

A Meander Line Microstrip Patch Antenna for Adaptive - GPS Application and Mid-Band 5G Spectrum

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

By

Shyam Parthasarathy (37130379)



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

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

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

MARCH - 2021



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www.sathyabama.ac.in

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of Shyam Parthasarathy (37130379). who carried out the project entitled “**A Meander Line Microstrip Patch Antenna for Adaptive - GPS Application and Mid-Band 5G Spectrum**” under the supervision from

Internal Guide

Dr. G. JEGAN, M.E., Ph.D.

Asso. Professor, Department of ECE

Head of the Department

Dr. T. RAVI, M.E., Ph.D.

Submitted for Viva voce examination held on _____

Internal Examiner

External Examiner

DECLARATION

I, **Shyam Parthasarathy (37130379)** hereby declare that the Project Report entitled “**A Meander Line Microstrip Patch Antenna for Adaptive - GPS Application and Mid-Band 5G Spectrum**” done by us under the guidance of **Dr. G. JEGAN** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Electronics and Communication Engineering.

1. 

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PLACE:

SIGNATURE OF THE CANDIDATES

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ABSTRACT

This project describes the design of a meander line shaped patch antenna to operate for an adaptive global positioning system (A-GPS) which is used in marine radio systems and mid-band 5G applications. To achieve integration in the micro-strip patch antenna, we will use different things such as DGS (Defective Ground Structure) and Meta-material to get the best result from the proposed MSPA. The material used in this meander line shaped antenna is FR-4 with the value of 4.4. The structure has been updated and analysed using HFSS, which provides a high degree of accuracy in the updated results. The field antenna is suitable for Mid-Band 5G applications.

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CHAPTER-1

INTRODUCTION

An antenna is called the device for the transmission and receiving of signals. An individual who needs a thought, idea, or doubt can do so through voicing. Communication occurs via sound waves. However, if two people want to communicate at longer distances, these sound waves have to be transformed into electromagnetic waves. An antenna is known as the device which converts the required signal to electromagnetic waves. An antenna is an electric power transducer that turns electric power into electromagnetic waves and vice versa. A transmission antenna or reception antenna can be used. An electromagnetic wave transmitting antenna converts and radiates electrical signals. The electromagnetic waves in the received transmission beam are converted into electrical signals by a transmitting antenna. In an end-to-end communication, the same transceiver can also be utilized for transmitting a beam plus receiving the beam. Whenever wireless networking is necessary, the necessity of an antenna arises in the field of communications systems [1]. For the purpose of communication, an antenna is able to send or receive electromagnetic waves in order to set up a cable system.

WIRELESS COMMUNICATION

Wireless flow of information over a long distance occurs without the use of wires, cables, or other types of electric conductors. Wireless communications comprise the full range of wireless communications techniques and devices which incorporate all the connection and communication processes between two or more devices using the WLAN signal.

Block diagram of a wireless communications:

The transmitter, Channel and Receiver are the three elements which can be separated from a typical wireless communications system.

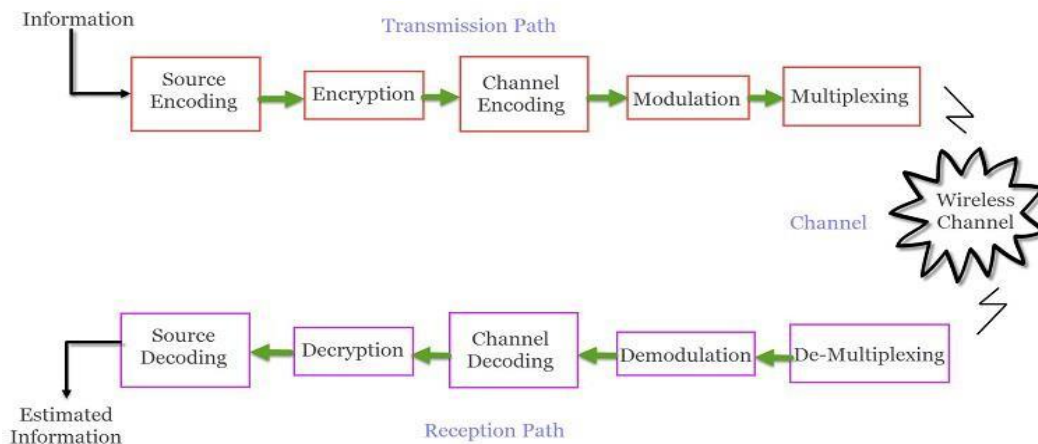


Fig: 1.1 Block diagram of Wireless Communication

The transmission path:

The Encoder, Encryption, Modulation and Multiplexing is a standard transmission track of a wireless communication system. The source signal is transmitted via an input encoder that transforms the signal into a format appropriate for signal processing.

In this process, overlapping signal data is removed to maximize resource use. Signal encryption is then carried by a Security Norm, to protect both the signal and the theft of information.

Encoding for channels is a technology used to reduce signal deficiencies such as interference, noise, etc. Throughout this procedure, the signal is introduced to a small amount of redundancy, which makes it resistant to noise. The beam is then modulated with the appropriate techniques (such as QPSK, PSK, FSK etc.) to enable antenna transmission of the signal.

The modulated signal is subsequently multiplied by other signals using a number of multiplexing technologies such as Time Multiplexing Division (TDM) or FDM to make use of the limited bandwidth.

The channel:

The wireless channel shows the transmission medium of beam, for instance: space. An unpredictable channel which is also extremely valuable plus nature's unpredictability. The signal received may be filled with error, and this may lead to interference, distortion, noise, dispersal, etc.

The reception path:

The receiver's role is to accumulate and replicate the input beam from the channel. The receive system path includes demultiplexing, demodulation, decoding of channels, decoding of sources and decoding of sources. From the reception path components, it is evident that the recipient's function is just the other way round.

The Demultiplexer receives the signal from the channel and is distinct from other beams. Signals are demodulated individually using the proper methods, plus the actual message signal can be retrieved if necessary. With the channel decoder, the foiled are eliminated from the packet.

Signal decryption eliminates the encryption of the message and reduces it to a simple bit series. Lastly, the source decoder receives this signal for returning the original message or signal transmitted.

Features of wireless communication

With many effective features, the development of wireless technology has led to advances.

The distance transmitted can be between a few meters and thousands of kilometres (such as remote control) (for example, radio communication).

Wireless - Advantages

Without a two or more points that are physically bounded, wireless communication involves the transfer of information. Since there is no infrastructure (physical), there are certain merits to wireless communication. Frequently this would include collapse of distance or room.

There are many advantages to wireless communication;

Cost effectiveness

Connection wires are used by wired communication. Communication in wireless networks requires no detailed physical or maintenance infrastructures. The costs are therefore lowered.

Flexibility

Wireless networking helps people to communicate regardless of geographic location. To receive messages, it is not required to stay in an office or a telephone stand

Convenience

Mobile phones and other wireless networking equipment are very straightforward to use, allowing us to use them anywhere. To receive or pass messages, there is no physical connection required.

Speed

Speed enhancements can also be seen. Accuracy and speed were greatly improved for network connectivity or accessibility.

Accessibility

Wireless technology facilitates easy access as ground lines are easily connected to the network in remote areas that cannot be properly laid.

Constant connectivity

People can also respond quickly to crises or emergencies owing to constant connectivity.

The following are amongst the most significant Wireless Communication Systems on the market today:

- Broadcasting Radio and TV
- Satellite communication with a radar mobile telephone (Cellular Communication)
- System of Global Positioning
- Wireless Fidelity is free (Wi-Fi)
- Cordless phones Bluetooth Paging
- Identification of radio frequency (RFID)
- Communication infrared

MICROSTRIP PATCH ANTENNA:

Low-profile antennas are micro strip antennas. A micro stripe or patch antenna is a metal plot mounted on a floor with a di-electric material in between. These antennas are very small and have low radiation [2,3].

Micro strip transceiver consisting of a very slim metal strip on a plane, with an intermediate di-electric medium. The radiating element and power lines are mounted on the dielectric material using a photo-etching technique. The square, circular or rectangular patch or micro strip is generally designed to facilitate analysis and production [4].

Frequency range of patch antennas:

For applications with low profile at frequencies above 100MHz, the patch antennas are popular.

