



**PENTAGON SHAPED PATCH ANTENNA
WITH EBG STRUCTURE FOR WLAN
APPLICATION**



A PROJECT REPORT

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BONAFIDE CERTIFICATE

Certified that this project report “**PENTAGON SHAPED PATCH ANTENNA FOR WLAN APPLICATION**” is the **bonafide work of Ms RAMYA.K [13BEC121], Ms SARANYA.R [13BEC138] and Ms VEERALAKSHMI.V [13BEC160], Ms SWATHIKA.R [13BEC220]** who carried out the project work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other project or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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INTERNAL EXAMINAR

EXTERNAL EXAMINAR

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ABSTRACT

The objective of this paper is to design and analysis the EBG structure based pentagonal patch antenna. In this method, to overcome several limitations of patch antennas such as constrict bandwidth, low gain, excitations of surface waves, the EBG concept is applied. The aim of this paper is to design, simulate and fabricate the new EBG structure operating at WLAN frequency and to study the performance of the pentagonal microstrip patch antenna in terms of the bandwidth and VSWR with and without EBG structure which are characterized in terms of return loss and radiation pattern.

Impedance, bandwidth, VSWR, return losses and smith charts are observed and experimentally studied using the high frequency structure simulator(HFSS).

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ABBREVIATIONS

EBG	ELCTROMAGNETIC BAND GAP
FR	FLAME RETARDENT
RHCP	RIGHT HAND CIRCULAR POLARISATION
LHCP	LEFT HAND CIRCULAR POLARISATION
SMA	SUB MINIATURE VERSION A
HFSS	HIGH FREQUENCY STRUCTURAL SIMULATOR
PML	PERFECTLY MATCHED LAYER
CAD	COMPUTER AIDED DESIGN
PCB	PRINTED CIRCIUT BOARD
VSWR	VOLTAGE STANDING WAVE RATIO
FEM	FINITE ELEMENT METHOD
WLAN	WIRELESS LOCAL AREA NETWORK

1.INTRODUCTION

With the drastic demand of wireless communication system and their miniaturization, antenna design becomes more challenging. Antenna is an important part of any wireless communication system as it converts the electronic signals (propagating in the RF Transceiver) into Electromagnetic Waves (Propagating in the free space) efficiently with minimum loss. Recently microstrip patch antennas have been widely used in satellite communications, aerospace,

radars, biomedical applications and reflector feeds because of its low profile, low cost, lightweight and conveniently to be integrated with RF devices.

1.1. ANTENNA PARAMETERS

An antenna is an electrical conductor or system of conductor. Transmitter Radiates electromagnetic energy into space. Receiver Collects electromagnetic energy from space.

The definition of an antenna as given by Stutzman and Thiele is, “That part of a transmitting or receiving system that is designed to radiate or receive electromagnetic waves”. The major parameters associated with an antenna are defined in the following sections.

1.1.1. ANTENNA GAIN

Gain is a measure of the ability of the antenna to direct the input power into radiation in a particular direction and is measured at the peak radiation intensity. Consider the power density radiated by an isotropic antenna with input power P_0 at a distance R which is given by $S = P_0/4\pi R^2$.

An isotropic antenna radiates equally in all directions, and its radiated power density S is found by dividing the radiated power by the area of the sphere $4\pi R^2$.

An isotropic radiator is considered to be 100% efficient. The gain of an actual antenna increases the power density in the direction of the peak radiation

$$S = \frac{P_0 G}{4\pi R^2} = \frac{|E|^2}{\eta} \quad \text{or} \quad |E| = \frac{1}{R} \sqrt{\frac{P_0 G \eta}{4\pi}} = \sqrt{S \eta}$$

Gain is achieved by directing the radiation away from other parts of the radiation sphere. In general, gain is defined as the gain-biased pattern of the antenna.

$$S(\theta, \phi) = \frac{P_0 G(\theta, \phi)}{4\pi R^2} \quad \text{Power density}$$

$$U(\theta, \phi) = \frac{P_0 G(\theta, \phi)}{4\pi} \quad \text{Radiation intensity}$$

1.1.2. ANTENNA EFFICIENCY

The surface integral of the radiation intensity over the radiation sphere divided by the input power P_0 is a measure of the relative power radiated by the antenna, or the antenna efficiency.

$$\text{Efficiency } \eta_e = \frac{P_r}{P_0} = \int_0^{2\pi} \int_0^\pi \frac{G(\theta, \phi)}{4\pi} \sin\theta \, d\theta \, d\phi$$

where P_r is the radiated power. Material losses in the antenna or reflected power due to poor impedance match reduce the radiated power.

