, front and back ratio, impedance plot, return loss, peak gain, radiated power, accepted power, radiation intensity, SAR.

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LIST OF ABBREVIATIONS

- RFID - Radio-Frequency Identification.
- GPS - Global Positioning System.
- WML - Wireless Markup Language.
- XML Extensible Markup language.
- PDAs - Personal Digital Assistants.
- UK - United Kingdom.
- PSK - Phase Shift Keying.
- FSK - Frequency-Shift Keying.
- QPSK - Quadrature Phase-Shift Keying.
- TDM - Time Division Multiplexing.
- FDM - Frequency Division Multiplexing.
- PCS - Personal Communications Service.
- MSA - Microstrip patch antenna.
- AM - Amplitude Modulation.
- EM – Electromagnetic.
- PCB - Printed Circuit Board.
- TEM - Transverse-Electric- Magnetic.
- eMBB - Enhanced Mobile Broadband.
- EBG - Electromagnetic Band Gap structures.
- HFSS - High-Frequency Structural Simulator.
- SAR - Specific Absorption Rate.
- VSWR - Voltage standing wave ratio.
- LTE - Long-Term Evolution.
- OFDM - Orthogonal Frequency Division Multiplexing.
- MIMO - Multiple inputs and multiple outputs.
- RPA - Rectangular Microstrip Patch Antenna.
- SLL - Sidelobe Level.
- UWB - Ultra-wideband.
- CPW - Coplanar Waveguide.
- DC - Direct Current.
- FEKO - Field Calculations involving bodies of arbitrary Shape.
- PTFE – Polytetrafluoroethylene.
- ERA - Extended Range Antenna.
- SMA – Sub-Miniature version A.
- DUT – Device-Under-Test.
- S21 and S12 - Sxy for greater than 2-ports.
- VNA - Vector Network Analyzer.
- ADAS - Advanced Driver Assistance Systems.
- IoT - Internet-of-Things.
- WMSPA - Western Motorola Service Provider Association.
- DGS - Defected Ground Structures.
- PBG - Photonic Band Gap.

- dB – decibels.
- SWR - Standing Wave Ratio.
- dBi - decibel-isotropic.

CHAPTER – 1

INTRODUCTION

1.1 ANTENNA:

The device used to transmit and receive signals is called an Antenna. Electric waves are often called radio waves. Most antenna works better in small frequency bands because most of them are sound devices. The antenna must be connected in a common band with a radio program to which it is connected, or else the reception and/ or transmission may be disabled.

Antenna plays a major role in communication systems and it is a device that converts electrical power into radio waves (vice versa). It is used in the transmission of radio receivers and transmitters. And its application involves radio broadcasting, television reception, two – ways radio, satellite communications, radar, RFID tags, cell phones, Biomedical instruments, etc....

1.1.1 History of Antenna:

Antenna acquired a new significance as a connecting link between a radio system and the 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 the 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 (a 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 a “log-periodic” antenna.

1.1.2 Characteristics of Antenna:

- The characteristics features of antenna are listed below:
- Light-Weight.
- Small Size.
- Effective and Efficient operation.
- Meeting various wireless application.
- Broadband Frequency.
- Cost efficient.
- Easy to design and manufacture.
- Robust.

1.1.3 Types of Antenna:

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 the future.

A few commonly used antennas are described in the following sections

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

1.1.3.1 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 onto a circuit board these are becoming increasingly popular in 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.

The microstrip patch antenna is a type of internal antenna. They are widely used in microwave frequencies. Microstrip antennas are low-profile antennas. A metal patch mounted at a ground level with a dielectric material in-between constitutes a Microstrip or Patch Antenna. These are very low-size antennas having low radiation.

1.1.3.2 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 a 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 a radius of curvature of at least $\lambda/4$ at the longest wavelength of operation.

1.1.3.3 Travelling Wave Antenna:

The traveling 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 traveling wave antenna is large bandwidth.

1.1.3.4 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 from 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 environmental conditions. This type of mounting does not disturb the aerodynamic profile of the craft.

1.2 WIRELESS COMMUNICATION:

1.2.1 Overview of Wireless Communication:

Wireless communications, System using a radio-frequency, infrared, microwave, or other types of electromagnetic or acoustic waves in place of wires, cables, or fiber optics to transmit signals or data. Wireless devices include cell-phones, two-way radios, remote garage-door openers, television remote controls, and GPS receivers. Wireless modems, microwave transmitters, and satellites make it possible to access the Internet from anywhere in the world. A Wireless Markup Language (WML) based on XML is intended for use in such narrow-band devices as cellular phones and pagers for the transfer and display of text.

Wireless communication (or just wireless, when the context allows) is the electromagnetic transfer of information between two or more points that do not use an electrical conductor as a medium by which to perform the transfer. The most common wireless technologies use radio waves. With radio waves, intended distances can be short, such as a few meters for Bluetooth or as far as millions of kilometres for deep-space radio communications. It encompasses various types of fixed, mobile, and portable applications, including two-way radios, cellular telephones, personal digital assistants (PDAs), and wireless networking. Other examples of applications of radio wireless technology include GPS units, garage door openers, wireless computer mouse, keyboards and headsets, headphones,

radio receivers, satellite television, broadcast television, and cordless telephones. Somewhat fewer common methods of achieving wireless communications include the use of other electromagnetic wireless technologies, such as light, magnetic, or electric fields, or the use of sound.

The term wireless has been used twice in communications history, with a slightly different meaning. It was initially used from about 1890 for the first radio transmitting and receiving technology, as in wireless telegraphy, until the new word radio replaced it around 1920. Radios in the UK that were not portable continued to be referred to as wireless sets into the 1960s. The term was revived in the 1980s and 1990s mainly to distinguish digital devices that communicate without wires, such as the examples listed in the previous paragraph, from those that require wires or cables. This became its primary usage in the 2000s, due to the advent of technologies such as mobile broadband, Wi-Fi, and Bluetooth. Wireless operations permit services, such as mobile and interplanetary communications, that are impossible or impractical to implement with the use of wires. The term is commonly used in the telecommunications industry to refer to telecommunications systems that use some form of energy (e.g., radio waves, acoustic energy,) to transfer information without the use of wires. Information is transferred in this manner over both short and long distances.

1.2.2 Block Diagram of Wireless Communication System:

A typical Wireless Communication System can be divided into three elements: The Transmitter, the Channel and the Receiver. The following fig 1.1 shows the block diagram of wireless communication system.

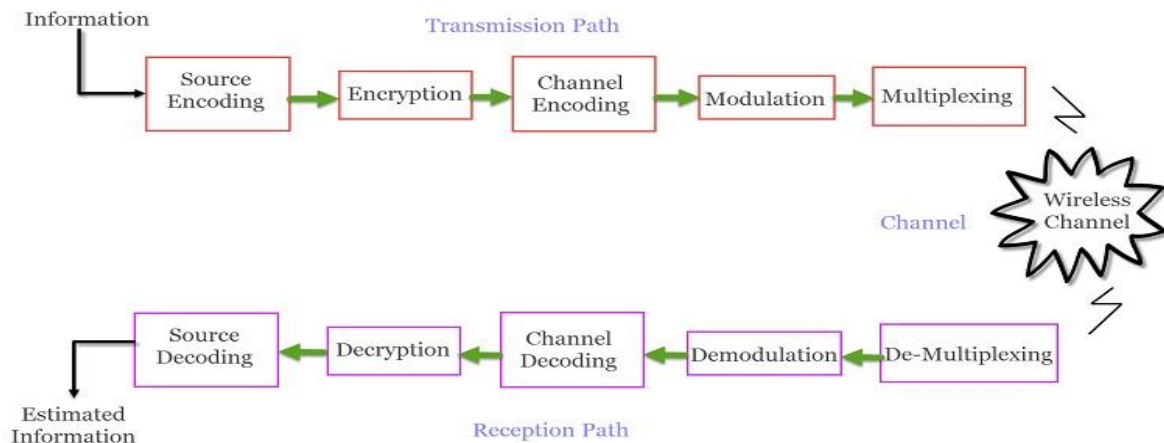


fig 1.1 Block Diagram of Wireless Communication System

1.2.2.1 The Transmission Line:

A typical transmission path of a Wireless Communication System consists of Encoder, Encryption, Modulation, and Multiplexing. The signal from the source is passed through a Source Encoder, which converts the signal into a suitable form for applying signal processing techniques.

The redundant information from a signal is removed in this process to maximize the utilization of resources. This signal is then encrypted using an Encryption Standard so that the signal and the information are secured and don't allow any unauthorized access.

Channel Encoding is a technique that is applied to the signal to reduce the impairments like noise, interference, etc. During this process, a small amount of redundancy is introduced to the signal so that it becomes robust against noise. Then the signal is modulated using a suitable Modulation Technique (like PSK, FSK, and QPSK, etc.) so that the signal can be easily transmitted using the antenna.

The modulated signal is then multiplexed with other signals using different Multiplexing Techniques like Time Division Multiplexing (TDM) or Frequency Division Multiplexing (FDM) to share the valuable bandwidth.

1.2.2.2 The Channel:

The channel in Wireless Communication indicates the medium of transmission of the signal i.e., open space. A wireless channel is unpredictable and also highly variable and random in nature. A channel may be subject to interference, distortion, noise, scattering, etc. and the result is that the received signal may be filled with errors.

1.2.2.3 The Reception Line:

The job of the Receiver is to collect the signal from the channel and reproduce it as the source signal. The reception path of a Wireless Communication System comprises Demultiplexing, Demodulation, Channel Decoding, Decryption, and Source Decoding. From the components of the reception path, it is clear that the task of the receiver is just the inverse to that of the transmitter.

The signal from the channel is received by the Demultiplexer and is separated from other signals. The individual signals are demodulated using appropriate Demodulation Techniques and the original message signal is recovered. The redundant bits from the message are removed using the Channel Decoder.

Since the message is encrypted, Decryption of the signal removes the security and turns it into a simple sequence of bits. Finally, this signal is given to the Source Decoder to get back the original transmitted message or signal.

1.2.3 Characteristics of Wireless Communication System:

The fundamental differences between the two systems are speech quality and the area covered by a base station. The high speech quality requirement in the cordless application is the consequence of the availability of tethered access in the home and office and the resulting direct competition with wire-line telephone services. In the mobile cellular application, the user has no alternative to wireless access and may be satisfied with lower, but still acceptable, quality of service.

In cordless telephone applications, the transmission range is short because the base station can simply be moved to a conveniently located wire-line access

point (wall jack) to provide wireless network access where desired. In contrast, the mobile cellular base station must provide access for users throughout a large geographical area of up to approximately 30 km (20 miles) around the base station. This large coverage area is necessary to economically meet the promise of uninterrupted service to roaming users.

The different range requirements directly affect the transmit power and antenna height for the two systems. High power transmitters used in mobile cellular user sets consume far more power than even complex signal processing hardware. Hence, sophisticated signal processing, including speech compression, voice activity detection, error correction and detection, and adaptive equalization, can be employed without substantial impact on the battery life in portable handsets. Furthermore, such techniques are consistent with the goals of increased range and support of large numbers of users with a single, expensive base station. On the other hand, the high mobile cellular base station antennas introduce delay spreads which are one or two orders of magnitude larger than those commonly observed in cordless telephone applications.

The two systems considered above are at extreme ends of the spectrum of wireless communications systems. Most notably, the emerging PCS systems fall somewhere between the two. However, the comparison above highlights some of the system characteristics which should be considered when discussing access methods for wireless communication systems.