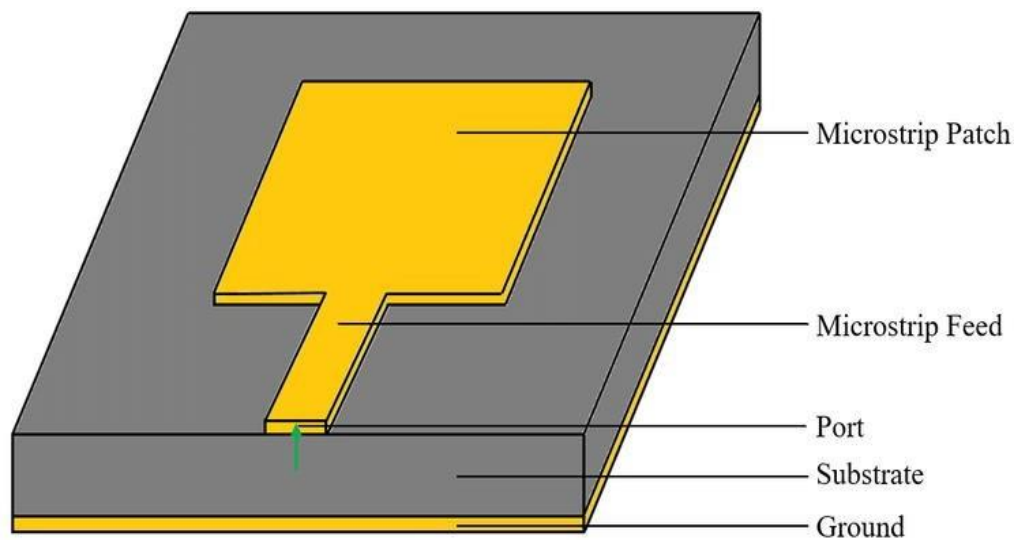


Fig: 1.2: Microstrip patch antenna

Different feeding techniques

A feedline is used for direct or indirect contact radiation. There are a number of different feeding techniques [5,6]. Four most popular techniques include coaxial probe feeding, microstrip connection, opening connection and close connection.

Coaxial probe feeding

The antenna's radiation patch is connected to a coaxial internal conductor, while the ground plane is connected to the outer conductor, in order to feed coaxial sensors. The advantages of coaxial feeding are that it is simple to manufacture and fit. The drawbacks are that it generates low spurious radiation and has a short bandwidth.

Microstrip line feeding

One of the easier methods to make Microstrip line feed is like a single leading band integrating to the patch, and thus can be called a patch expansion. It's simple to model and fit the inset location. The drawback of this procedure, however, is that with the substrate's increased thickness, the bandwidth is limited by the rise in surface wave and falsely fed radiation.

Aperture coupled feeding

The opening connected feed comprises two separate substrates, a terrestrial plane which separates them. The feed line should be positioned on the underside of the lower substrate, plus its energy will be connected via a hole in the ground that separates the two di-electric substrates. The feed mechanism and the radiating feature can both be optimised independently with this device. Upper layer of substratum normally uses a thick low dielectric substratum while it is a higher dielectric substrate for a lower substratum. The middle ground plane isolates from the radiation factor, reducing fake radiation disturbance for pattern formation as well as polarisation integrity. Benefits allow indeptibility.

Proximity Coupled feeding

Close connection has the largest bandwidth, low falsified radiation. The manufacture, however, is hard. The match is controlled by stub feeding length and patch width-to-length ratio. It is capacitive in nature in its coupling mechanism. The main disadvantage of this feeding technology is that due to the two dielectric layers which need proper harmonization, it is hard to produce. The overall thickness of the antenna is also increased. The various structures of the Microstrip antennas are available in the wide variety of antenna models, but the antenna has 4 basic parts: It is the following:

- The patch
- Dielectric Substrate
- Ground Plane
- Feed Line

Advantages of Micro strip transceiver:

The following are the advantages of Micro strip transceiver:

- Ease of installation
- Minimal rates
- Light weight [7].

Disadvantages Micro strip transceiver:

The following are the drawbacks of Micro-strip transceiver:

- Inadequate radiation
- Bandwidth of narrow frequency [8].

Applications of Micro strip transceiver:

The following are applications of Micro-strip transceiver:

- Applications are utilized in spacecraft
- Applications are utilized in aircraft
- Used for applications with low-profile antennas.

DEFECTED GROUND STRUCTURE

A defective ground structure (DGS) on the floor of a printed microstrip board is a deliberately created defect. It is usually created in the shape of an out-of-the-ground pattern. It is also one of the techniques of antenna optimization that are used to produce the desired results. DGS is a simplified structure for electromagnetic strip gap (EBG). This EBG is a periodic model with a band stop property, but the DGS consists of either one defect or a very small number of defects with periodical/apperiodic configurations.

DGS for channels below the microstrip line was initially reported. Deficient Ground Structure is used under the microstrip to accomplish band stop features and to eliminate harmonics and common connectivity of higher mode. DGS has been used in the microstrip antennas field in order to increase bandwidth and microstrip transceivers gains, furthermore, to stifle harmonics of the greater mode, mutual interconnection between the contiguous component and cross-extremity to improve the microstrip transceiver's radiation properties [9].

DGS was incorporated into the plane with a planar exchange line, i.e. microstrip, coplanar waveguide, and a coplanar waveguide, backed by a conductor. Defects on the ground disturbs the plane's existing conveyance, which changes the properties of an exchange line (or design) for certain boundaries (opening opposition, space capacitance and space inductivity) in line boundaries (line obstruction, line capacitance, and line inductance). Eventually, the viability of the limit and inductance of microstrip line can be changed by adding an opening strength, capacitance or acceptance in the dirt under a microstrip line.

MID-BAND 5G SPECTRUM

The 5G is the next generation of the 4G network [10]. Most of business 5G organizations are depending on range inside the 3.3 - 3.8 GHz range. Different groups which work for 5G incorporate 1.8, 2.3 and 2.6 GHz. The range of Mid-Band 5G is in between 1.7 – 2.8 GHz. This frequency band is suitable for 5G baseband communications, Maritime Radio, A-GPS, Virtual Reality and Augmented Reality. The frequency range for A-GPS is also between 1.54 – 1.575 GHz. The frequency range of Virtual is 1.7 – 2.1 GHz. This means that this antenna is a multi-purpose antenna.

CHAPTER - 2

LITERATURE SURVEY

Compact Dipole Antenna Based on Meander Line Structure for Unmanned Aerial Vehicle Application

AUTHOR: R. Rahardi, M. Rizqi, W. D. Lukito, M. Hilmi, R. Virginio and A. Munir

This paper concerns a compact, 433 MHz dipole antenna which is nothing but an ISM band for aerial vehicles without a man (UAV). FR4 Epoxy Resin with a density of 1.5 mm shall be the dielectric material or dielectric substratum used here. The antenna is 232.5 x 16.4 mm² in size. The return loss of this antenna is -17.19 dB. The profit amounts to 1.82 dBi. These are results obtained by simulation.

The real time measurement values are Return loss = - 20.17 dB, Gain = 0.79 dBi. This antenna exhibits an Omni - directional radiation pattern.

A Compact Multiple Slot Microstrip Antenna for Modern Mobile Communications

AUTHOR: M.Sugadev, Dr. E. Logashanmugam

This paper deals with a compact three-band antenna microstrip. At 3.6 , 5.6 and 7.9 GHz the frequency at which the antenna resonates. The triple band antenna design was miniaturized here. Due to its rigid structure and the loss of the substrate used here, FR-4 Epoxy resin. For the triple band, both simulation and measured results, the antenna has achieved a s11 value of less than -10 dB. For this antenna, the VSWR value is under 2 and the gain is 0.86 dB. The antenna's dimensions are 13.6 x 13.6 mm² and thus the substratum used is a square substratum.

Design of Meander Line Triple Band Antenna for Wireless Applications

AUTHOR: S. Nej and A. Ghosh

This paper concerns a patch antenna for the microstrip line. This antenna is suitable for MIMO purposes. It's a small electrical transceiver with a zig - zag or slim folded cable structure. Simulated antenna values for this antenna regarding the directives, front to rear ratio, plus the patterns of radiation are considered to be acceptable. The transceiver has the size $0.375 \times 0.375 \lambda^2$ for which the wavelength in wave propagation is λ . A square substratum is the substratum used here. It will be suitable for MIMO applications since it is a compact size antenna.

Design of meander line antenna for wearable applications

AUTHOR: R. Monisha and B. Bhuvaneshwari

This article is about the antenna in the form of a meander line which is intended for operation at 2.45GHz. FR4 having a permittivity value equals to 1.6 plus density equals to 3.6 mm are the dielectric material or dielectric substrate used here. The dimensions of the substrate is about 13 x 28 mm; this makes as a rectangular substrate the return loss is achieved to be 37.9 dB and the gain is said to be 2.3 dB and the VSWR value is below 2 and acceptable. The antenna resonates from 2.4 to 2.53 GHz with the bandwidth of 120 MHz.