1.1.3. DIRECTIVITY

Directivity is a measure of the concentration of radiation in the direction of the maximum.

$$\text{Directivity} = \frac{\text{maximum radiation intensity}}{\text{average radiation intensity}} = \frac{U_{max}}{U_0}$$

1.1.4. RADIATION PATTERN

The radiation pattern of an antenna is a plot of the far-field radiation properties of an antenna as a function of the spatial co-ordinates which are specified by the elevation angle (θ) and the azimuth angle (ϕ). More specifically it is a plot of the power radiated from an antenna per unit solid angle which is nothing but the radiation intensity. It can be plotted as a 3D graph or as a 2D polar or Cartesian slice of this 3D graph. It is an extremely parameter as it shows the antenna's directivity as well as gain at various points in space.

1.1.5. RETURN LOSS

It is a parameter which indicates the amount of power that is "lost" to the load and does not return as a reflection. Hence the RL is a parameter to indicate how well the matching between the transmitter and antenna has taken place. Simply put it is the S11 of an antenna. A graph of s11 of an antenna vs frequency is called its return loss curve. For optimum working such a graph must show a dip at the operating frequency and have a minimum dB value at this frequency.

1.2. MICROSTRIP PENTAGON SHAPED PATCH ANTENNA

Microstrip patch antennas are relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry. They are usually employed at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength at the resonant frequency. A single patch antenna provides a maximum directive gain of around 6-9 dB. It is relatively easy to print an array of patches on a single (large) substrate using lithographic techniques. The ability to

create high gain arrays in a low-profile antenna is one reason that patch arrays are common on airplanes and in other military applications. Such an array of patch antennas is an easy way to make a phased array of antennas with dynamic beam forming ability. An advantage inherent to patch antennas is the ability to have polarization diversity. Patch antennas can easily be designed to have vertical, horizontal, right hand circular (RHCP) or left hand circular (LHCP) polarizations, using multiple feed points, or a single feed point with asymmetric patch structures. This unique property allows patch antennas to be used in many types of communications links that may have varied requirements.

However, microstrip antennas also have disadvantages such as the radiation of electromagnetic energy in different directions from radiation source (i.e. patch) which cause the electromagnetic energy due to the patch and feed of microstrip antenna, divide in all direction in the space that it results to reduce directivity, gain and wide radiation beam.

Pentagon microstrip patch antenna supports both linear and circular polarization. It gives better performance compared to the rectangular patch antenna. The pentagonal patch antenna gives circular polarization with only one feed whereas a rectangular patch antenna requires multiple feeds to get circular polarization. The pentagonal patch antenna can also use multiple feeds. And this type of antenna multiple feeds can also give multiband operations.

1.3. ELECTROMAGNETIC BAND GAP

EBG structures are periodic structures that are composed of dielectric, metal or metallo-dielectric materials. These structures can prevent or assist wave propagation in special directions and frequencies therefore they can be used as spatial and frequency filters. Electromagnetic Band Gap structures produced a

wide variety of design alternatives for researchers working in the area of microwave and photonics. Focus is now towards on finding real applications combined with detailed modelling.

There are several configurations of EBG structures according to their application in antenna. Two main configurations are

- EBG structures are placed on antenna substrate that by creation band gap in certain frequency range Suppress from propagation of surface wave. This configuration is defined as EBG substrate. In this configuration both of mushroom-like EBG and uniplanar EBG is used.
- EBG structure place at certain distance above radiation source of antenna i.e. patch and by creation ultra-refraction phenomenon, concentrate radiation in various direction normal to EBG structure. This configuration is defined as EBG superstrate or Metamaterial superstrate and only the uniplanar EBG is used in this one.