1.2.4 Application of Wireless Communication System:

Applications of wireless communication involve security systems, television remote control, Wi-Fi, Cell phones, wireless power transfer, computer interface devices, and various wireless communication-based projects.

1.3 MICROSTRIP PATCH ANTENNA:

1.3.1 Overview of Microstrip Antenna:

The Microstrip antenna was proposed by G.A. Deschamps in 1953. The proposed concept of a Microstrip antenna to transmit radio frequency signals could not gain much ground till the 1970s. Its practicability remained hampered due to various inherent defects. Further, the development of the printed circuit board (PCB), microwave techniques, and many kinds 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 the 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, which are widely employed. Square patches are used to generate a pencil beam, rectangular patches for a fan beam in the view of their straightforward fabrication, and a 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 centimetre 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 are usually photo etched on the dielectric substrate. The EM waves firing off the top of the patch into the substrate and radiated out into the air after reflecting off the ground plane.

1.3.2 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 an array may have high gain, customizable beam and return loss properties, and other unique features at low cost. Depending on the directivity requirement, such an array may contain from few to a very large number of elements. The use of such an array with a large number of elements is quite common in radar applications for electronic scanning. One of the major drawbacks of such arrays is a mutual coupling. These techniques are used to reduce the coupling between surrounding patch elements and metal walls. It effectively prevents the surface mode from being excited in a substrate, thus allowing the substrate thickness to be increased without serious effects.

1.3.3 Characteristics of Microstrip Patch Antenna:

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. 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 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 a single-mode operation that radiates mainly linear polarization. For circular polarization radiation, a patch must support orthogonal fields of equal magnitude but in-phase quadrature. This requirement can be accomplished by a single patch with proper excitations or by an array of patches with an appropriate arrangement and phasing.

1.3.4 Working of Microstrip Patch Antenna:

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

The length of the metal patch is $\lambda/2$. When the antenna is excited, the waves generated within the dielectric undergo reflections and the energy is radiated from the edges of the metal patch, which is very low.

One microstrip antenna consists of a piece of metal with a variety of shapes (patch antenna) on the surface of the PCB (printed circuit board), with a metal plane on one side of the board.

Advantages:

The following are the advantages of Microstrip antenna:

- Lightweight.
- Low cost.
- Ease of installation.

Disadvantages:

The following are the disadvantages of Microstrip antenna:

- Inefficient radiation
- Narrow frequency bandwidth

Applications:

The following are the applications of Microstrip antenna:

- Used in Spacecraft applications.
- Used in Aircraft applications.

1.4 METHOD 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, arbitrarily shaped elements, and coupling. These give less insight as compared to the two models mentioned above and are far more complex in nature.

1.4.1 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. Most of the electric field lines reside in the substrate and parts of some lines in the air. As a result, this transmission line cannot support the 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 to account for the fringing and the wave propagation in the line.



fig 1.2 Microstrip line and Electrical field line

The value 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 1.2 above.

The expression for ϵ_{reff} is given by Balanis as:

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{w} \right]^{-1/2} \quad (1.1)$$

Where	ϵ_{reff}	= Effective dielectric constant.
	ϵ_r	= Dielectric constant of the substrate.
	H	= Height of dielectric the substrate.
	W	= Width of the patch.

1.4.2 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 modelled 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 and in the region bounded by the patch metallization and the ground plane.

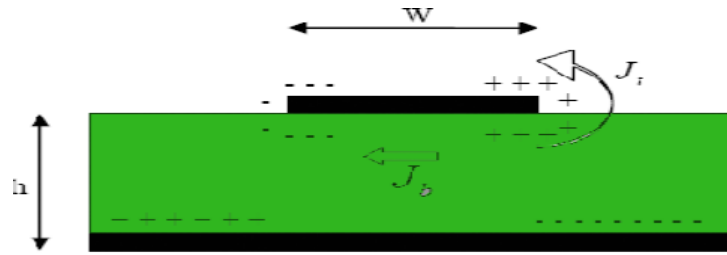


fig 1.3 Cavity Model

Consider figure 1.3 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 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 the patch is modelled as a cavity bounded by electric walls on the top and bottom, and magnetic walls 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 modelled 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, to account for radiation and a loss mechanism, one must introduce a radiation resistance and a loss resistance. 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_T 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 microstrip patch antenna plays a prominent role in communication systems in recent years because the transceiver is the largest component in wireless communication systems nowadays this wireless has become popular due to its ease of installation and without this transceiver helps the communication is not possible. Among various types of antennas, the micro-strip patch antenna took into account in the 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 microstrip patch antenna, the substrate materials also play a major role in transceiver operation in real-time so 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 the sub-6GHz band.

From most of the other literature study of fifth-generation (5G) applications, only Millimetre waves are 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- Radiocommunications 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 are boosted and considered as advancement. Three categories are taken into account in the fifth generation they are enhanced mobile broadband (eMBB), massive machine-type communication, and ultra-reliability & low latency communication. This paper mainly aims at mobile communication in fifth-generation applications and the proposed

antenna resonates at the sub-6GHz frequency for the IEEE std P 802.11 ax applications, when compared to prior generation this coverage range is less because the frequency is inversely proportional to wavelength. In the upcoming literature, the shape of the patch is taken into account and its role in the function of the antenna.

A micro-strip patch antenna is made up of radiating plate which is called the patch and this patch may be in different shapes such as square, rectangular, circular, and triangular. This patch in the antenna is going to act as the radiating element and the material used in the patch and ground are the same either copper or gold. The antenna can be in a 3D structure so this is referred to as a planar antenna. This radiating element (patch) in the antenna radiates the energy from the current as electromagnetic waves and the proposed antenna patch is designed in arrow shape with a 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 the 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 sides 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 high transmission efficiency. The radiation characteristics of a regular triangular micro-strip antenna have been reported in 1998 and in recent 300 -600 -900 shaped triangular patch antenna is reported in cavity model. Most of the literature study is focused only on the 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 stripline feeding yes, the feed line of the patch antenna plays a prominent role in impedance matching of the particular device.

CHAPTER – 2

LITERATURE SURVEY

Design and Optimization of a microstrip patch antenna for increased bandwidth have been discussed by Archana Agrawal (2013). The need for wireless communication is ever increasing and it is important to design broadband antennas that 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 is by the use of a 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. The wide bandwidth of 4.15 to 5.27 GHz is achieved and frequency resonated at 4.17GHz with a -38.6db Reflection Coefficient. The wideband 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 a 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 a gain of 6.1db. By looking at shapes among rectangular, circular, triangular, and annular patches circular patch is the second most popular shape that can be easily optimized and analysed to get improved impedance values, radiation pattern, and frequency of operation.

Touko Tcheutou Stephane Borel (2019) explained the design of a rectangular patch array antenna for satellite communication. A 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 exact resonators in 12GHz with a bandwidth of 693.2MHz with a 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 an 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. The resonant frequency can change by changing the length of the patch whereas by changing the width impedance matching can be changed. Various parameters are analysed for understanding the performance of the 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 the most important factor and here full port impedance of 50Ω is used. The dual sloth-shaped antenna resonates exactly in 2.2GHz with a return loss of -22.7db and the obtained VSWR value is 1.2 with a gain of 3.65dBi. The obtained specific absorption rate value is 0.39W/Kg is much less than the allowable limit by TEC as 1.6W/Kg.

The design of a multiband Microstrip Antenna for a 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 of less than -10db and the gain of the antenna in all the bands are 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 inputs and multiple outputs (MIMO), which can be used in the development of an intelligent power grid. To improve the stability of the signal 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. 40mm x 50mm x 10mm 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 the patch without altering the dimension resonates at 3.5 GHz with a good return loss performance of -30.77 dB and gain of 5 dB. The dimension of compact TSRMPA with MTM ground is 30.2 x 36.4 mm². These antennas are investigated using High-Frequency Structural Simulator (HFSS) software. Finally, good concurrence between simulated and tested results is presented to prove the functioning of the proposed antenna design.

Timoty A. Hill (2018) proposed a 28GHz Taylor feed network for sidelobe 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 00 to 480 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 a phased array with a 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

480 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 overall dimensions of $106 \times 34 \times 0.813$ mm³ and is 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. The 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 a thickness of 3.175mm and permittivity of 2.2. The length and width of the antenna are 67 x 74mm.

A 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 the range from 3.1GHz to 10.6GHz and it has

exactly resonated in 5.5GHz for WLAN Application. Metamaterial antennas are used to enhance the performance of the 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 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 users 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 arrays 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 a 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 a 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 the design and analysis of multiband antenna for S and C bands. 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 the S-Band of radar frequency and from 5GHz to 6.25Ghz fall on the C Band. The antenna is designed in RT Duroid as s 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 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 users 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 a 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 one 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 a 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 of less than -10db in all three resonating frequencies of 2.48GHz, 5.72GHz, and 6.26GHz, and the bandwidth achieved is 50MHz, 290MHz, and 310MHz respectively with VSWR value less than 2 in all three bands.

Electromagnetic Band Gap Structures in a microstrip patch antenna improve 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 a wide range of wireless communication systems 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 device unipolar EBG structures can be used. EBG structures are also used to reduce the power loss through a substrate of a conventional antenna. Most Commonly EBG Structures produce a smoother radiation profile, lower back radiation, high gain, and efficiency. Unipolar EBGs are framed by interconnecting unit cells 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 feeding by coupled microstrip line. The improved gain of the antenna is 14.75dBi with a frequency range of 4.93 GHz – 5.05 GHz. The improved gain has been produced by the array structure of the antenna.

CHAPTER – 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

3.1 EXISTING METHODOLOGY:

By analyzing the previous microstrip patch antenna design for sub 6GHz applications. The Microstrip patch antennas are designed with various sizes, structures, and different design factors. The designed antenna which is used in the existing design resonates in the dual-band or multi-band and also produces a fringing effect with less efficiency. More complicated structures are used in the design to resonate in a single band frequency which can be achieved in a simple structure also with higher efficiency. In existing antenna designs high-cost materials are used to design and fabricate the antenna-like Rogers, RT Duroid, Cotton, etc.

3.1.1 Drawbacks:

The microstrip patch antenna has been designed for 5G applications and it covers a frequency range from 3.3GHz to 3.6GHz and is a narrow band but in this place, if a wideband wide bandwidth is obtained and it's a drawback of the structure. The previously designed antenna which we have analyzed have lower gain this also affects the efficiency of the antenna and for the 5G application antenna design the efficiency of the designed structure should be more. The Specific absorption rate is very high in fewer analyzed design structures with high scattering loss.

3.2 PROPOSED SYSTEM:

The fractal antenna is capable to work efficiently at many different frequencies simultaneously. The fractal antennas are very compact, and have useful applications in cellular telephone and microwave communication. But the disadvantages of existing fractal antenna are low gain, low power handling capability, low efficiency, etc. The proposed antenna overcomes the previously mentioned drawbacks by providing high gain, high power handling capability, and high efficiency along with the compact size of a fractal antenna.

3.2.1 Advantages:

The bandwidth is high compared to the existing antenna, the gain and directivity is also high, the radiation efficiency is 98% (internal loss is taken into consideration), SAR value is low, the value of return loss is below -25 dB.

CHAPTER – 4

MATERIALS AND METHOD FOR THE EXPERIMENT

4.1 HARDWARE REQUIREMENT:

- Substrate Material (FR – 4 epoxy material)
- SMA Connector (50 Ohm impedance)
- Copper (Patch and ground)
- Vector Network Analyser.
- ANSYS HFSS (Software)

4.1.1 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 considerable interest in minimizing the cost of these systems. Substantial cost savings could be realized by using FR4 in place of costly PTFE-based substrates for microwave circuits and antennas. This paper describes a program of work that 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 a high-speed network environment 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 applies to network equipment with low dielectric loss and low permittivity.