A Modified Meander Line Microstrip Patch Antenna with Enhanced Bandwidth for 2.4 GHz ISM-Band Internet of Things (IoT) Applications

AUTHOR: M. Shahidul Islam, M. T. Islam, M. A. Ullah, G. Kok Beng, N. Amin and N. Misran

The antenna dimensions are 40 x 10 mm². The substratum is rectangular; the simulated radiation efficiency of this antenna is 1,347 dBi. This article is a modifiable meander-line microstrip patch antenna that have been introduced for Internet of Things applications at 2.4 GHz. The dielectric material or dielectric substratum used for this application is FR4 Epoxy resin while the relative permeability level of 4.4 and a thickness of 1.6 mm.

Design of Microstrip Patch Antenna on Rubber Substrate with DGS for WBAN Applications

AUTHOR: N. Sakib, S. N. Ibrahim, M. Ibn Ibrahimy, M. S. Islam and M. M. H. Mahfuz

This paper concerns a microstrip patch antenna for the use of the substratum or dielectric material in the Wireless Bodily Network (WBAN), which is said to be 3.1 rubber permitted and 1.88 mm thick. The designed antenna operates within the ISM range with a temperature of about 2.4 GHz.

In order to improve antenna performance, the deficient ground-structure (DGS) technology is utilized. In order to modify the transceiver's base structure, the DGS is implemented in the soil. DGS is a technology that can decrease VSWR, increase the loss of return and increase surface current, which is why we can say it improves the performance of the antenna. With this DGS technology, the gain is increased by 7.5%. The loss of return for the antenna is -37,33 dB at 2.4 GHz. The VSWR is 1.03, lower than 2, and is therefore acceptable. The radiator patch has achieved an increment of 3.4 dB and the greatest radiation effectiveness surpasses 60%. The computer simulation software (CST) was used to design, simulate and analyse the antenna performance.

A High Gain Microstrip Patch Antenna with Slotted Ground Plane for Sub-6 GHz 5G Communications

AUTHOR: Olawoye, Taiwo & Kumar, P

This article is on the slotted ground-mounted patch antenna for wireless communications of sub-6 GHz 5th generation. The defective ground structure (DGS) technique has now been introduced. In the ground level, there is a "C"-shaped slot. FR4 epoxy resin is used as the dielectric material or the dielectric substratum. The relative permeability is 4.4 and insert feeding technology is used here. The antenna is 28.03 x 23.45 mm² in size. This clearly shows that the rectangular substratum used here resonates between 4.8 GHz and 5 GHz in the sub-6 band in 5G communications. The transceiver's maximum gain is 5.49 dB, the directivity maximum is 7.12 dB. The CST studio suite simulates and optimizes this antenna.

Design Array Antenna Using Different Feeding Technique in HFSS

AUTHOR: K. DurgaRao and K. N. Pillai

This article deals with antennas in a design array using various feeding methods. Corporate feeding and series feeding techniques are the feeding methods used here. The return loss is -27.57 dB for a single microstrip antenna. VSWR 1.083 with 7.2601 dB of gain. The return loss is -10.5767 dB in series feed technique, 1.8406 for VSWR, 12.28 dB for Gain. The S11 parameter in corporate feed -29.818 dB, VSWR is 1.0668 and a profit of 13.5 dB. The design was optimized with HFSS software and simulated.

Design and analysis of insert-fed reconfigurable antenna for 5G (sub-6GHz) applications

AUTHOR: M. Vinoth, J. Belbin Lijjo, S. Allen, Dr. M. Sugadev

This paper is about the microstrip patch antenna for 5G (Sub-6GHz) applications. The dielectric substrate or dielectric material used in this antenna is FR-4 epoxy resin with permittivity of 4.4. The dimension of this antenna is 35.6 x 35.6 mm². The dimensions clearly convey that the substrate used is a square substrate. The thickness of the substrate is 1.1mm. The frequency at which the antenna resonates is 3.5 GHz and 6.68 GHz. The gain of this antenna is 3.2 dB. The return loss of this antenna is -23 dB for 3.5 GHz and -21 dB for 6.86 GHz. The minimal rated loss is achieved at 3.5 GHz which clearly indicates that this antenna is suitable for 5G wireless applications.

Design and Implementation of Microstrip Patch Antenna for 5G applications

AUTHOR: J. Colaco and R. Lohani

This paper discusses the 5G microstrip patch antenna with a resonating frequency of 26 GHz. This paper is used on 5G millimetre. Specifications in India for the Radio Frequencies Spectrum range from 24.5 GHz to 29.5 GHz for millimetre wave bands. Rogers RT / Duroid with a 0.65mm which is the height of the substrate and a dielectric constant value of 2.2 is the dielectric substrate or dielectric material used in this case. This antenna is -3,4 degree in the reflection coefficient or in the return loss. The VSWR value of this particular antenna is 1.03 which is less than 2 at 26GHz. The maximum gain is achieved to be 10dB and the antenna radiation efficiency is about 99.5%. This antenna is optimized and designed using FEKO software.

A 30GHz Microstrip Square Patch Antenna Array for 5G Network

AUTHOR: D. Okwum, J. Abolarinwa and O. Osanaiye

This paper covers the 5G mobile communication microstrip array antenna. This antenna is designed for use in a wave band with a millimetre. FR-4 epoxy resin with a permittivity of 4.4 and a thickness of 1.6mm is the dielectric or dielectric material used here. The substratum used is a large 10 x 10 mm² square substratum. The array consists of a 4 x 2 square array of antennas. At 30 GHz a high gain, power efficiency, and better bandwidth are achieved with this array of antennas.

Stacked frequency reconfigurable Yagi-like MIMO antenna system

AUTHOR: D. Hussain, R., Jehangir, S., Khan, M., & Sharawi, M

This paper is about Yagi-like many-input-many-output (MIMO) transceiver systems. This MIMO transceiver comprises of 4 indistinguishable active transceiver components. This antenna resonates between 1.5 GHz to 2.1 GHz. The dimension of this antenna is 100 x 100 mm² and the reflector size is 110 x 110 mm². The dimension clearly shows that it is a square patch antenna. The front to back ratio (FBR) of this particular antenna is ranging from 5 – 13 dB.

CHAPTER 3

AIM AND SCOPE OF PRESENT INVESTIGATION

EXISTING ANTENNAS:

- The existing antennas are of compact size
- It has wide operating bandwidth
- The power handling capacity is moderate.

DRAWBACKS:

- The Gain is considered to be low.
- The radiation efficiency is less.
- The reflection coefficient is low.

PROPOSED ANTENNA:

- The dimensions are very less
- Defected Ground Structure (DGS) technique is used in the ground.
- Meander line shaped patch is used here.
- Strip-line feeding is used here.

ADVANTAGES:

- The Gain, return loss, VSWR and other parameter values have been achieved in a more efficient manner.
- Higher Efficiency is achieved.
- Size reduction is done.
- Low power handling capacity.

COMPARISON OF PREVIOUS PUBLISHED PAPERS:

Table 3.1: Comparison of Parameters of the Reference Papers

TITLE	GAIN	VSWR	RETURN LOSS (dB)	RADIATION EFFICIENCY (%)	DIMENSION (mm ²)
Compact Dipole Antenna Based on Meander Line Structure for Unmanned Aerial Vehicle Application	1.82 dBi	< 2	-17.19	-	232.5 x 16.4
A Compact Multiple Slot Microstrip Antenna for Modern Mobile Communications	0.86 dB	< 2	- 10	-	13.6 x 13.6
Design of Meander Line Triple Band Antenna for Wireless Applications	0.8 dB	< 2	- 10	-	0.375 x 0.375 λ^2
Design of meander line antenna for wearable applications	2.3 dB	< 2	- 37.9	-	13 x 28

TITLE	GAIN	VSWR	RETURN LOSS (dB)	RADIATION EFFICIENCY (%)	DIMENSION (mm ²)
A Modified Meander Line Microstrip Patch Antenna with Enhanced Bandwidth for 2.4 GHz ISM-Band Internet of Things (IoT) Applications	1.347 dBi	< 2	- 17.9	79	40 x 10
Design of Microstrip Patch Antenna on Rubber Substrate with DGS for WBAN Applications	3.4 dB	1.03	- 37.33	> 60	42.76 x 34.12
A High Gain Microstrip Patch Antenna with Slotted Ground Plane for Sub-6 GHz 5G Communications	5.49 dB	< 2	-	-	28.03 x 23.45
Design Array Antenna Using Different Feeding Technique in HFSS	7.26, 12.27, 13.5 (in dB)	1.083 1.84 1.06	- 27.57 - 10.57 -29.81	-	18.62 x 21.42

TITLE	GAIN	VSWR	RETURN LOSS (dB)	RADIATION EFFICIENCY (%)	DIMENSION (mm ²)
Design and analysis of insert-fed reconfigurable antenna for 5G (sub-6GHz) applications	3.2 dB	< 2	- 23	-	35.6 x 35.6
Design and Implementation of Microstrip Patch Antenna for 5G applications	10 dB	1.03	- 33.4	99.5	6 x 6
A 30GHz Microstrip Square Patch Antenna Array for 5G Network	High gain	<2	-	-	10 x 10
Stacked frequency reconfigurable Yagi-like MIMO antenna system	2.23 dBi	<2	- 11	-	100 x 100

CHAPTER-4

EXPERIMENTAL OR MATERIALS AND METHOD

HARDWARE REQUIRED:

- Substrate Material (FR-4 epoxy material)
- SMA connector (50 Ohm impedance)
- Copper (for patch and ground)
- Vector Network Analyser.