The characteristics of EBG depend on the shape, size, symmetry and the material used in their construction. Surface waves are reduced by using EBG substrate which leads to increase the directivity, bandwidth and radiation efficiency. EBG were realized to reduce and eliminate surface waves, which leads to an increase in directivity, bandwidth and radiation efficiency. It is also useful to reduce the side lobes of the radiation pattern and hence radiation pattern front-to-back ratio and overall antenna efficiency are improved. This proposed antenna gives better performance compare to the conventional microstrip patch antenna. A substantial gain and bandwidth enhancement has been obtained.

The birth of the electromagnetic band gap structure has triggered many novel antenna applications. Electromagnetic band gap structures can be defined as

artificial periodic (or sometimes non-periodic) objects that prevent or assist the propagation of electromagnetic waves in a specified band of frequency for all incident angle and polarization state. Two commonly employed features are suppressing unwanted substrate modes and acting as an artificial magnetic ground plane.

The main advantage of EBG structure is their ability to suppress the surface wave current. The generation of surface waves degrades the antenna efficiency and radiation pattern. Furthermore, it increases the mutual coupling of the antenna array which causes the blind angle of a scanning array. EBG structures are usually realized by periodic arrangement of dielectric materials and metallic conductors. In general, they can be categorized into three groups according to their geometric configuration:

- (i) three-dimensional volumetric structures,
- (ii) two-dimensional planar surfaces, and
- (iii) One-dimensional transmission lines.

The parameters that are affecting the performance of EBG structures are directly dependent on the operating wavelength.

1.4. FEEDING METHOD

Microstrip patch antennas can be fed by a variety of methods. These methods can be classified into two categories- contacting and non-contacting. In the contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. In the non-contacting scheme, electromagnetic field coupling is done to transfer power between the microstrip

line and the radiating patch. The four most popular feed techniques used are the microstrip line, coaxial probe, aperture coupling and proximity coupling.

1.4.1. COAXIAL FEEDING

The Coaxial feed or probe feed is a very common technique used for feeding Microstrip patch antennas. The inner conductor of the coaxial connector extends through the dielectric and is soldered to the radiating patch, while the outer conductor is connected to the ground plane. The main advantage of this type of feeding scheme is that the feed can be placed at any desired location inside the patch in order to match with its input impedance.

However, its major drawback is that it provides narrow bandwidth and is difficult to model since a hole has to be drilled in the substrate and the connector protrudes outside the ground plane, thus not making it completely planar for thick substrates. Also, for thicker substrates, the increased probe length makes the input impedance more inductive, leading to matching problems. It is seen above that for a thick dielectric substrate, which provides broad bandwidth, the microstrip line feed and the coaxial feed suffer from numerous disadvantages.

2. SOFTWARE DESCRIPTION

2.1. INTRODUCTION

The software simulations of this project focused on designing and testing of pentagon shaped patch antenna with ebg structure using software ANSYS HFSS. It excels at a wide variety of frequency. It uses multiple advanced solver

techniques to simulate not just the antenna and also the effects of its interaction with the entire system. This software is the leading 3D electromagnetic simulation tool for high frequency and high speed electronic components. With multiple simulation technologies and powerful automated adaptive mesh refinement provides the standard accuracy.

HFSS can help antenna designers who are constantly challenged with implementing designs across more and more frequency bands inside a smaller and smaller footprint. With these additional technical challenges along with the ever shrinking time to market, simulation with HFSS is a must-have in the antenna design and integration process. Miniaturization of the antennas, achieves limited bandwidth, reduces design time HFSS gives accurate and efficient solutions. The basic characteristics of the antenna are return loss, input impedance, gain, directivity and variety of polarization can be analyzed in HFSS.