4.1.2 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 different types of SMA connectors are SMA male connector, SMA female connector, RP-SMA female connector, RP-SMA male connector. It is shown in fig 4.1.

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 have a 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 are 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 4.1 SMA Connector

4.1.3 Vector Network Analyzer:

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. It is shown in fig 4.2.

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 performs 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 (Sxy 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. Instead, the reflection measurement measures the signal that travels back towards the source due to reflections.



fig 4.2 Vector Network Analyzer

4.1.4 Software:

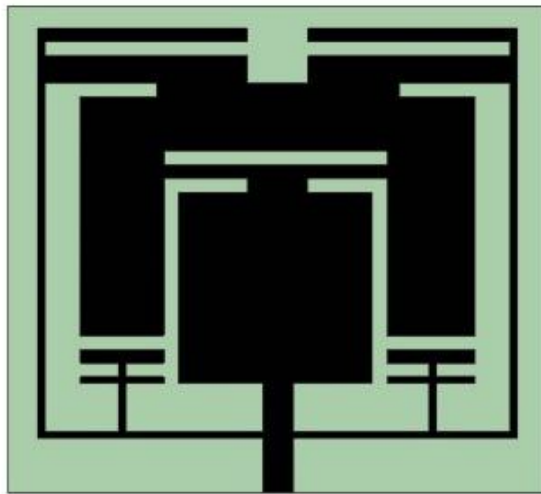
Ansys HFSS is a 3D electromagnetic (EM) simulation software for designing and simulating high-frequency electronic products such as antennas, antenna arrays, RF or microwave components, high-speed interconnects, filters, connectors, IC packages and printed circuit boards. Engineers worldwide use Ansys 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.

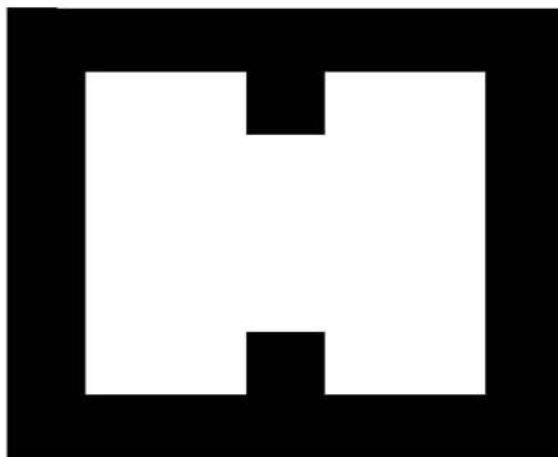
The proposed wearable microstrip patch antenna is simulated using the ANSYS EM suite version 20 which is described above in detail and in the next part the simulated WMSPA is place and given some detailisation on the design and done analysis in the proposed design.

4.2 ANTENNA DESIGN:

Antennas can be designed to transmit and receive radio waves in all horizontal directions equally (omnidirectional antennas), or preferentially in a particular direction (directional, or high-gain, or “beam” antennas). The proposed antenna has fractal design and H-shaped ground as shown in fig 4.3.



(a)



(b)

fig 4.3 Representation of proposed fractal antenna (a) Patch (b) Ground

The combined geometric spaces embedded in the ground structure of the microwave circuit are called DGS. Therefore, the periodic and / or aperiodic paralysis that is concentrated in the ground structure of the plane microwave circuit is called DGS. Previously Photonic Band Gap (PBG) and Electromagnetic Band Gap (EBG) were reported to have illegal aircraft. Comparisons between PBG, EBG, and DGS are shown. The DGS is integrated into the earth surface with a plane transmission line, i.e., microstrip, coplanar wave guide, etc. Flight errors disrupt the current dispensation of the aircraft; the interference alters the feature of the transmission line by adding other components slot (resistance, capacitance and inductance) to the line parameters like line (resistance, capacitance, and inductance). On the contrary any deformity recorded on the plane below the microstrip line alters these power and the efficiency of the microstrip line by increasing the slot resistance, strength of the capacitance and inductance. Occasional Defective Ground Structure planar microwave circuits find great attraction for microwave investigators. Introduced Microstrip lines with DGS periodically: bandpass filters and low pass filters. By using the events of a temporary structure a high degree of slow motion with high levels of miniaturized is achieved. The recurrence of single element in a limited space is known as time structure. By transmitting deformities (resonant cell) into the earth structure the rate of recovery loss and the bandwidth is increased according to the no. of times. The status of the Defective Ground Structure unit, the gap between two Defective Ground Structure units and the dispensation of various DGS are the important parameters that influence that shows the DGS from time to time. Two DGS sessions form an intermittent DGS (HPDGS) and an intermittent DGS (VPDGS).

CHAPTER – 5

RESULT AND ANALYSIS

Various parameters of the proposed fractal antenna are discussed and analyzed by stimulating it with the help of HFSS software.

- Return Loss.
- Voltage Standing Wave Ratio.
- Impedance Plot.
- Antenna Gain.
- Directivity.
- Peak Gain.
- Radiated Power.
- Front to Back Ratio.
- Accepted Power.
- Radiation Efficiency.
- Radiation Intensity.
- Specific Absorption Rate (SAR)
- Surface Current.
- Radiation Pattern.

5.1 RETURN LOSS:

The Return Loss of the antenna is a number that reflects the number of radio waves that reach the antenna installation which is rejected as a measure compared to the acceptable ones. Specified in decibels (dB) relative to short circuit. Consider the antenna used in the transmission mode.

Therefore, part of the radio waves will be displayed and down in the transmission line from the antenna input flange connection. The rest will continue in the feed system. However, any imperfections within the feed system will also cause a small number of event radio waves to be reflected back to the input side.

The stimulated result from the proposed antenna for 6 different frequency are 3.46 GHz - -26.5485, 4.12 GHz - -27.0251, 6.5 GHz - -24.3299, 7.6 GHz - -55.2697, 9 GHz - -31.8524, 9.72 GHz - -17.5845, it can be shown in fig 5.1.

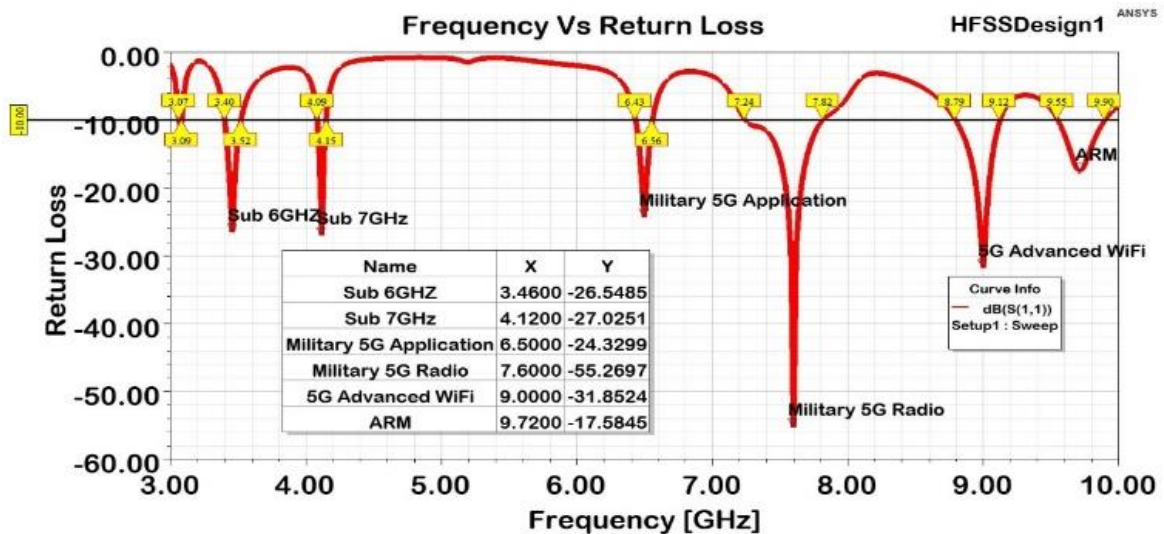


fig 5.1 Graphical Representation of Return Loss.

5.2 VOLTAGE STANDING WAVE RATIO:

The Voltage Standing Wave Ratio (VSWR) is an indication of the value of the variance between the antenna and the supply line to which you are connected. This is also known as the Standing Wave Ratio (SWR). VSWR price range from 1 to ∞ . VSWR value less than 2 years is considered appropriate for most antenna systems.

The Voltage Standing Wave Ratio (VSWR) is a distinct representation of Return Loss. VSWR refers to the actual voltages created within the transmission system where radio waves are moving and display simultaneously. Although static waves and VSWR are very important, often VSWR's theories and statistics can obscure what is happening. Fortunately, it is possible to get a good idea of the topic, without going too deep into the concept of VSWR.

The stimulated Voltage Standing Wave Ratio result from the proposed antenna are 3.46 GHz – 1.0987, 4.12 GHz – 1.0932, 6.5 GHz – 1.1293, 7.6 GHz – 1.0035, 9 GHz – 1.0035, 9.72 GHz – 1.3043. It is shown in fig 5.2.

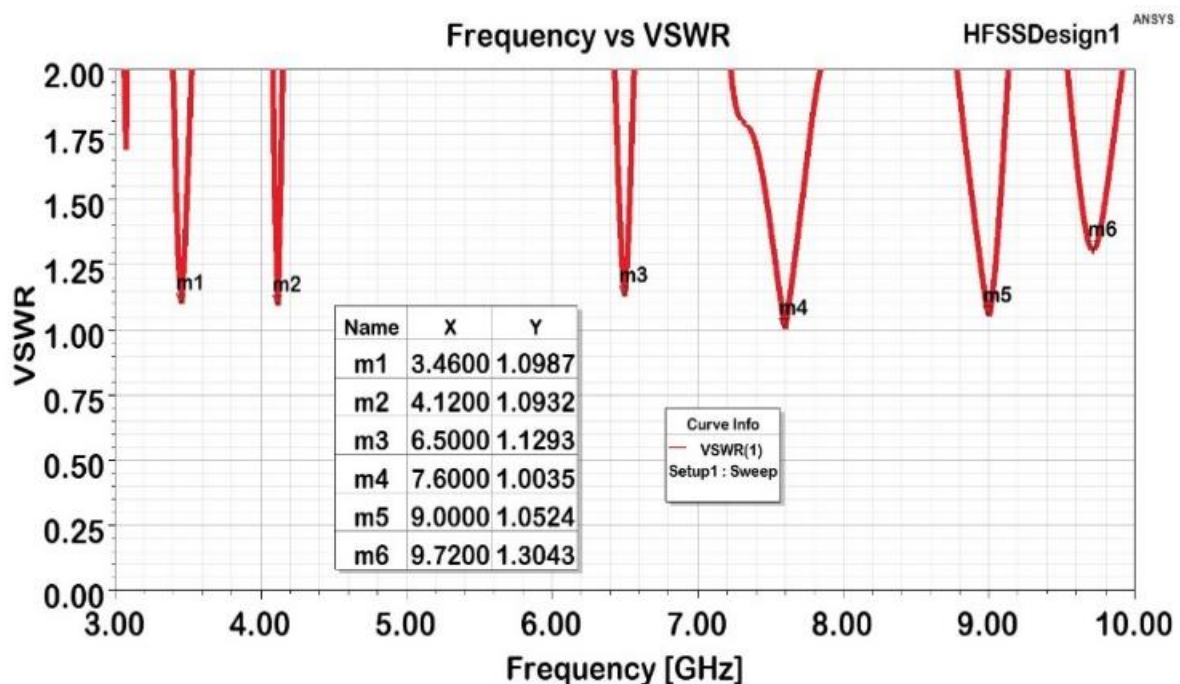


fig 5.2 Graphical Representation of VSWR.