Substrate material:

The material of choosing for most PCB applications is the FR4 epoxy glass substrates. The material has excellent mechanical characteristics and is very cost-effective, making it suitable for an expansive scope of applications based on electronics. As increasingly more microwave frameworks are being produced for shopper markets, the cost of these systems is significantly reduced. The utilization of FR4 rather than expensive PTFE substrates for microwave circuits and transceivers could lead to substantial cost savings. The qualities of this material at a microwave recurrence between 1 GHz and 15 GHz are depicted in a work program embraced at ERA Technology as a component of their Membership Research Program. It is inferred that, because of its high misfortunes, the utilization of FR4 isn't suitable for radio wire taking care of designs. In any case, the material could be utilized instead of regular microwave substrate materials for high thickness microwave circuits, where the way lengths are more limited, and for broadband receiving wire components, where misfortunes and total dielectric consistent qualities are looser, with massive expense investment funds.

A multi-PC PCB that can send advanced signs at fast in the high-recurrence area is required for providing the high-velocity network atmosphere to cope with big volume of data. The FR-4 material is applicable to network gear with low dielectric-loss and low permittivity.

SMA connector

SMA is a half exactness sub-smaller than normal RF and microwave connector which is extensively utilized for the RF connection of frequencies up to 18 GHz and sometimes more in electronic systems.

SMA connector is available in a number of different formats, including male, female, straight, right-angled, bulkhead and many more which make it possible to meet most needs. It can also be used in relatively small pieces of electronic devices due to its sub-miniature size.

Although well established, the SMA connector will probably expand its use, as many new RF systems can be seen to expand their operating frequencies well into the microwave area.

SMA connectors are designed to have a 50-ohm connector impedance. The SMA connectors were originally designed to run up to 18 GHz, but some versions have 12.4 GHz high frequencies, some less and some up to 24 or 26.5 GHz. There may be a greater return loss for higher frequency top limits.

A 36-thread-per-inch threaded barrel is used for the SMA connector.

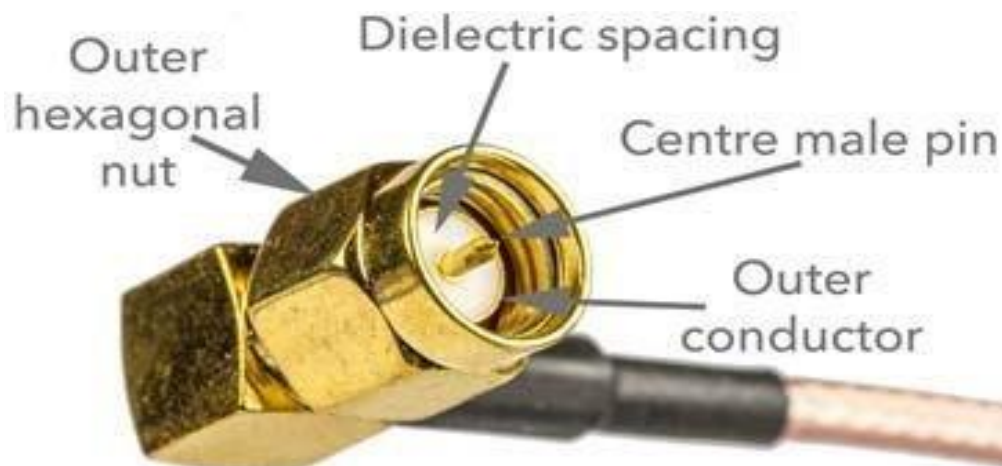


Fig:4.1: SMA Connector

Vector network analyser:

The Vector Network Analyser possess a source that generates a known boost signal plus a set of recipients that are used by the device or DUT to determine changes.

The stimulus signal is injected to the DUT, and the input beam reflected in the input side and the output side of the DUT are estimated in the VNA. The receivers of the VNA measure and compare the resulting signals with the known boost signal. Then the estimated results are prepared and sent to a display by an internal or external PC.

Two types of measurement performed by Vector Network Analyser – one is transmission and the other is reflection. Transmission measures the boost signal of the Vector Network Analyzer via the test device and then are measured by the receivers of the VNA on the opposite side. S-parameter measurements are most common in S12 parameter and S21 parameter transmission (S_{xy} for more than 2-ports). The swept power is a type of measurement of transmission. Other instances are insertion loss, gain, electrical delay or length, and group delay. In comparison, reflex estimates but do not pass through the VNA boost signal which occurs on the DUT. The reflection measurement estimates the beam returning to the source from the target due of reflections.

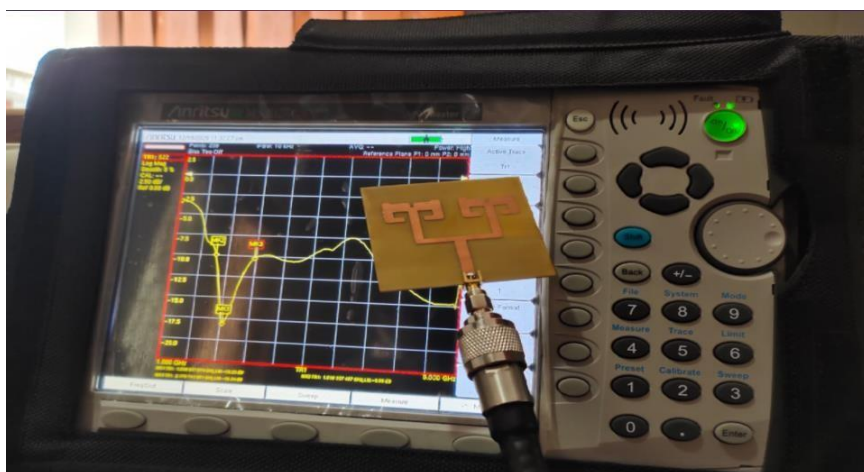


Fig: 4.2: Vector Network Analyser

ANTENNA DESIGN

The antenna is called Meander Line Antenna (MLA). A meander line is a design or structure that is used on the patch of the antenna. The patch is redefined in such a way where it resembles a meander line structure. The purpose of the meander line structure because at the expense of a restricted bandwidth it provides the greatest size reduction for a specific frequency. MLA is a dipole antenna transformation. The radiant part of the folded dipole antenna is formed by folding. Therefore, the antenna used here is the integration of the meander line in the microstrip patch antenna. A high gain and low power management capacity are the advantages of using the meander line structure. The patch is a structure of a t-shaped colouring arm. This material is FR-4 (Flame Retardant 4), which is of 4.4 value. The grounding technique used here is called Defective Ground Structure technique (DGS). In DGS half-wave ground method is applied. The dimensions are 60x48 mm².

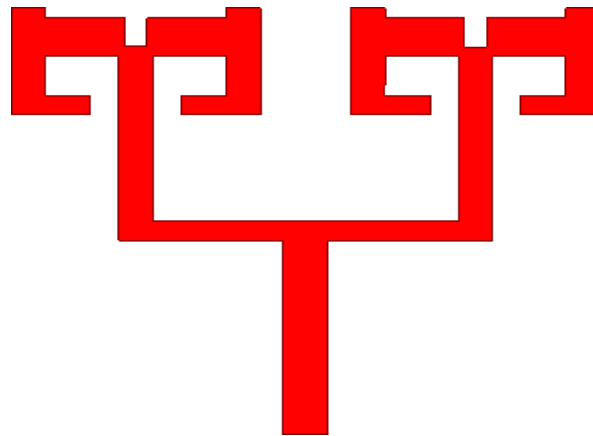


Fig:4.3 : Patch Design of Antenna



Fig:4.4: Ground design of Antenna

SOFTWARE:

Ansys HFSS is a three-dimensional electromagnetic simulation programme that designs plus model high-frequency electronic items such as RF or microwave transceivers, transceiver arrays, fast speed connectors, IC packets, and filters. Globally, the engineers are using this software to develop high-frequency and high-speed communications electronics, radar system, state-of-the-art driver aid systems (DAAS), satellite devices, IoT products, and more.