2.2. ANSYS HFSS SIMULATION SOFTWARE

ANSYS is the leading developer of electromagnetic field simulation software used by engineers to design electronic and electromechanical products across a broad range of industries. The electromagnetic product focuses on improving the physical design by leveraging advanced electromagnetic field simulators dynamically linked to powerful circuit and system simulation. This methodology allows users to design and optimize smarter, more automated, efficient and mobile electronic and electromechanical products without costly physical prototypes.

ANSYS electromagnetic solutions allows to gain an understanding of:

- Device performance characteristics under applied loads/excitations and boundary conditions
- Visualization of the electromagnetic field in and around a device
- Joule heating effects and resultant temperatures
- Force distribution and resulting deformation
- Key design parameters: torque, force, resistance, inductance, capacitance, impedance, S-parameters and radiated fields and emissions



Fig 2.1. HFSS Software

2.3. ANSYS HFSS SIMULATION

Electromagnetic Field Simulation HFSS sets the standard for accuracy, advanced solver and high-performance computing technology, making it the 'go to' tool for engineers designing high-frequency and high-speed electronics found

in communication systems, radar systems, satellites, smart phones and tablet devices. Rigorous Validation Sign-off quality high-frequency EM results that allow customers to simulate and go straight to manufacturing. Using HFSS, engineers can extract parasitic parameters (S, Y, Z), visualize 3D electromagnetic fields (near- and far-field) and generate Full-Wave SPICE models that link to circuit simulations. This software is easy to use, versatile and fast features such as automatic adaptive meshing, versatile design entry and advanced high-performance computing technology put analyst-quality solvers in the hands of the designer.

2.3.1. SIMULATION- SWEEPS

This frequency sweep used to generate a solution across a range of frequencies. The sweep types are:

- Fast: Generates a unique full-field solution for each division within a frequency range. Best for models that will abruptly resonate or change operation in the frequency band. A Fast sweep will obtain an accurate representation of the behavior near the resonance.
- Discrete: Generates field solutions at specific frequency points in a frequency range. Best when only a few frequency points are necessary to accurately represent the results in a frequency range.
- Interpolating: Estimates a solution for an entire frequency range. Best when the frequency range is wide and the frequency response is smooth, or if the memory requirements of a Fast sweep exceed your resources.

2.3.2. SIMULATION- EXCITATIONS

Assigning excitations to an HFSS design enables to specify the sources of electromagnetic fields and charges, currents, or voltages on objects or surfaces.

- Wave port
- Lumped port
- Incident wave
- Voltage source
- Current source
- Magnetic Bias source

2.3.3. SIMULATION- BOUNDARIES

Boundary conditions specify the field behavior on the surfaces of the problem region and object interfaces. This area of the technical notes includes information about the following boundary types:

- Perfect E
- Perfect H
- Impedance
- Radiation
- PML
- Finite Conductivity
- Symmetry
- Master and Slave
- Lumped RLC
- Layered Impedance
- Infinite Ground Planes

2.3.4. SIMULATION- MATERIALS

Linear material properties

- Relative Permeability

- Relative Permittivity
- Bulk Conductivity
- Dielectric Loss Tangent
- Magnetic Loss Tangent

Ferrite material properties

- Magnetic Saturation
- Lande G Factor
- Delta H

2.3.5. SIMULATION- SOLUTIONS

- Driven Modal Solution

Choose the Driven Modal solution type when you want HFSS to calculate the modal-based S-parameters of passive, high-frequency structures such as microstrips, waveguides, and transmission lines. The S-matrix solutions will be expressed in terms of the incident and reflected powers of waveguide modes.

- Driven Terminal Solution

Choose the Driven Terminal solution type when you want HFSS to calculate the terminal-based S-parameters of multi-conductor transmission line ports. The S-matrix solutions will be expressed in terms of terminal voltages and currents.

- Eigenmode Solution

Choose the Eigenmode solution type to calculate the eigenmodes, or resonances, of a structure. The Eigenmode solver finds the resonant frequencies of the structure and the fields at those resonant frequencies.