5.3 IMPEDANCE PLOT:

The impedance correlates the voltage and current of the input to the antenna. The actual impedance component of the antenna represents the energy emitted from a distance or embedded within the antenna. The hypothetical part of the impedance represents the energy stored in the nearest antenna field. The impedance of measuring the current electrical capacity in the port. The antenna impedance is calculated as the measurement of the phasor voltage, which is 1V at an angle of 0 deg, to the current in the port. The number of impedances is:

$$Z = V / I = R + jX$$

where:

- V is the Antenna excitation power voltage.
- I is current.
- R is the antenna resistance at ohms.
- X is the antenna reaction mechanism at ohms.

Antenna installation impedance size depends on frequency. The structure shows the input impedance of a dipole antenna above the frequency band 20-120 MHz Response resistance varies in frequency. Differences can be correctly defined in terms of resonance.

The impedance plot of the proposed antenna are 3.46 GHz – 0.9491+0.0764i, 4.12 GHz – 0.9925+0.0885i, 6.5 GHz – 0.8856+0.0050i, 7.6 GHz – 1.0024+0.0025i, 9 GHz – 0.9503+0.0042i, 9.72 GHz – 1.3043+0.0039i. The mentioned stimulated results are shown in a smith chart in fig 5.3.

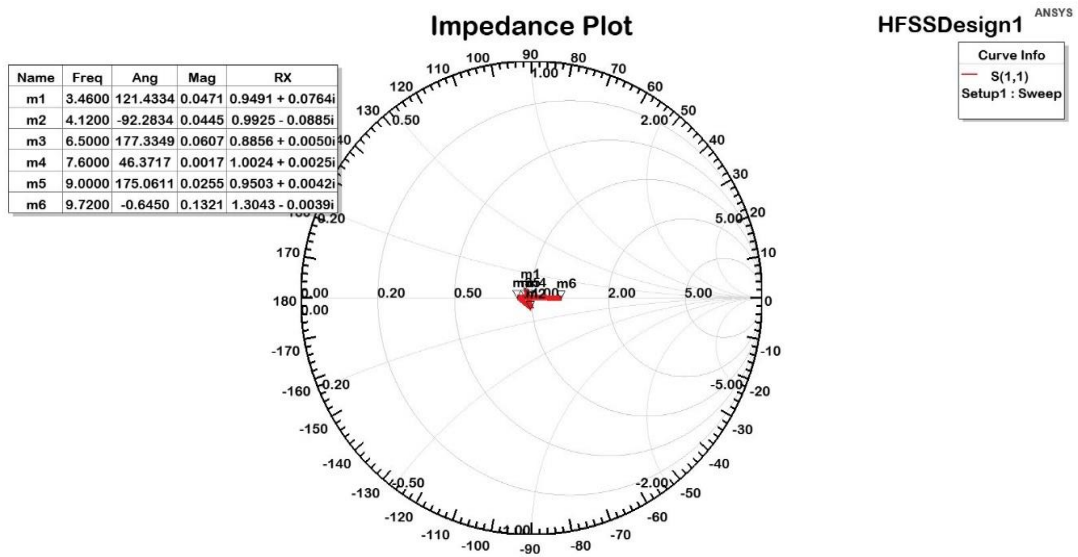


fig 5.3 Smith Chart Representation of Impedance plot.

5.4 ANTENNA GAIN:

The gain of the antenna is often defined as the measurement of the antenna-generated power from a remote field source to the antenna axis axle to the power generated by the isotropic antennae, which is equally sensitive to signals from all indicators. This measure is usually expressed in decibels, and these units are called decibel-isotropic (dBi). A different definition compares the power obtained with the power obtained of a non-lost dipole antenna, in which the units are written as dB the antenna gain indicates that the antenna signal can send or receive how strong it is in a certain direction. Profit is calculated by comparing the rated power transferred or received by the antenna in a specific direction to the power transferred or received by a suitable antenna in the same condition. The total gain measured in the proposed antenna is 5dB. It is shown in fig 5.4.

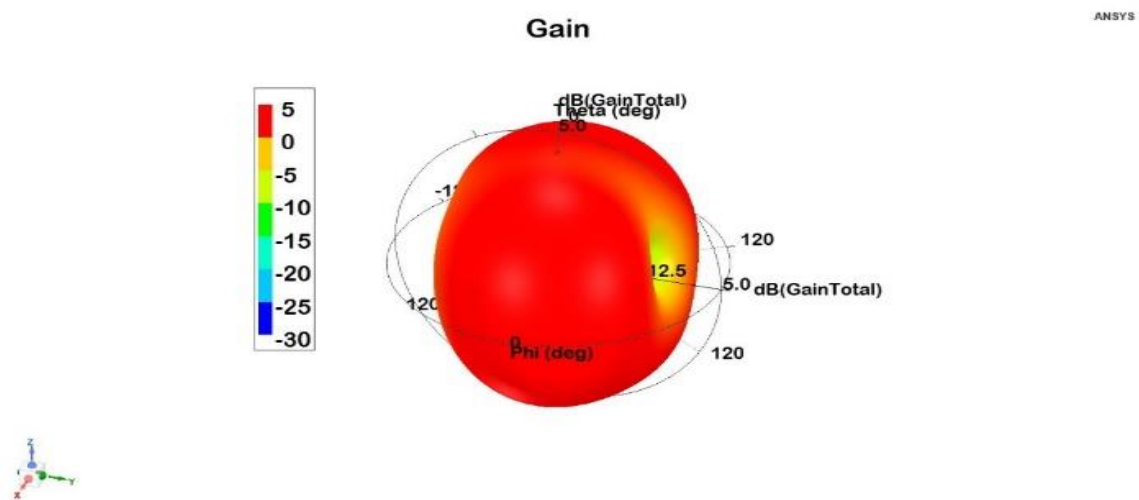


fig 5.4 3D Model of GAIN.

5.5 DIRECTIVITY:

Directivity is a measure of the concentration of the antenna radiation pattern on a particular side. The direction is shown in dB. The height of the direction is very focused or focused on a beam out of wood. A high direction also means that the beam will continue to move. It is the limit of the magnitude of the radiation on the given side from the antenna to the limited radiation potential in all directions (IEEE 1993). The equivalent radiation intensity is equal to the total power emitted by the antenna divided into 4π . The direction is shown in dB. The height of the direction is very focused or focused on a beam out of wood. A high direction also means that the beam will continue to move. An evenly illuminated antenna in all directions can be self-directed and have 1 direction (0 dB). The directivity of the proposed antenna is 5dB. It is shown in fig 5.5.

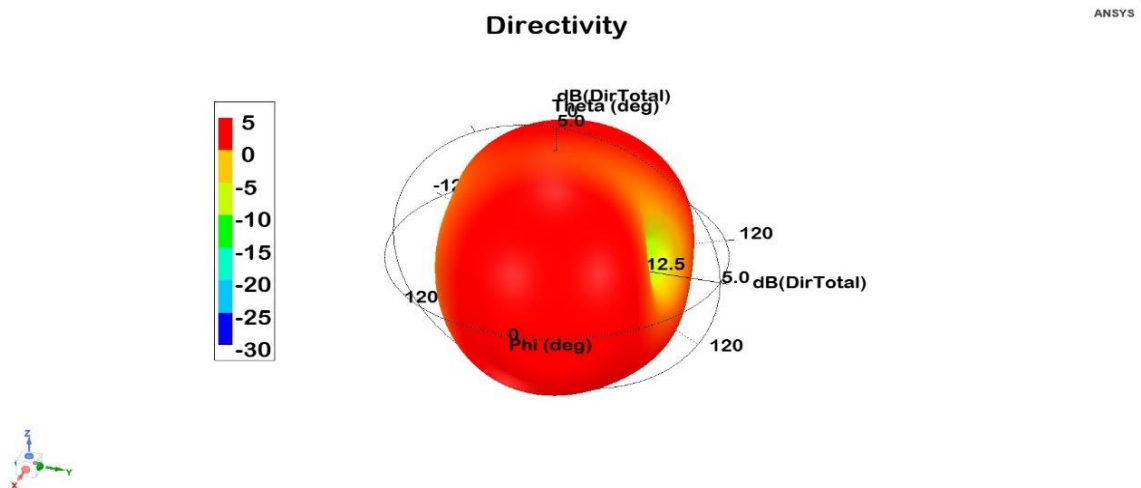


fig 5.5 3D Model of Directivity.

5.6 PEAK GAIN:

Peak gain is a measure of input power concentration in the main beam direction as a ratio relative to an isotropic antenna source. It is determined as the ratio of the maximum power density in the main beam peak direction, at a defined input power, compared to the power density of a lossless isotropic radiator with the same input power. It is defined in the far-field of the antenna. Peak gain can also be referred to as Directivity, the key difference however is that directivity neglects antenna losses such as dielectric, resistance, polarisation, and VSWR losses. The peak gain of the antenna in different frequency are 3.46 GHz – 4.1216, 4.12 GHz - -2.8096, 6.5 GHz – 2.9463, 7.6 GHz – 5.7556, 9 GHz – 4.6535, 9.72 GHz – 8.3926.

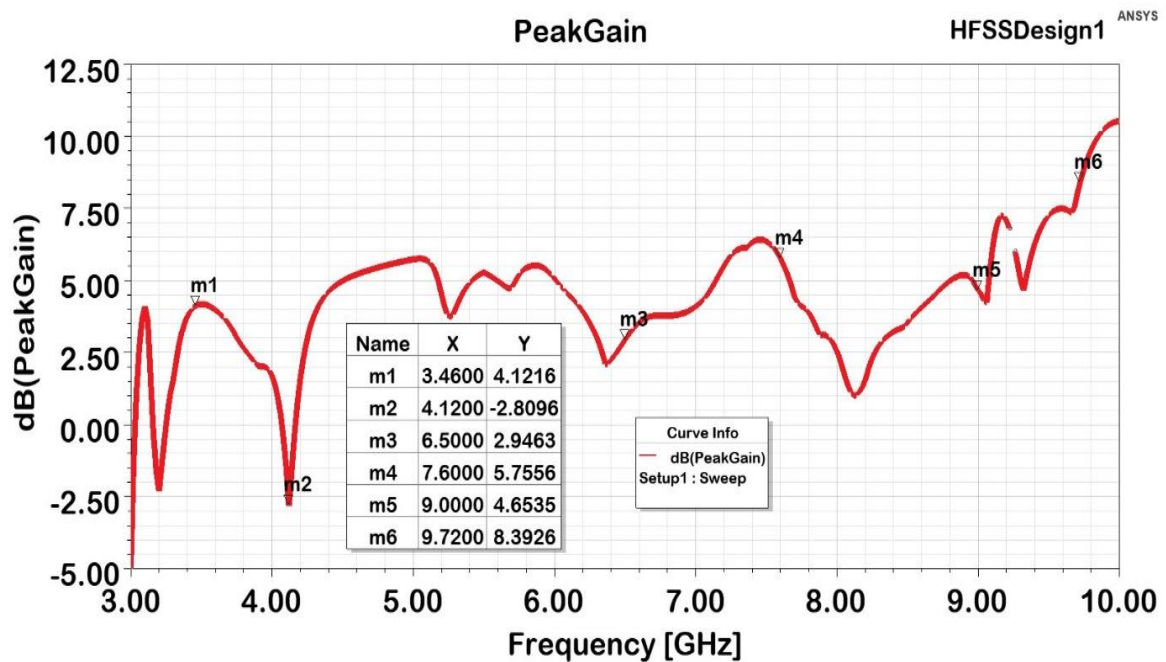


fig 5.6 Peak Gain

5.7 RADIATED POWER:

The power that would have to be supplied to the antenna *on the satellite* if that antenna radiated equally in all directions. If the antenna on the satellite radiated equally in all directions, a typical transmitter output power on the satellite would be somewhat above 3,000 watts. This is hardly practical, but then the satellite does not need to radiate signal in all directions. It is necessary only to radiate a signal in the direction of that portion of the earth that is to receive the signal. By concentrating power in that direction, the power required on the satellite is reduced drastically. The radiated power of the proposed antenna are 3.46 GHz – 30.6414, 4.12 GHz – 22.7856, 6.5 GHz – 24.8623, 7.6 GHz – 28.6142, 9 GHz – 28.0939, 9.72 GHz – 29.1350. It is shown in fig 5.7.