The HFSS utilizes adaptable solvers and an instinctive GUI to give us unparalleled execution plus a thorough understanding of all our 3D Electromagnetic issues. HFSS offers powerful plus comprehensive Multiphysics examination of electronic items through combination with Ansys thermal, fluid and structural dynamics tools that guarantee structural and thermal reliability. This software stands for best standard reliability and accuracy, which can be speeded-up by higher performance computing technology known as HPC, in order to meet 3D EM's challenges thanks to its automatically adaptive meshing techniques and sophisticated solvers.

VALUES AND OPERATIONS:

- Permittivity = 4.4
- Frequency = 1.5 GHz – 2.1 GHz
- Velocity of Light = 3×10^{11} mm/sec
- Wavelength = 166.66 mm/sec
- Width = 48 mm
- Length = 60 mm
- Thickness $h = 1.6$ mm
- Effective Permittivity = 2.7

For Ground Length = 60 mm (SGL)

Ground Width = 20 mm (SGL)

1. Substrate Placing (3D)

Position: $(x, y, z) = (0, 0, 0)$

$X(\text{SGL}) = 48$

$Y(\text{SGL}) = 60$

$Z(h) = 1.6$

2. Ground (2D)

Position: $(x, y, h) = (0, 0, 0)$

$X(\text{SGL}) = 60$

$Y(\text{SGL}) = 20$

3. Feed Line (2D)

Position: $(x, y, h) = (28, 0, 1.6)$

$X(W_f) = 4$

$Y(L_f) = 21$

4. Port (2D)

Position: $(x, y, h) = (28, 0, 0)$

$X(W_f) = 4$

$Z(h) = 1.6$

CHAPTER-5

RESULT & ANALYSIS

FABRICATION

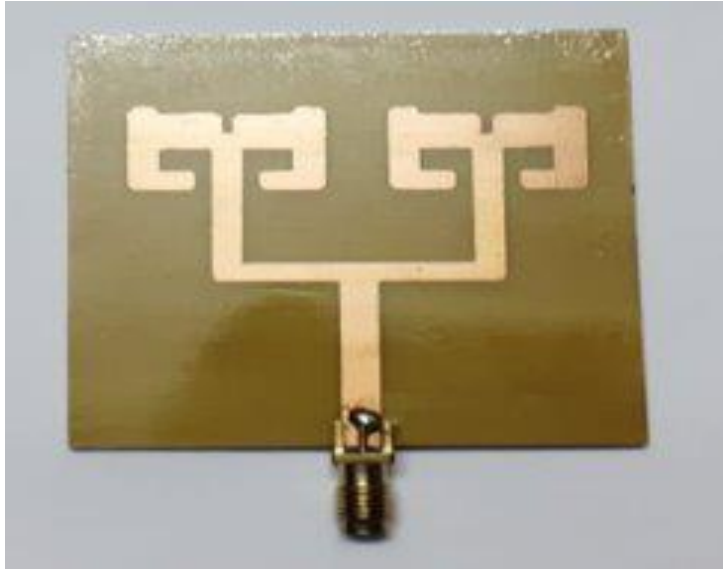


Fig: 5.1: Fabricated image of the patch



Fig:5.2: Fabricated image of the ground

The fabrication is done by WC - Groups using FR-4 material and the testing is done in Sathyabama institute of science and technology, Chennai.

RETURN LOSS:

The antenna's Return Loss is a numerical indicator reflecting the number of radio waves reaching a rejected antenna installation compared to an acceptable one. The antenna S11 parameter is the power loss in the beam returned by an interruption in the transmission line. It is the part of a signal which is returned due to a failure of impedance. At the maximum frequency of 1.78 GHz, we have achieved a return loss of -24.39dB. Higher the S11 parameter of the antenna greater the gain.

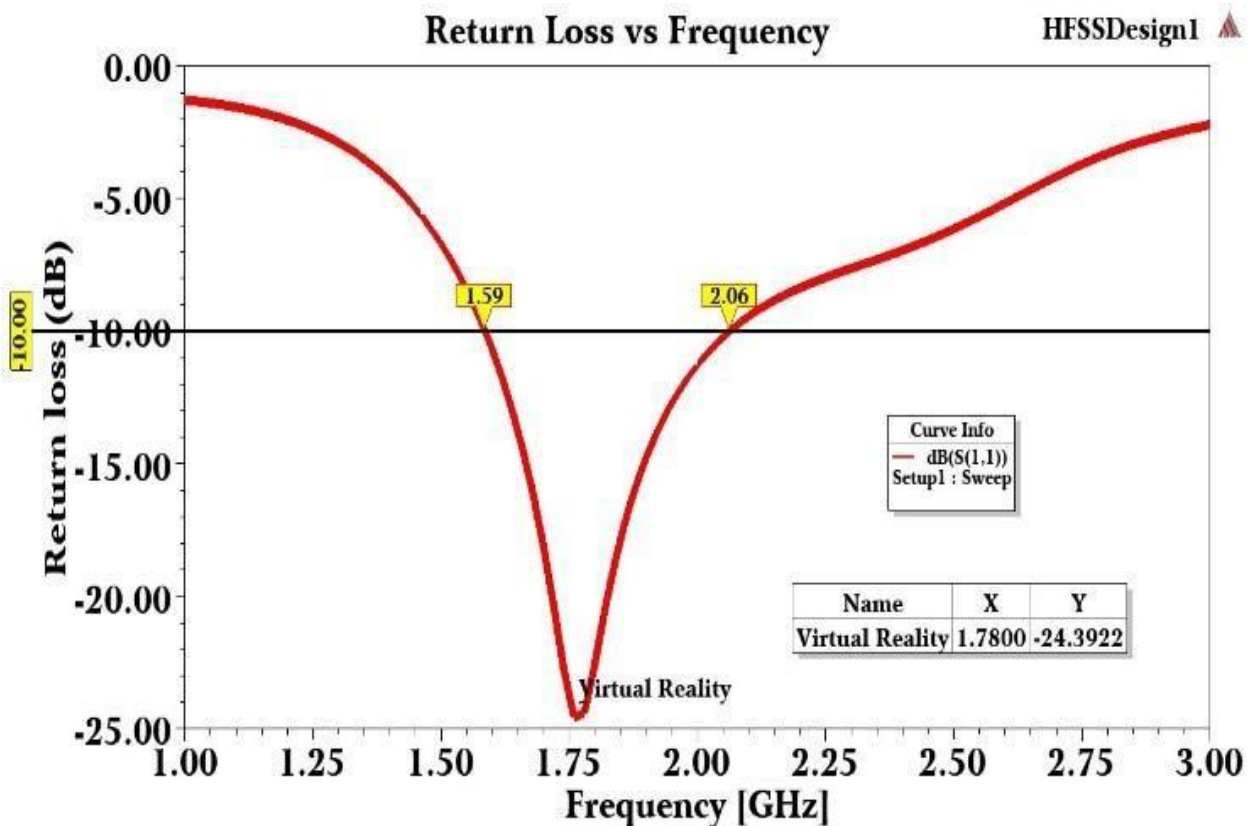


Fig:5.3 : Return Loss

VOLTAGE STANDING WAVE RATIO (VSWR):

VSWR is the value indicator of fluctuation between the antenna and supply line to which it is connected. The permanent wave ratio is also known as the (SWR). Prices vary from 1 to ∞ . VSWR price range. For most antenna systems, VSWR value less than 2 is considered suitable.

The Voltage Standing Wave Ratio (VSWR) represents the return loss in essence. VSWR refers to the current voltages created by radio waves moving in the transmission system. Although static waves and VSWR are very important, theory and statistics of VSWR often obscure what is going on. Fortunately, a good idea of the topic can be obtained without deepening the VSWR concept. Our value for VSWR is 1.12, which is less than 2 and very close to 1. This is an acceptable value, therefore.