2.4. HFSS FEATURES

- 3-D full-wave EM field simulation
- Tangential vector finite elements
- Automatic adaptive mesh generation and refinement
- S-, Y-, Z-parameter extraction via transfinite elements
- Model healing, automatic feature recognition, mesh resolution control and fault-tolerant meshing for CAD import
- Low-, medium- and higher-order basis functions
- Direct and iterative matrix solvers (64-bit capability)
- Eigenmode matrix solver (64-bit capability)
- Generalized multi-mode port definitions including lossy and Floquet ports
- Auto-assign for terminal-driven ports
- Multiple incident field sources including small current loop, dipoles and arbitrary plane waves.

2.5. HFSS APPLICATIONS

- **Passive Components**
 - Antenna feed structures
 - Filters, circulators, connectors, waveguide transitions
 - Embedded passives (i.e., spiral inductors, MIM and MOM capacitors)
 - MEMS

- **RF PCBs**

- Wireless devices, guidance systems, mobile base station
- MRI devices, SAR studies
- **High Speed ICs**
 - Embedded passives
 - Spiral inductors
 - Transformers
 - MOM and MIM capacitors
 - Critical interconnects
 - Vias
 - Clock trees
 - Transitions
 - MMICs, RFICs, MEMS
- **IC Packages**
 - SiP, PoP, CSP, BGA, LTCC, MCM, LTCC, MCM
 - Lead-type (QFP, QFN, DiP, SO)
 - PGA, BGA (wire-bonded, flip chip)
- **Printed Circuit Boards**
 - Vias, lands
 - Transmission lines
 - Gridded power/ground planes
 - Rigid/build-up/flexible PCBs.

3. DESIGN OF ANTENNA GEOMETRY

A pentagonal microstrip patch antenna gives better performance than the rectangular patch antenna; in particular, it supports both linear and circular polarizations. The pentagonal patch antenna provides circular polarization with only one feed whereas rectangular patch antenna requires multiple feeds to get circular polarizations. Hence the proposed antenna geometry is chosen to be a pentagonal patch antenna and fed with a 50 ohm coaxial cable for better impedance matching.

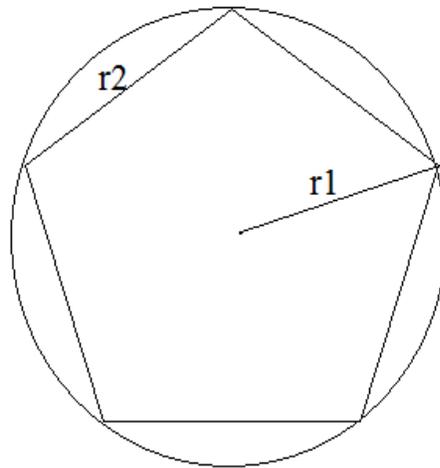


Fig 3.1. Geometry of regular pentagonal shape

The relationship between the circles (r1) to the side arm of the regular pentagon (r2) is given in equation

$$r_2^2 = \frac{\pi r_1^2}{2.37} \quad \text{eq (1)}$$

side arm of the pentagon $r_2 = 1.175 r_1$

In the derivation of the eq (1), the pentagonal patch is assumed to be a resonant cavity with perfectly conducting side walls.

The resonant frequency of the dominant as well as for the higher order modes can be calculated from the formula given below

$$f_{np} = \frac{X'_{np}c}{2\pi r_1 \sqrt{\epsilon_r}}$$

where X'_{np} are the zeros of the derivative of the Bessel function $J_n(x)$ of the order n , as is true for TE mode circular waveguides, however for the lowest order modes

$$X'_{np} = 1.84118$$

3.1. DESIGN SPECIFICATIONS

The proposed pentagonal patch antenna has been designed using following specifications:

Geometry	Pentagonal
Side arm length	8.9mm
Substrate(FR4)	$\epsilon_r = 4.4$, $h = 1.6\text{mm}$ $\tan\delta = 0.002$
Centre frequency	5.8GHz
Feed location	Xf=1mm Yf=0.7mm
Coaxial cable dimension	Inner radius: 0.5mm Outer radius: 0.7mm