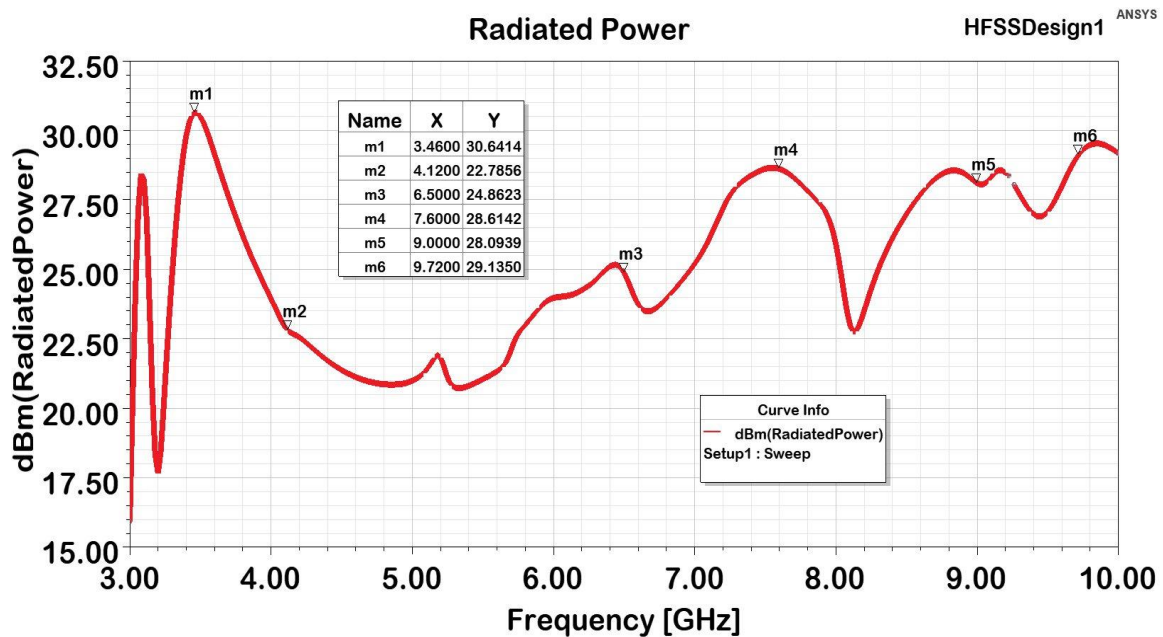


fig 5.7 Graphical Representation of Radiated Power.

5.8 FRONT TO BACK RATIO:

The Front to Back Ratio (F/B Ratio) of an antenna is the ratio of power radiated in the front/main radiation lobe and the power radiated in the opposite direction (180 degrees from the main beam)

$$\text{Front to Back ratio} = \frac{\text{Forward Power (F)}}{\text{Backward Power (B)}}$$

This ratio tells us the extent of backward radiation and is normally expressed in dB. This parameter is important in circumstances where interference or coverage in the reverse direction needs to be minimized. The front to back ratios of the proposed antenna are 3.46 GHz – 1.1608, 4.12 GHz – 0.8136, 6.5 GHz – 9.0450, 7.6 GHz – 4.9868, 9 GHz – 10.9794, 9.72 GHz – 4.0239. It is shown in fig 5.8.

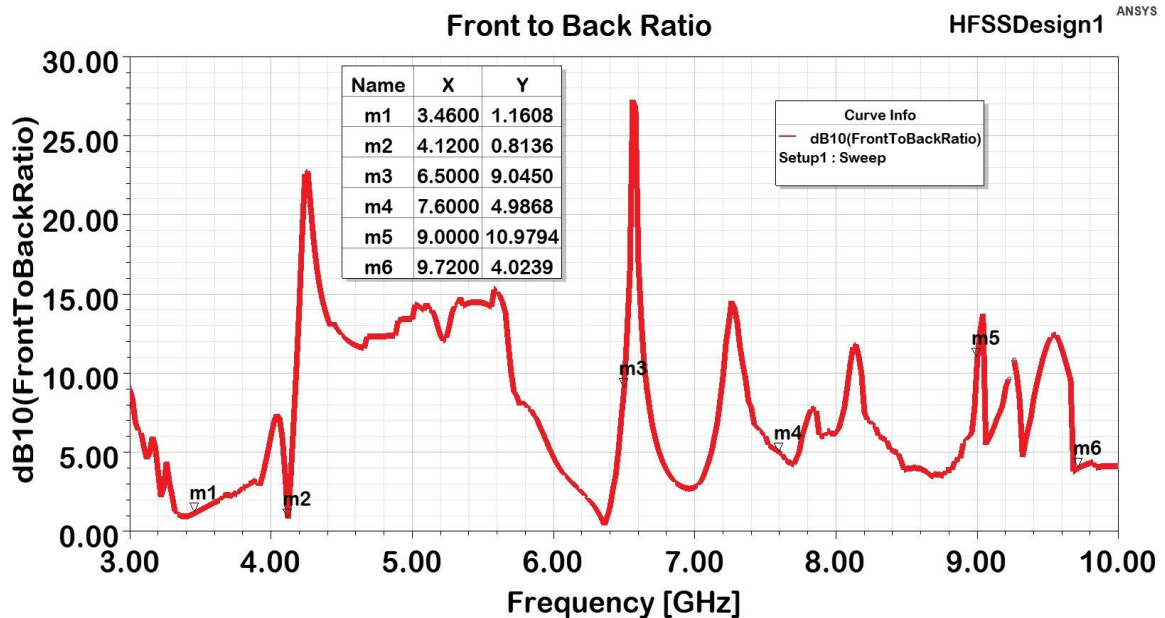


fig 5.8 Graphical Representation of Front to Back Ratio.

5.9 ACCEPTED POWER:

Mismatch loss in transmission line theory is the amount of power expressed in decibels that will not be available on the output due to impedance mismatches and signal reflections. A transmission line that is properly terminated, that is, terminated with the same impedance as that of the characteristic impedance of the transmission line, will have no reflections and therefore no mismatch loss. Mismatch loss represents the amount of power wasted in the system. It can also be thought of as the amount of power gained if the system was perfectly matched. Impedance matching is an important part of RF system design; however, in practice, there will likely be some degree of mismatch loss. In real systems, relatively little loss is due to mismatch loss and is often on the order of 1dB. The accepted power of the proposed antenna on different frequencies are 3.46 GHz – 29.9904, 4.12 GHz – 29.9914, 6.5 GHz – 29.9839, 7.6 GHz – 30.0000, 9 GHz – 29.9972, 9.72 GHz – 29.9236 It is shown in fig 5.9.

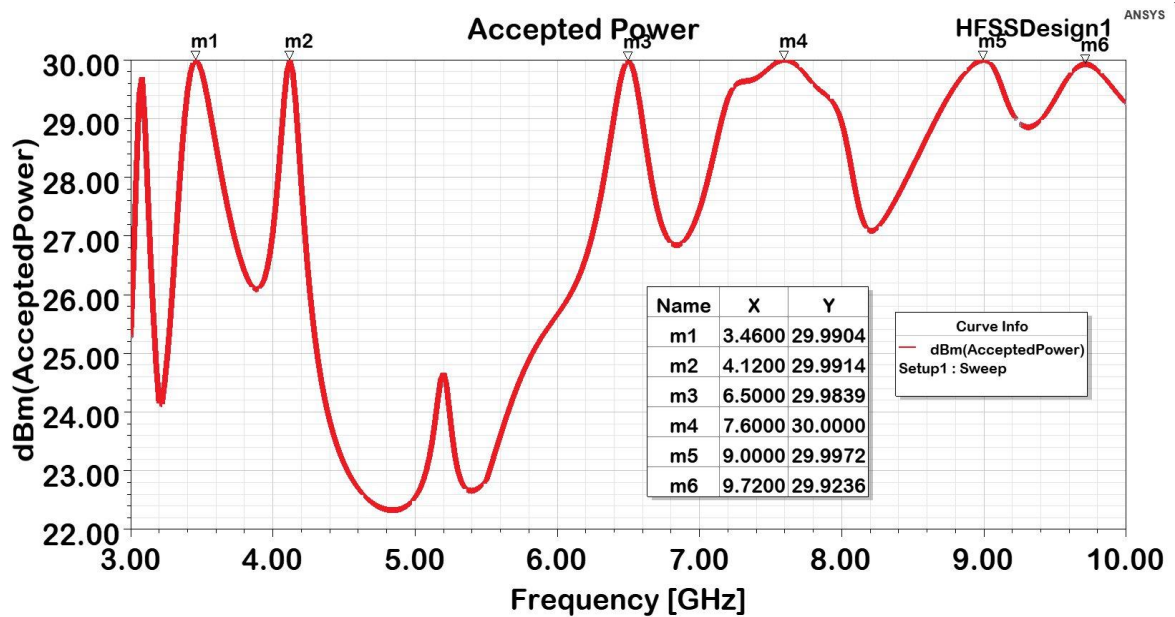


fig 5.9 Graphical Representation of Accepted Power.

5.10 RADIATION EFFICIENCY:

In antenna theory, antenna efficiency is most often used to mean radiation efficiency. In the context of antennas, one often just speaks of "efficiency." It is a measure of the electrical efficiency with which a radio antenna converts the radio-frequency power accepted at its terminals into radiated power. Likewise, a receiving antenna describes the proportion of the radio wave's power intercepted by the antenna which is delivered as an electrical signal. It is not to be confused with aperture efficiency which applies to aperture antennas such as the parabolic reflector. The radiation efficiency of the proposed antenna are 3.46 GHz – 1.1617, 4.12 GHz – 0.1903, 6.5 GHz – 0.2899, 7.6 GHz – 0.7268, 9 GHz – 0.6452, 9.72 GHz – 0.8339. It is shown in fig 5.10.