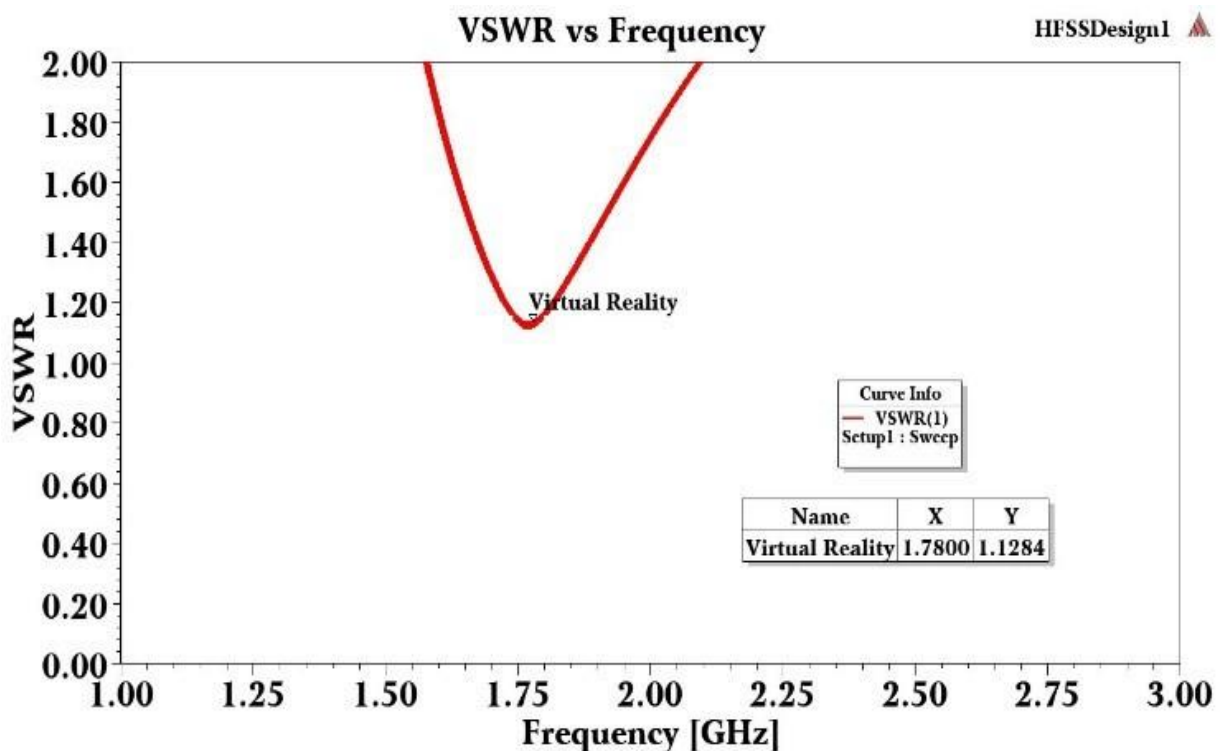


Fig:5.4: Voltage Standing Wave Ratio

IMPEDANCE PLOT:

The impedance correlates the antenna input voltage and current. The antenna's real impedance component is the energy emissions or integrated in the antenna from a distance. The hypothesis of the impedance is energy saved in the nearest field of the antenna.

The impedance of measurement of current port power. A measurement of a phasor voltage of 1 V at a 0 grade angle to the current in the port is calculated as the antenna impedances. The impedances are numbered:

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

where:

- V is power voltage of the excited transceiver
- I is the current of the transceiver
- R is the resistance which is represented in ohms
- X is represented in ohms which is nothing but the antenna reaction mechanism

The hypothetical part of the impedance represents the energy stored in the nearest antenna field. So, we can neglect the imaginary part. If Z and R parameters are the same then the impedance is said to be perfectly matched. Here we have achieved a perfect impedance of 1.0039 which is approximated to 1.

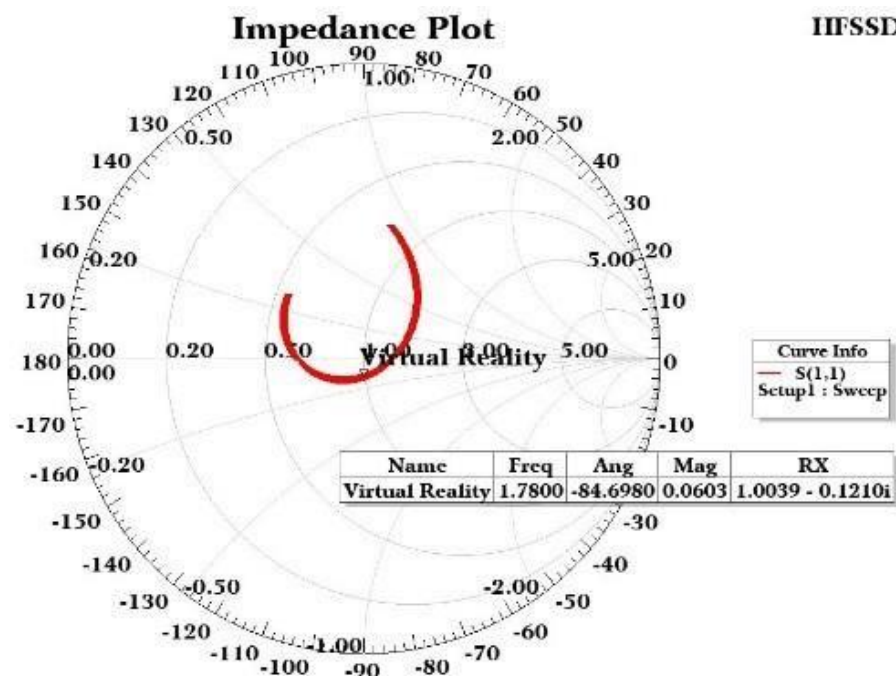


Fig:5.5: Impedance plot

ANTENNA GAIN:

The transceiver gain is often defined as measuring antenna generated power in all indicators from a remote field source to the antenna axis, to the transceiver power generated by the isotropic transceiver. This measure is usually expressed in decibels, which are called isotropic decibels (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 or gain is computed by comparing the rated power that the antenna transfers or receives in a particular direction to the transmitted power or receives in the same condition by an appropriate antenna. The maximum gain is approximately 9.42 dB.

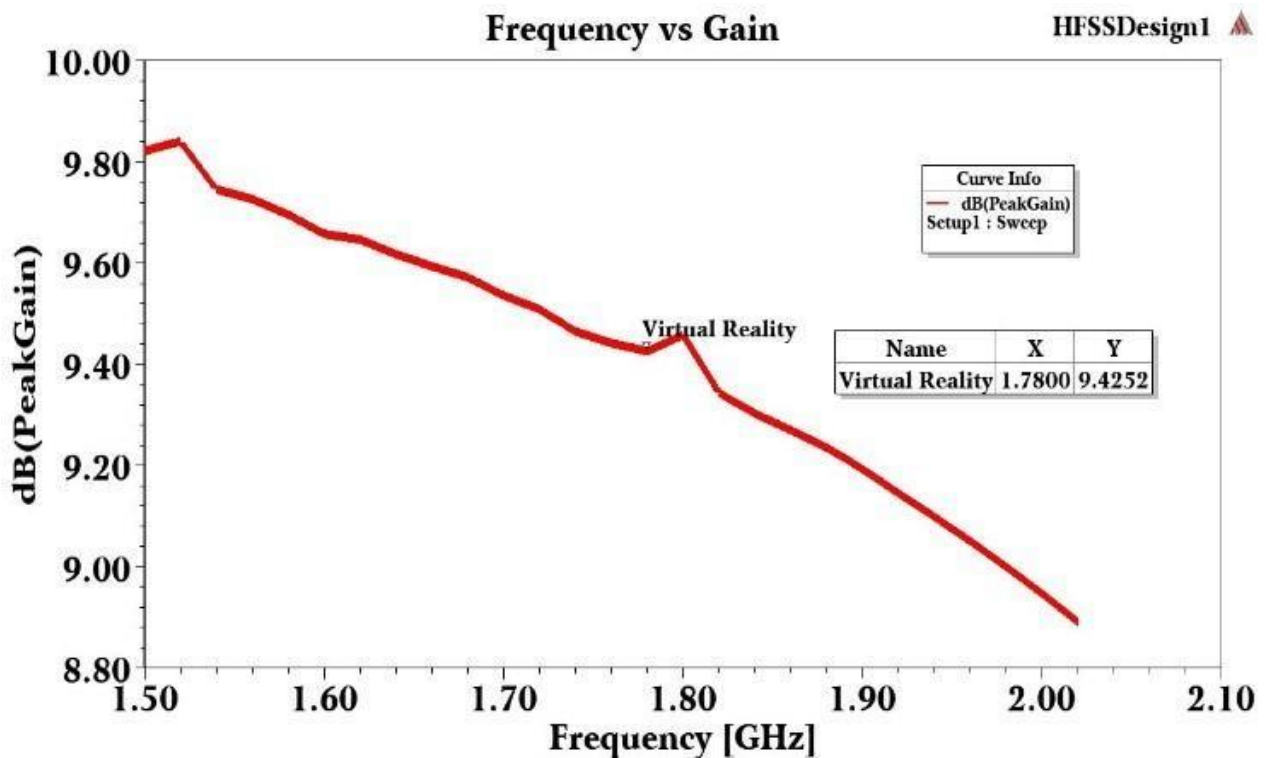


Fig :5.6: Gain

RADIATED POWER

If the antenna was equal in all directions, it would have to be supplied to the antenna on the satellite. The typical transmitter's power over the satellite would be somewhat above 3.000 Watts, if the satellite antenna radiated in all directions equally. This is difficult to do, but the satellite doesn't have to radiate the signal in every direction. The signal must be radiated only to that part of the earth, which is to receive the signal. The power required on the satellite is drastically reduced by focusing in this direction. The amount of power radiated from an antenna is measured by means of radiated power. The radiated power that is achieved is 37.49 dBm. So, we can convert the above dBm value to watts using the formula mentioned in the accepted power. We get 0.6 watts if we convert. A ratio between the radiated power and the antenna power is defined as the efficiency of the antenna.