Table 3.1 Design specification

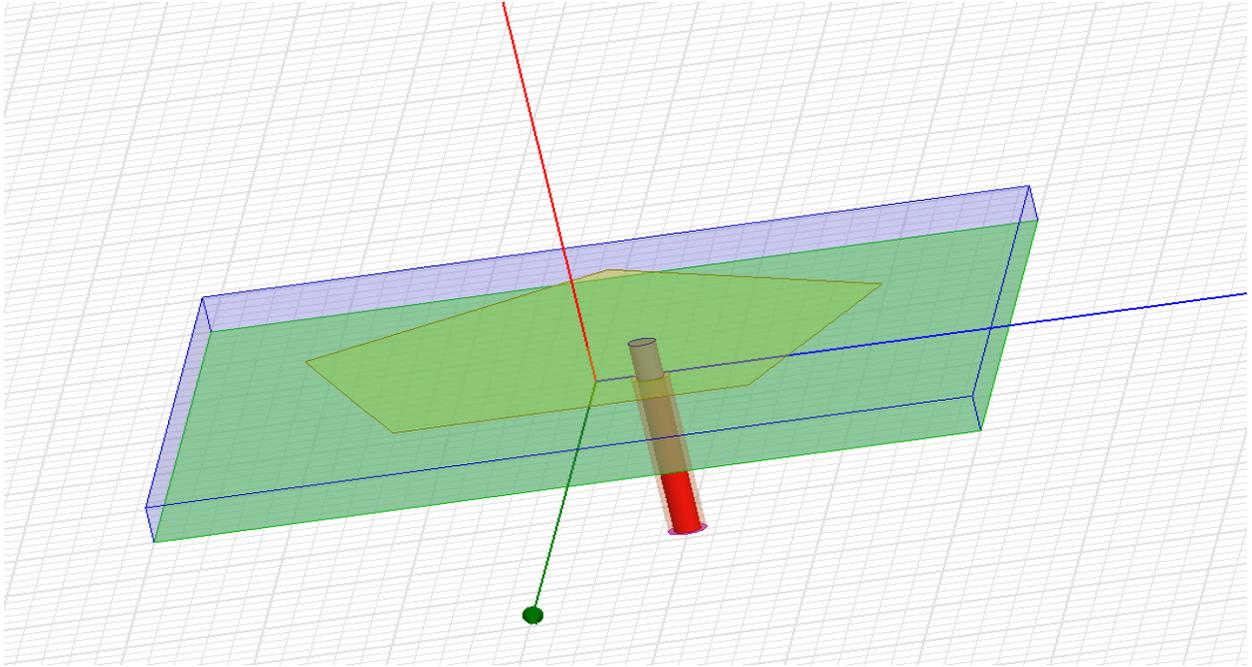


Fig 3.2. Designed antenna without EBG