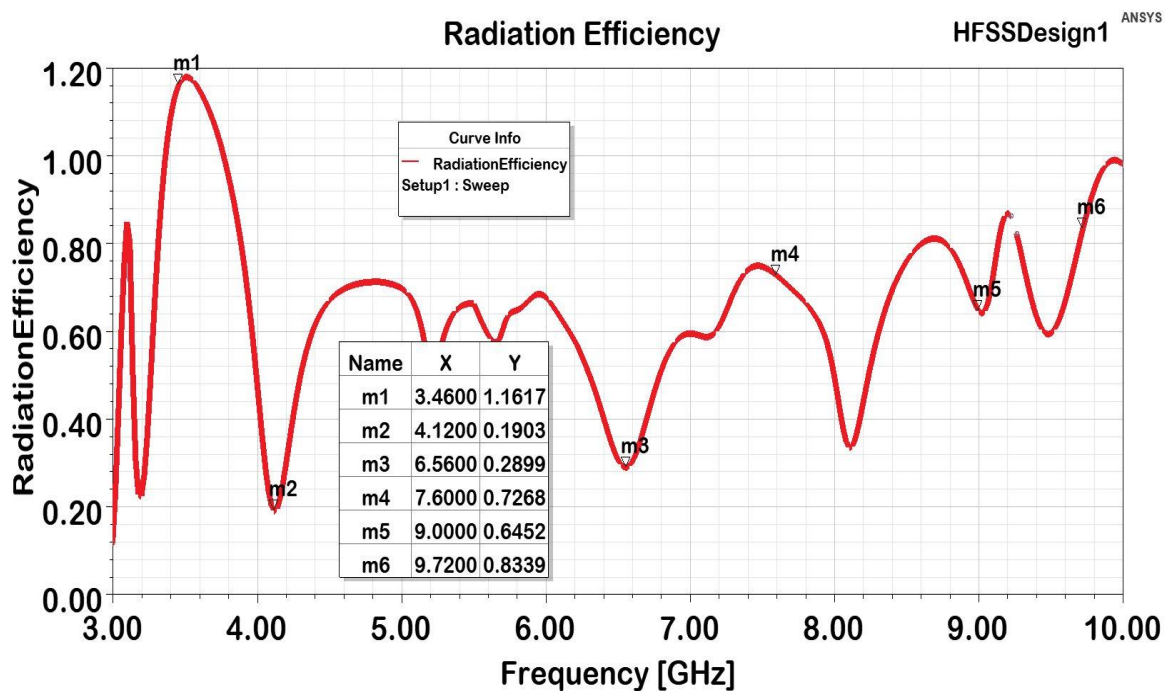


fig 5.10 Graphical Representation of Radiation Efficiency.

5.11 RADIATION INTENSITY:

Radiation intensity, or the antenna power pattern, in a given direction, is defined as the power radiated from an antenna per unit solid angle. The radiation intensity is a far-field parameter that can be obtained by simply multiplying the radiation power density by the square distance. The radiation intensity of the proposed antenna at different frequencies are 3.46 GHz – 0.2051, 4.12 GHz – 0.0416, 6.5 GHz – 0.1562, 7.6 GHz – 0.2995, 9 GHz – 0.2322, 9.72 GHz – 0.5400. It is shown in fig 5.11.

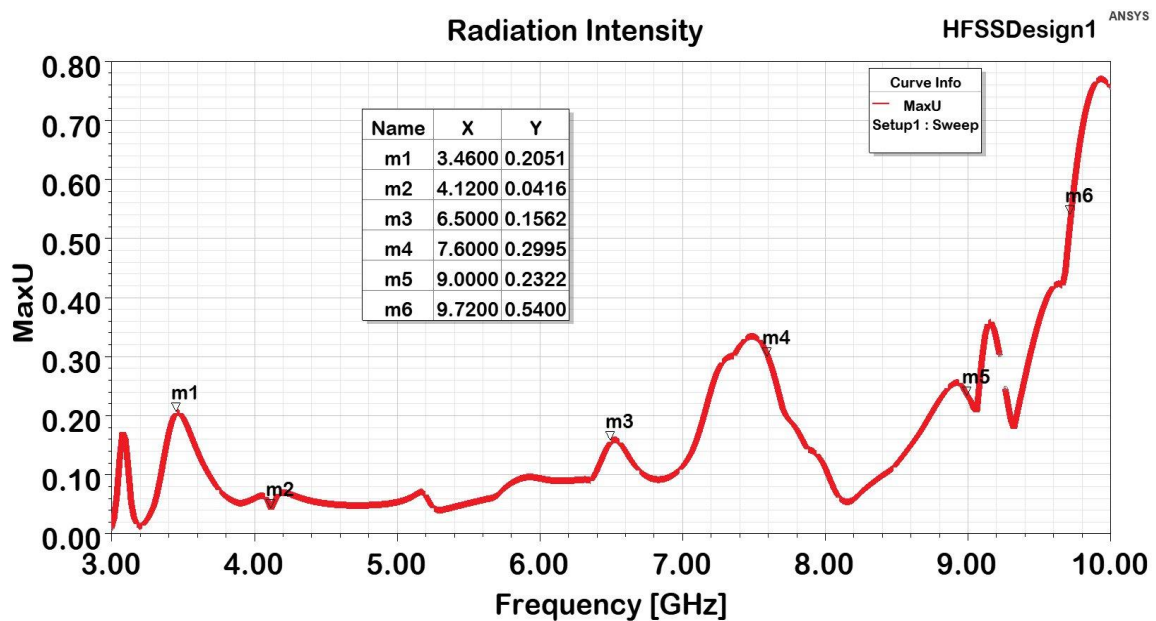


fig 5.8 Graphical Representation of Front to Back Ratio.

5.12 SPECIFIC ABSORPTION RATE (SAR):

Specific absorption rate (SAR) is the measure of the allowable level of EM radiation to be produced by communication antenna in wireless devices. In antenna transmit power is lowered when SAR is too high. It is a measure of the rate at which energy is absorbed by the human body when exposed to a radiofrequency electromagnetic field. It is defined as the power absorbed per mass of tissue and is expressed in units of watts per kilogram (W/kg). The SAR rate in the proposed antenna is zero. It is shown in fig 5.12.

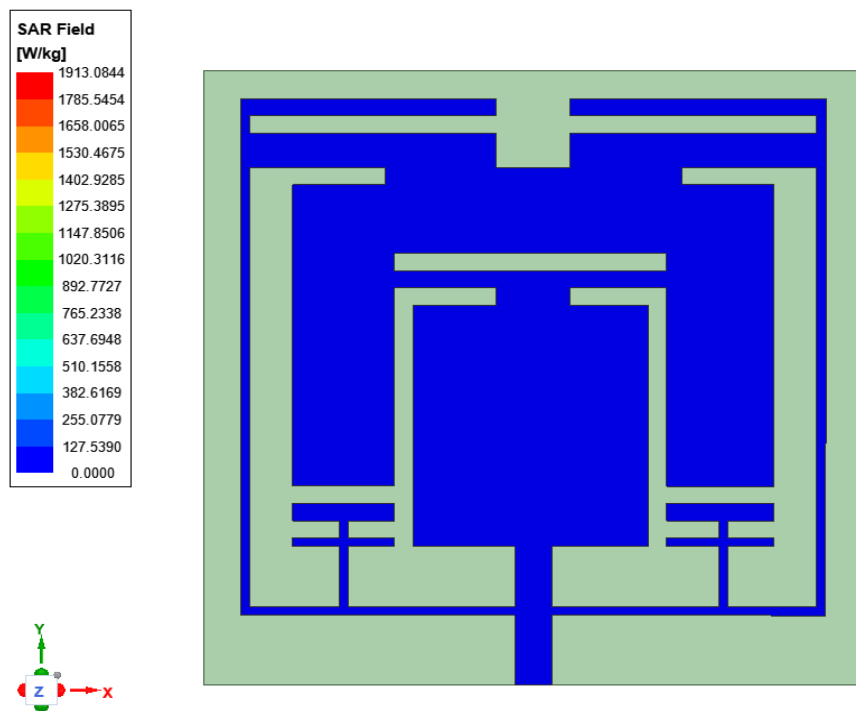


fig 5.8 SAR Rate.

5.13 SURFACE CURRENT:

The surface current antenna is an actual electric current that is induced by an applied electromagnetic field. The surface current is denoted using the letter J . The surface current density is defined as a vector whose magnitude is the electric current per cross-sectional area at a given point in space. The current density is the amount of charge per unit time that flows through a unit area of the chosen cross-section. The SI unit is used to measure the surface current density in amperes per square meter. The surface current loss is very low in the proposed antenna. It is shown in fig 5.13.

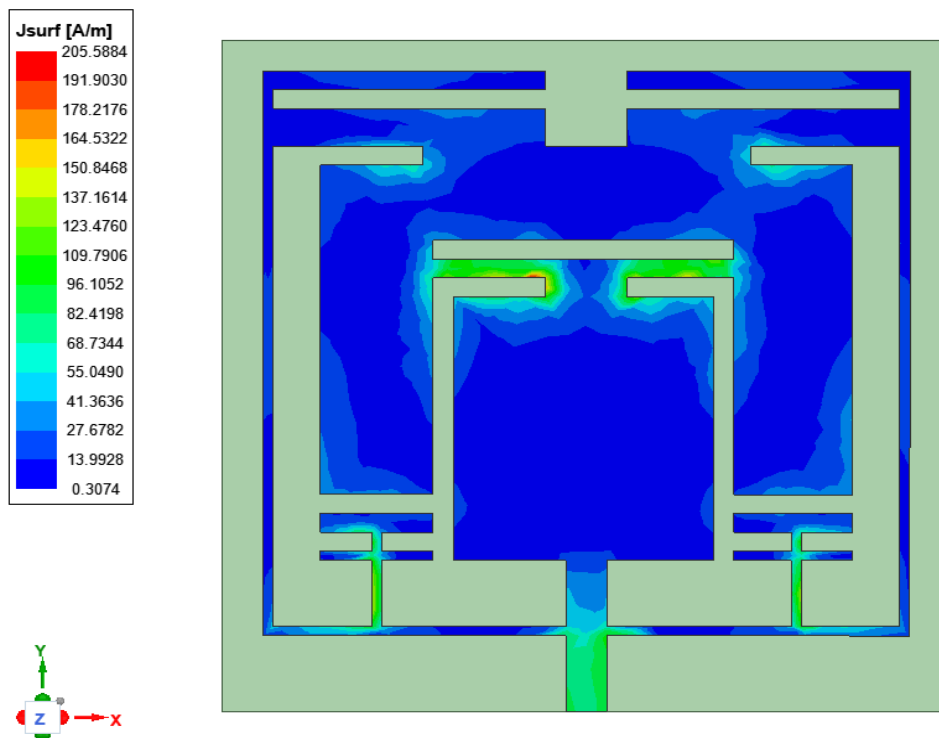


fig 5.8 Surface Current.

5.14 RADIATION PATTERN:

The solar radiation pattern in the field antenna design (either an antenna pattern or a remote field pattern) refers to the radiofrequency energy from an antenna to another source which is directly dependent. It is shown in fig 5.14.

Especially in the field of fiber optics, lasers, and composite optics, radiation patterns can be used as the same name for a nearby field pattern or Fresnel pattern. This means depending on the state of the electromagnetic field in a nearby field, or the Fresnel region of the source. A nearby field pattern is best defined by a plane placed in front of the well, or above a circular or circular area that encloses it.

The remote field antenna pattern may be determined by experimenting with the antenna range, or else, the proximity field pattern can be detected using a nearby field scanner, as well as the radiation pattern extracted from it. The remote radiation pattern can also be calculated from antenna design by EM Software such as HFSS.