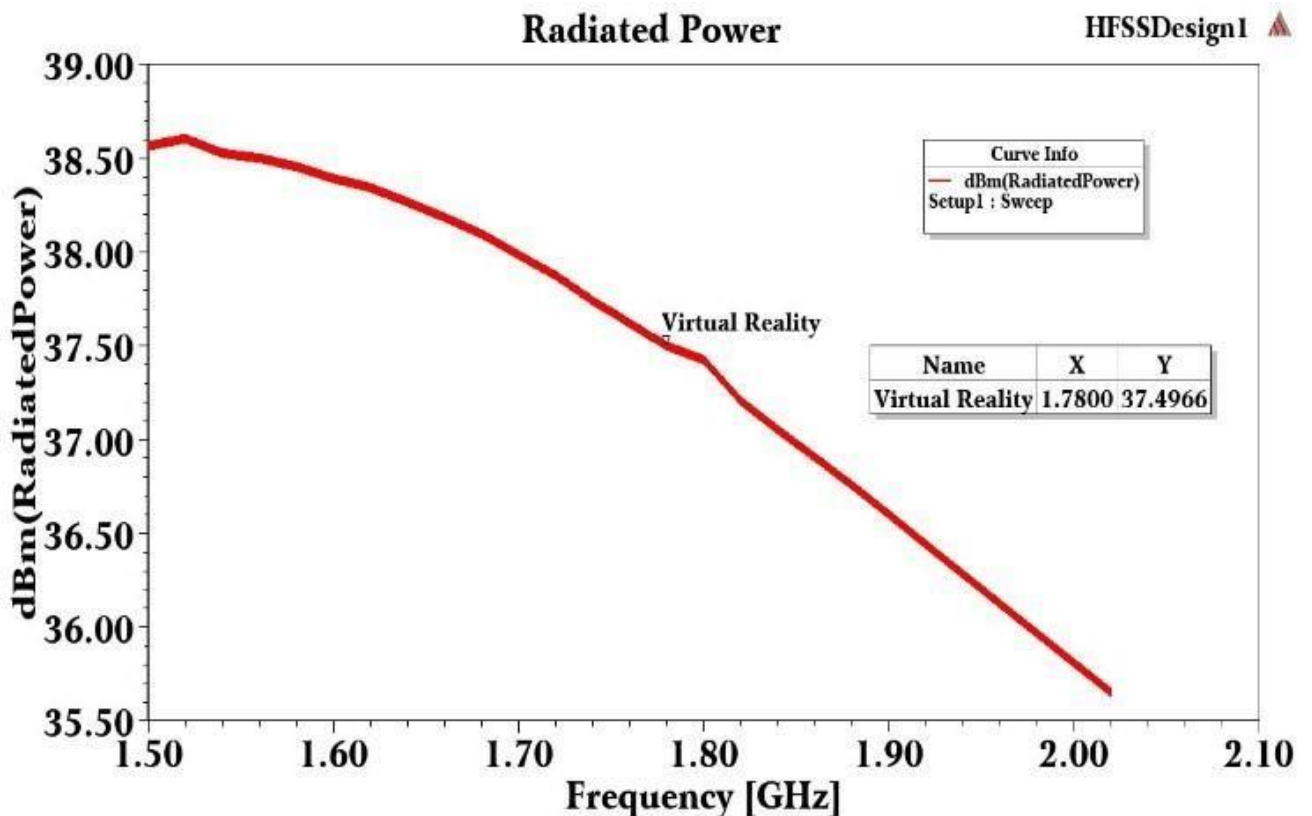


Fig: 5.7: Radiated Power

ACCEPTED POWER:

Power that is achieved is 29.98 dBm. Usually, the power will be shown in dBm.

So, we can convert the dBm into watts using the equation

$$P(\text{watt}) = 1\text{mw} \cdot 10^{[P(\text{dbm})/10]}$$

Where,

$P(\text{watt})$ = Power in watt

$P(\text{dbm})$ = Power in dbm

If we convert our power to watts, we get power equals to 0.9 watt

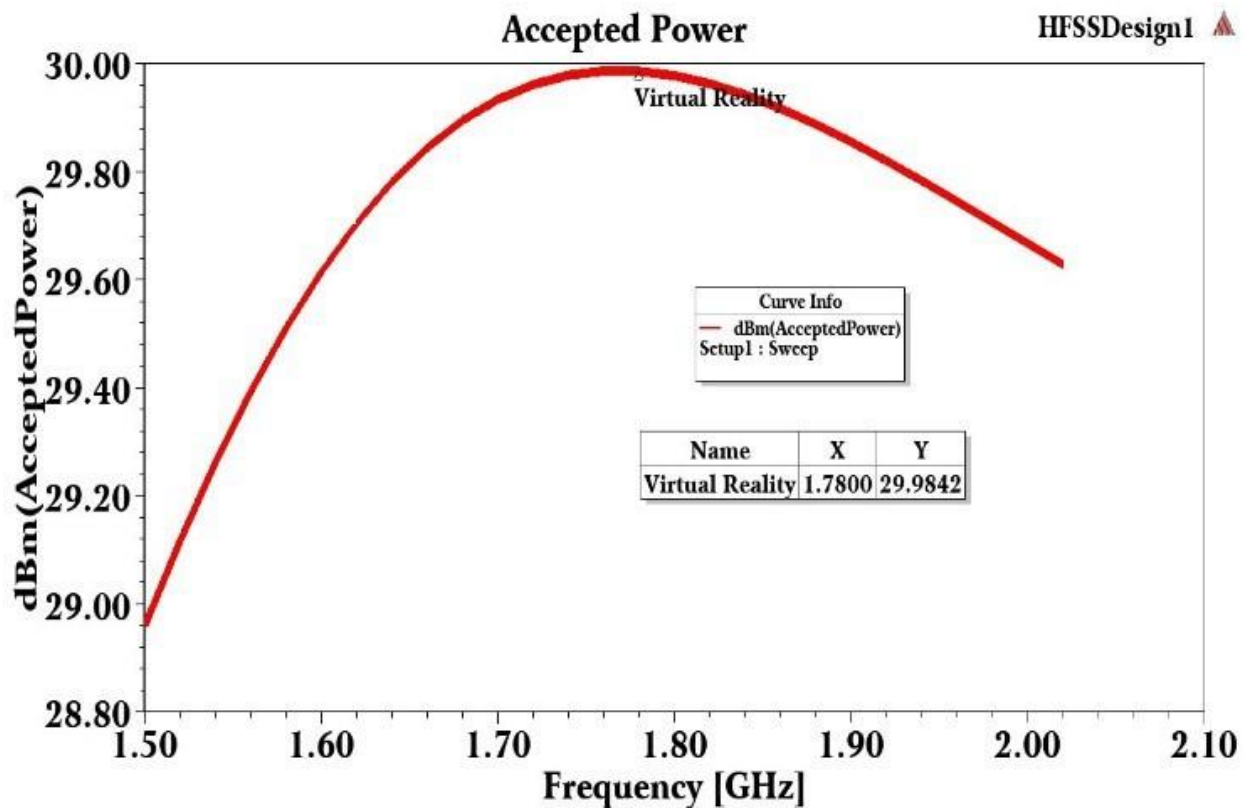


Fig: 5.8: Accepted Power

RADIATION PATTERN:

The solar radiation pattern (or antenna pattern or remote field pattern) in the field antenna design refers to the energy of a radio frequency from an antenna to another directly dependent source.

The remote field antenna pattern can be determined by an antenna range experiment, or by using an adjacent field scanner as well as radiation pattern extracted from it, the proximity field pattern can be detected. EM software such as HFSS can also calculate remote radiation patterns from the design of the antenna.

The antenna radiation pattern is a diagrammatic representation of the antenna-radiated signal. The red line is the angle of Azimuth in the below pattern, and the blue line represents the angle of elevation. The Theta is 0 and π at 90 the azimuth and elevation angle meet each other at 0 degree. Now when Theta is 90 and π at 0 the azimuth and elevation angle does not meet each other at 0 degree. This shows that the antenna has co-polarization with linear characteristics.

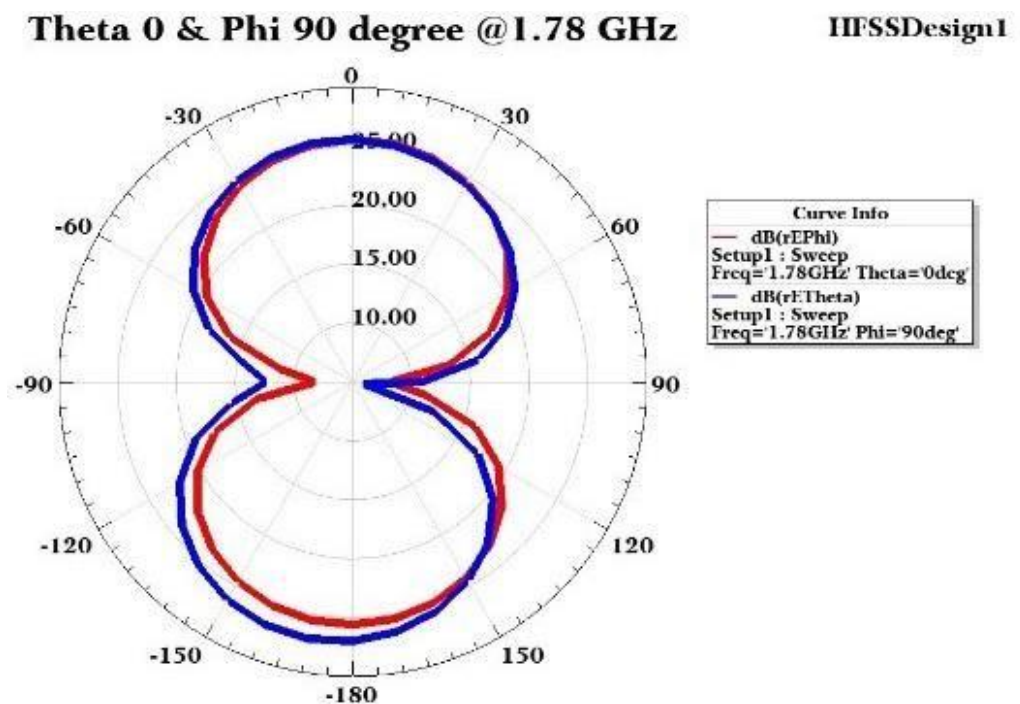


Fig: 5.9: Theta 0 & Phi 90 degree

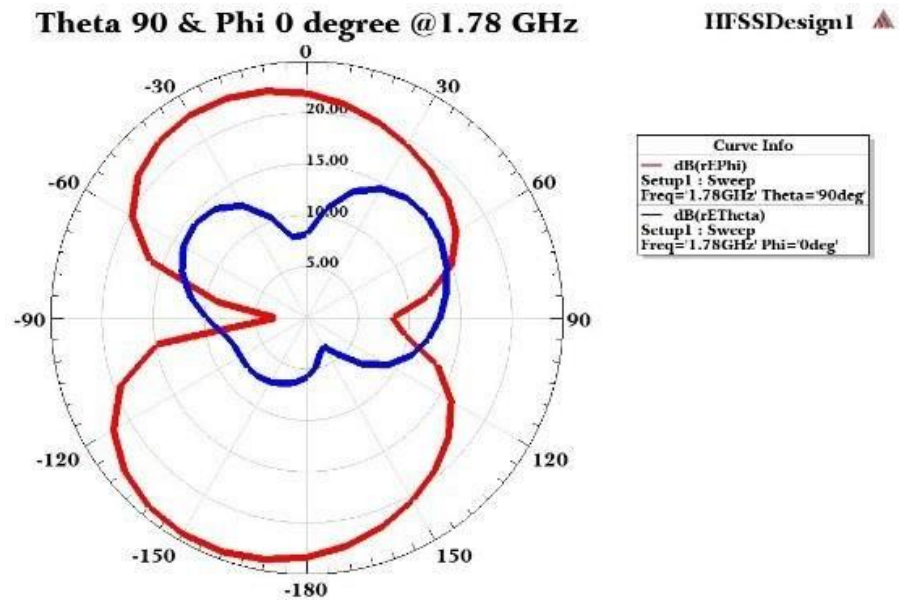


Fig:5.10: Theta 90 & Phi 0 degree

SURFACE CURRENT:

The surface flow is an actual electrical flow induced by an applied electromagnetic field. The field of electricity pushes the load. The below picture shows the surface current range from 0.15 to 3.04, which is the blue colour that is spread throughout the antenna.

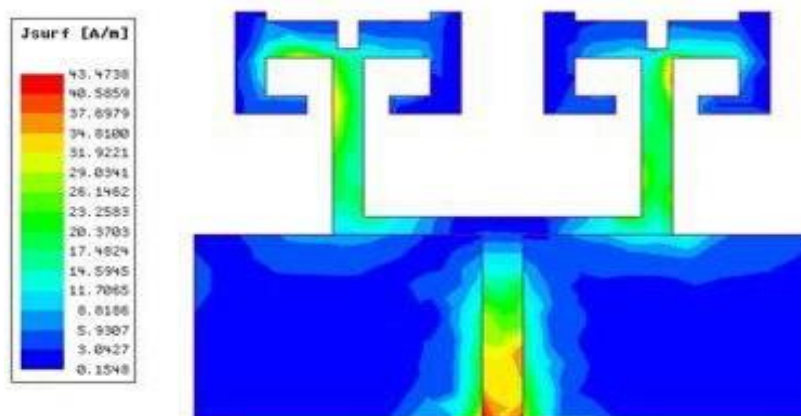


Fig:5.11: Surface Current

SAR FIELD:

Specific Absorption Rate (SAR) is a measure of how much human tissue absorbs radiated RF energy. 1.6 W/Kg SAR levels are considered safe for the body or below. In India we follow the same measurement. For government authorities in Europe, a SAR value of less than 2 W/kg should be available for the phone. Here the blue colour represents the less radiation and red represents the high radiation part. Since the radiating patch has blue colour which is 0 to 0.5. So, this is acceptable and safe.

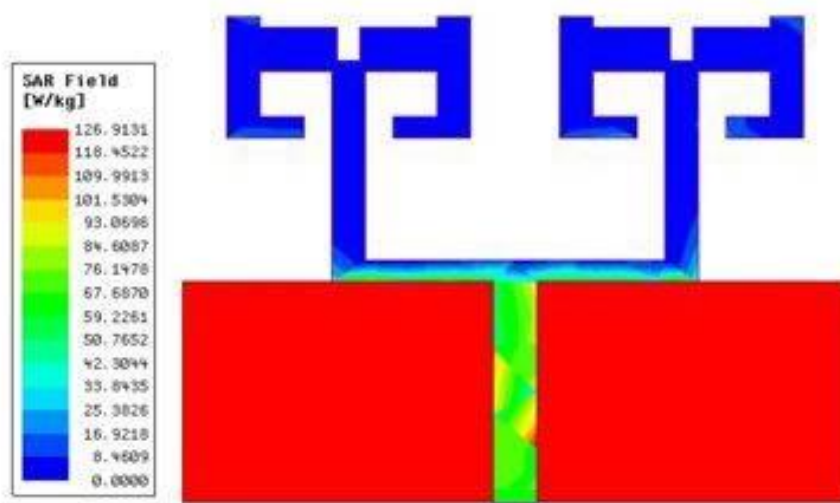


Fig:5.12: Sar Field

CHAPTER-6

CONCLUSION AND SUMMARY

For mid-band 5G frequency applications, a meander line antenna is designed. Resonate from 1.5 – 2.1 GHz in the proposed antenna. The antenna's efficiency is 62.5%. The antenna is manufactured and its parameters S11 in Anritsu VNA are measured. The results simulated are closer to the results measured, so that the data can be transmitted most efficiently in all resonating frequencies in real time.

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