The Radiation pattern are determined using azimuth and elevation angle and the smith chart representation of the proposed antenna is given in fig 5.14(a), (b), (c), (d), (e), (f).

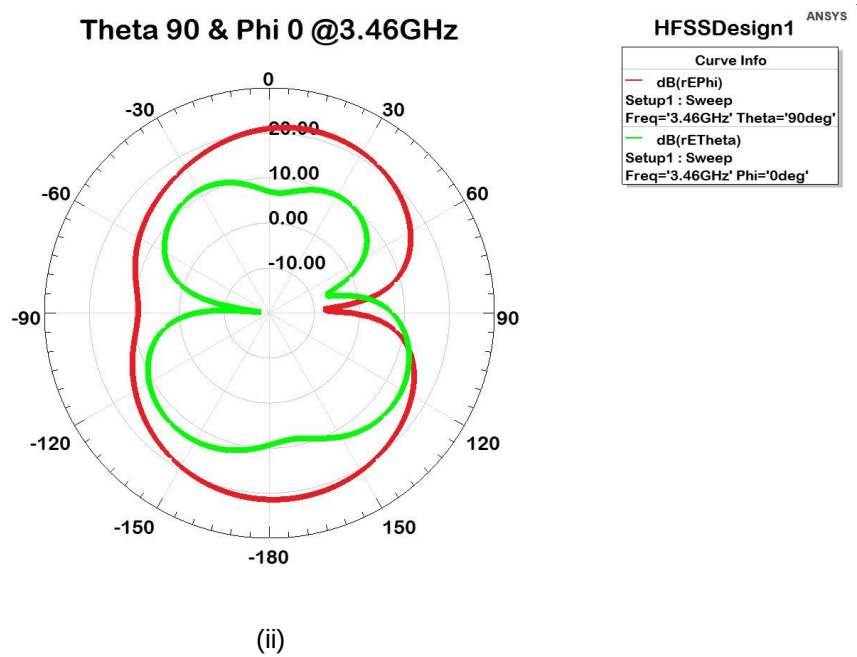
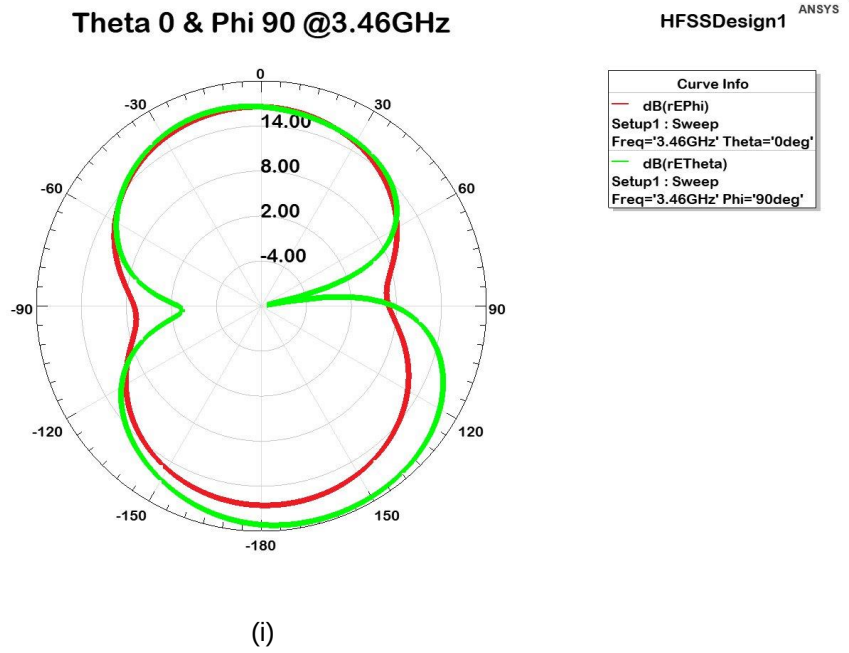


fig 5.14(a) The Radiation pattern at frequency 3.46 GHz.

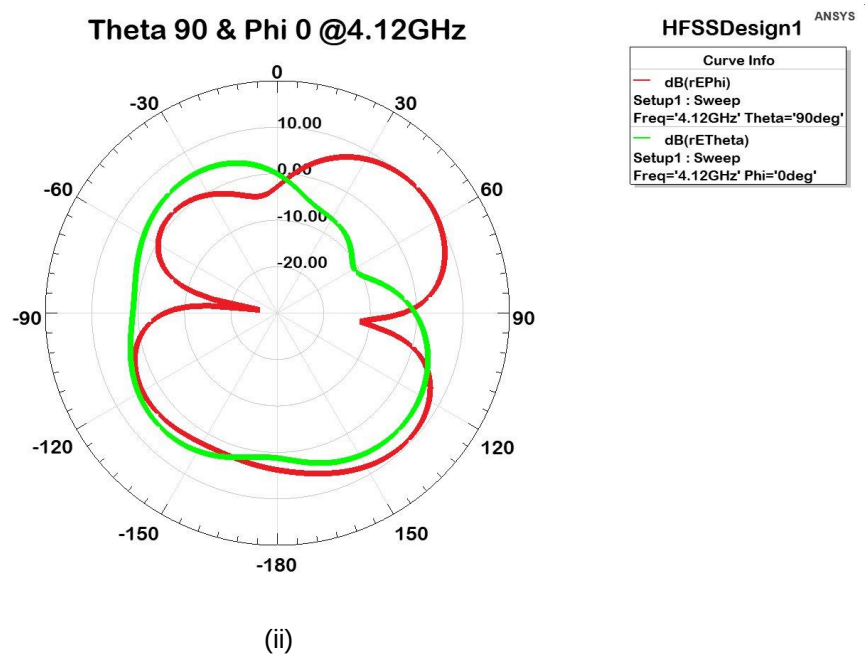
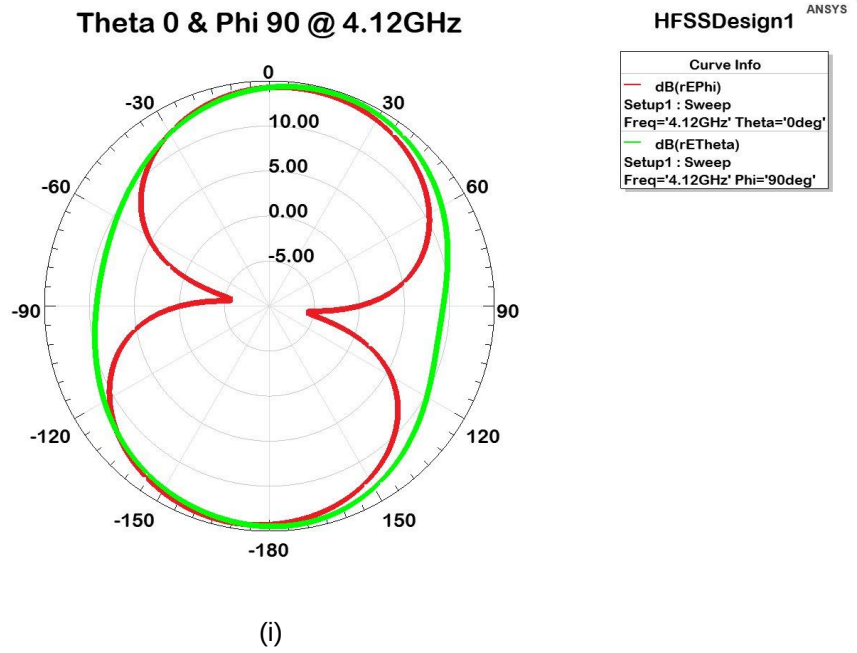
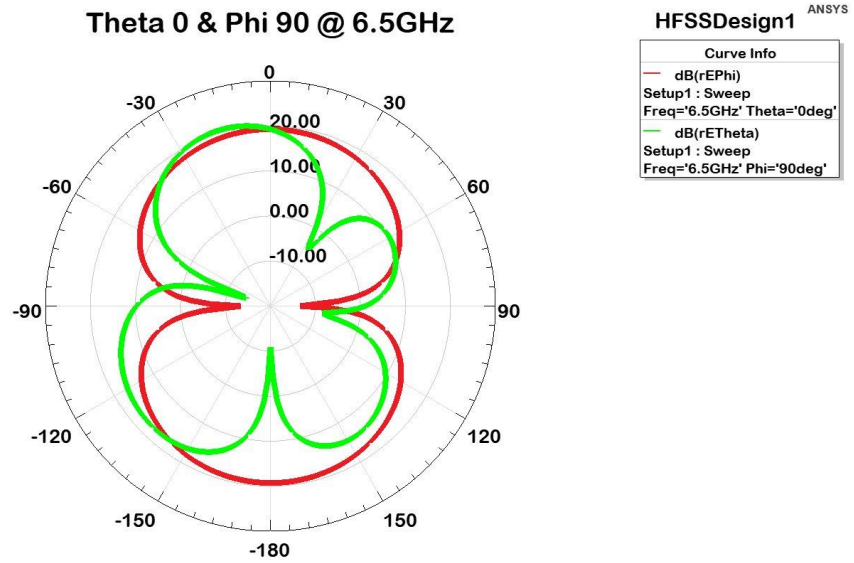
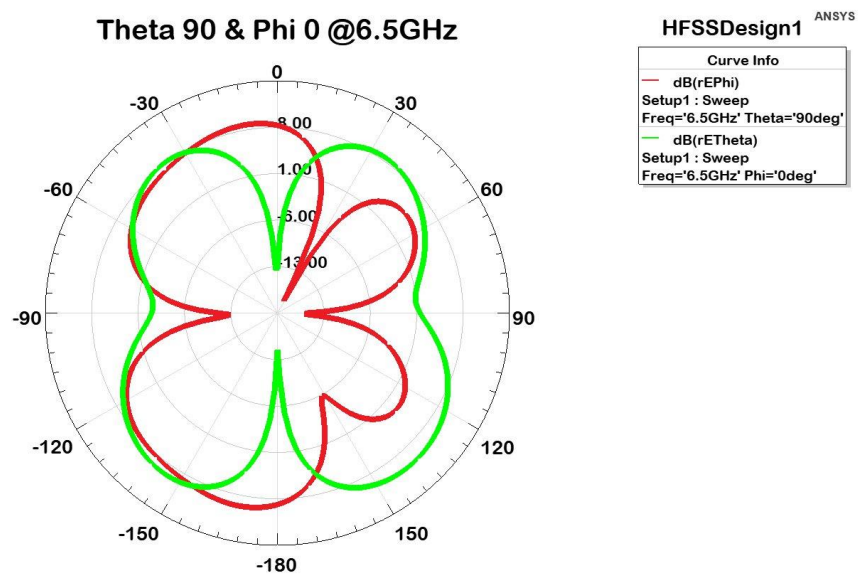


fig 5.14(b) The Radiation pattern at frequency 4.12 GHz.



(i)



(ii)

fig 5.14(c) The Radiation pattern at frequency 6.5 GHz.

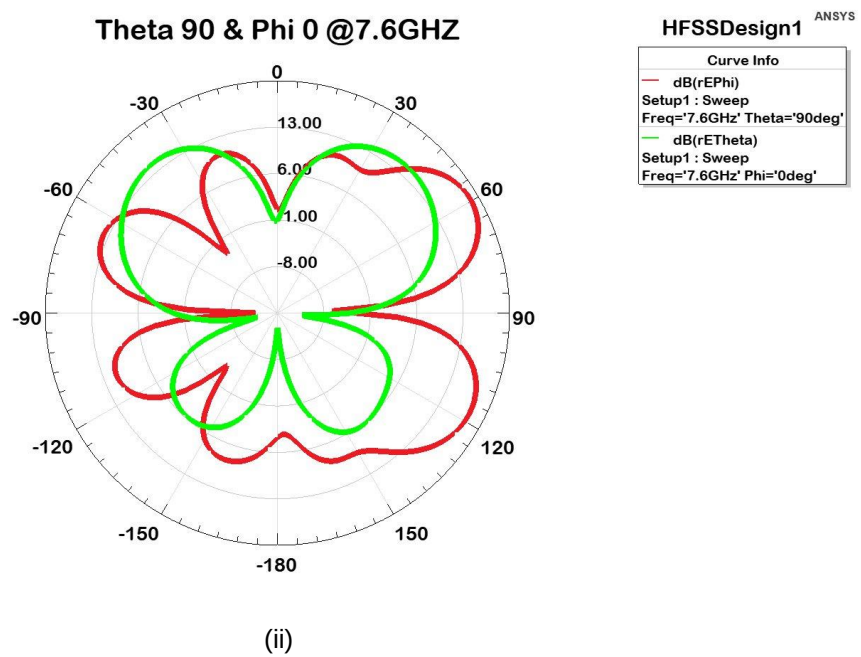
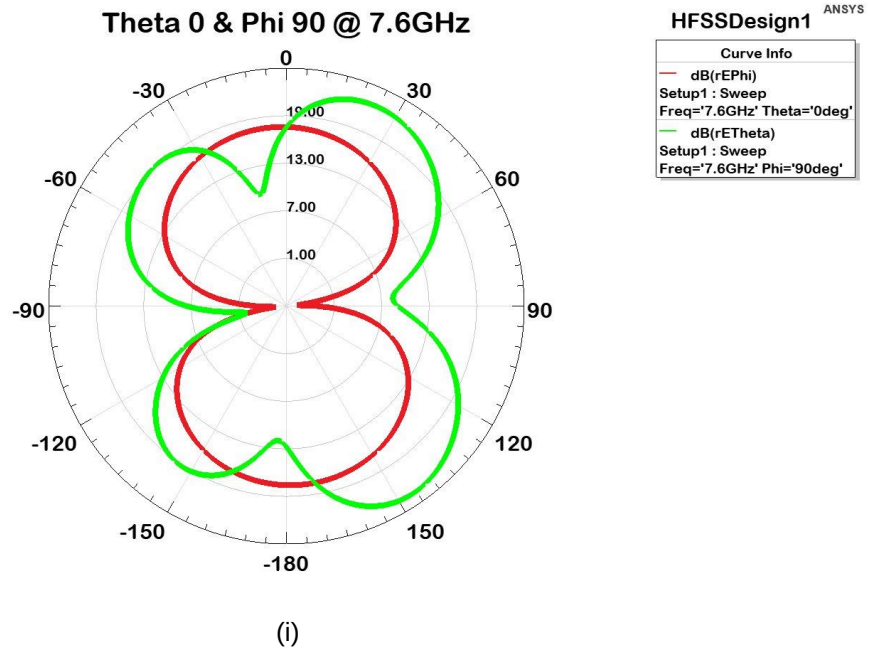


fig 5.14(d) The Radiation pattern at frequency 7.6 GHz.

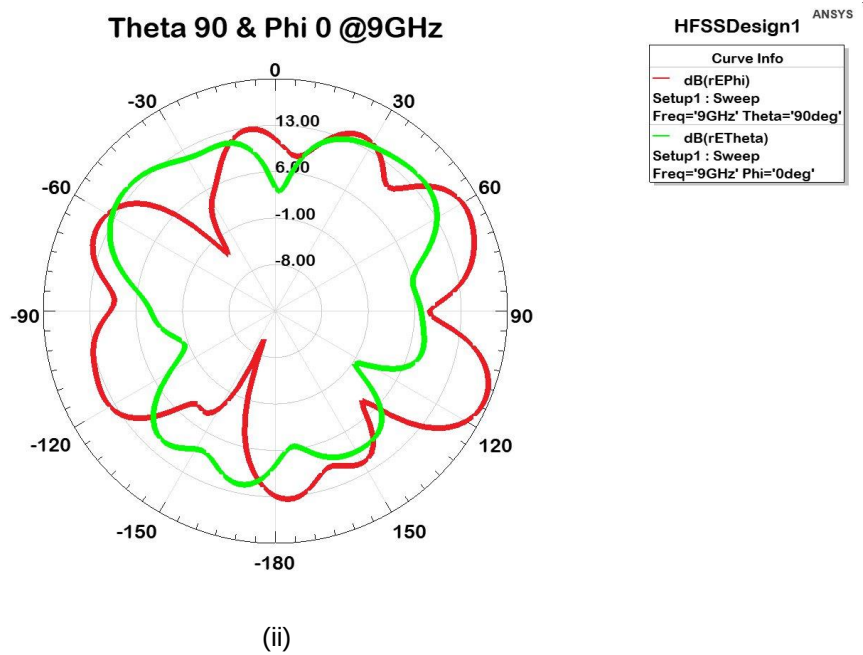
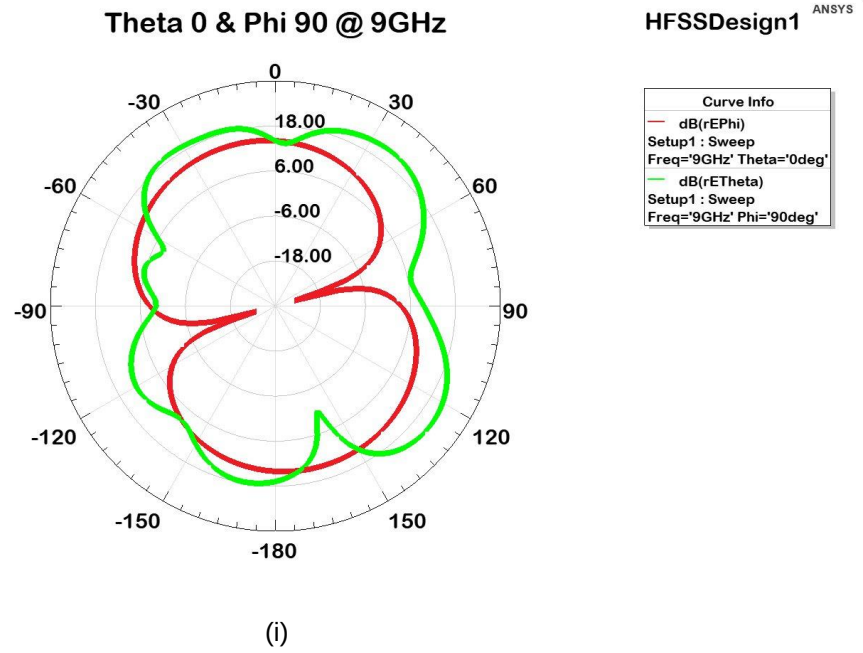


fig 5.14(e) The Radiation pattern at frequency 9 GHz

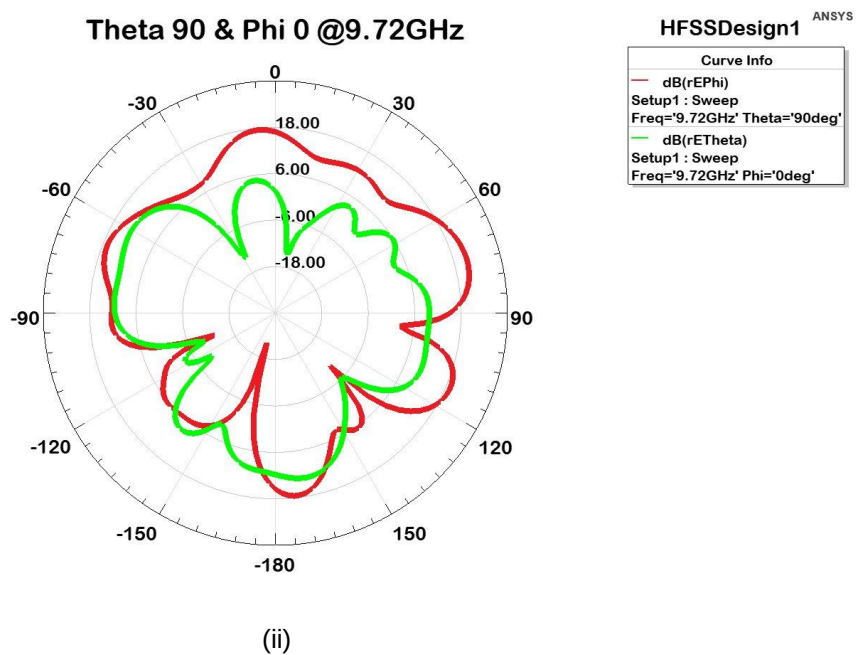
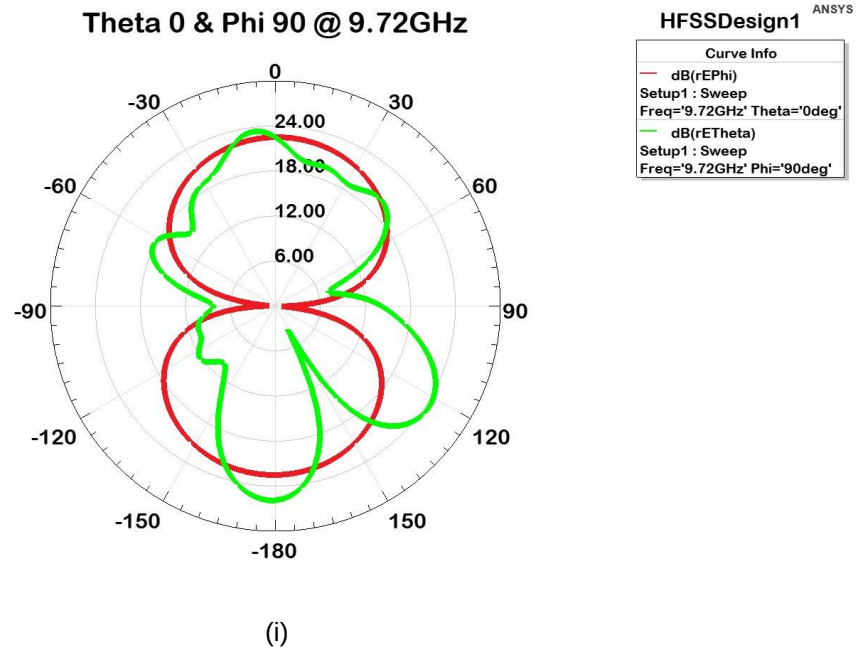


fig 5.14(f) The Radiation pattern at frequency 9.72 GHz.

CHAPTER – 6

CONCLUSION AND SUMMARY

A stripline-fed fractal-inspired antenna is designed for multi-band operation. The H-shaped slots defect in the ground and all this technique contributed to the resonance of multiband frequency at 3.46 GHz, 4.12 GHz, 6.5 GHz, 7.6 GHz, 9 GHz, and 9.72 GHz respectively. The proposed fractal-based antenna is fabricated and its S11 parameters are measured in Anritsu VNA. The simulated results are closer to that of the measured results so in real-time it can transmit the data most efficiently in all the resonated frequency. The existing fractal antenna works in different frequency simultaneously yet does not provide with high gain, directivity, efficiency, VSWR, low loss, and since the stimulated value are closer to the result of real time value, the proposed antenna can be used in all future multiband wireless communication.

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