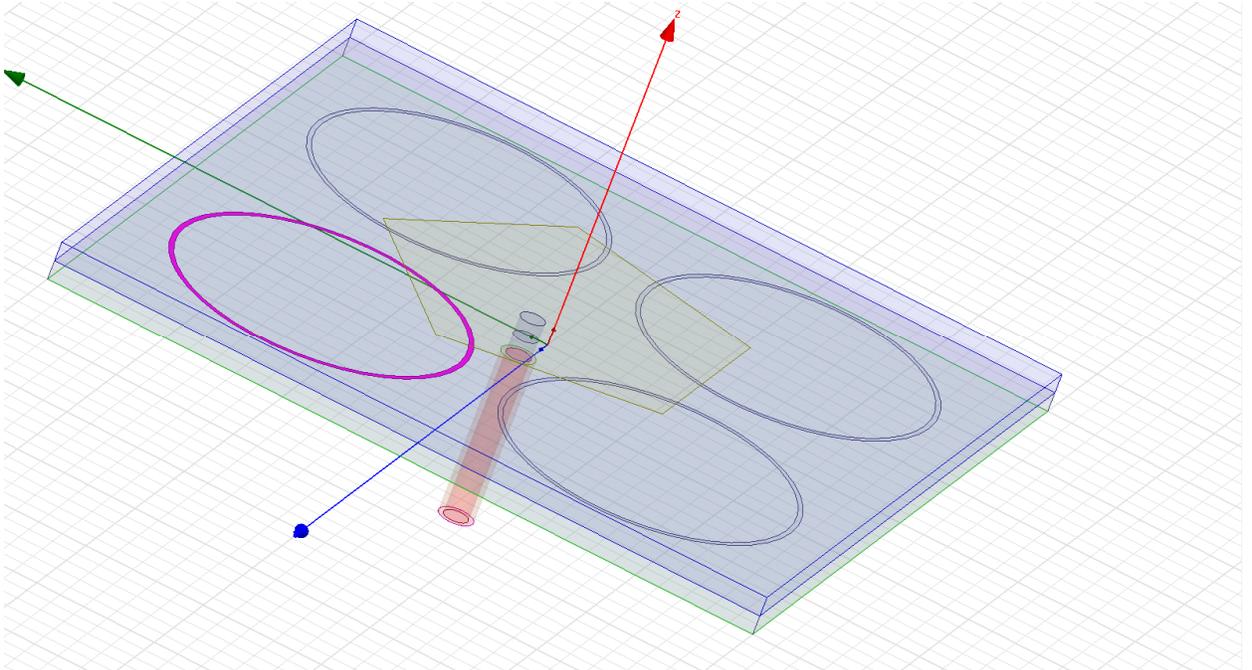
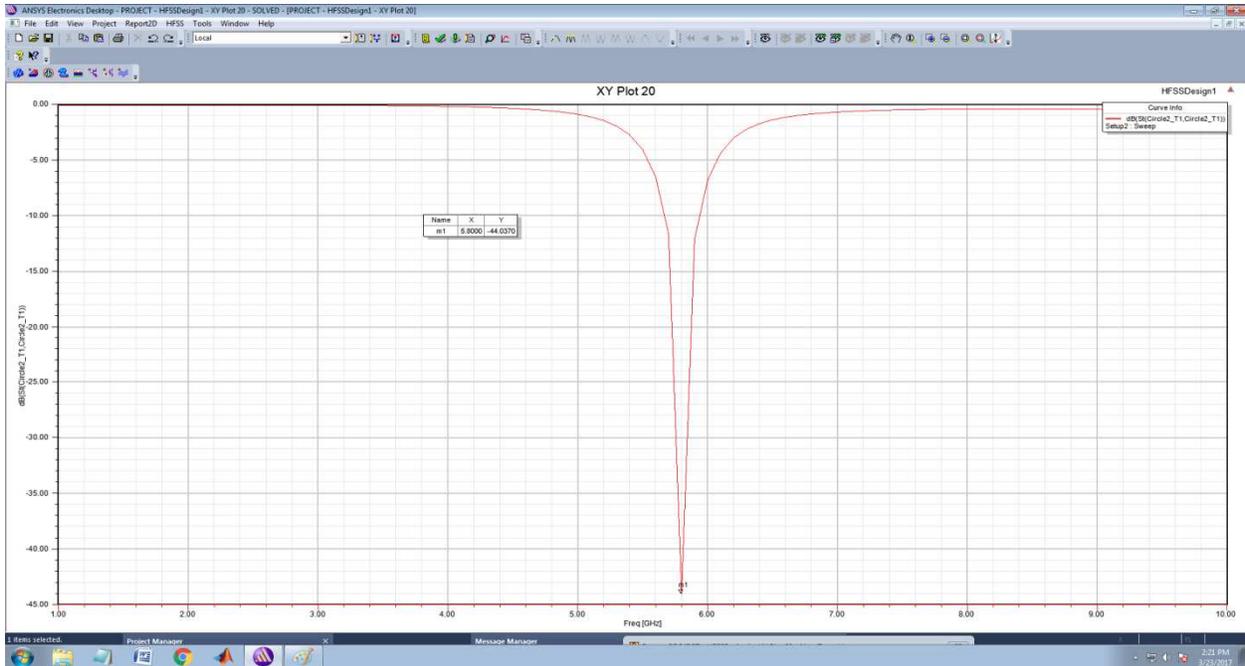


Fig 3.3. Designed antenna with EBG

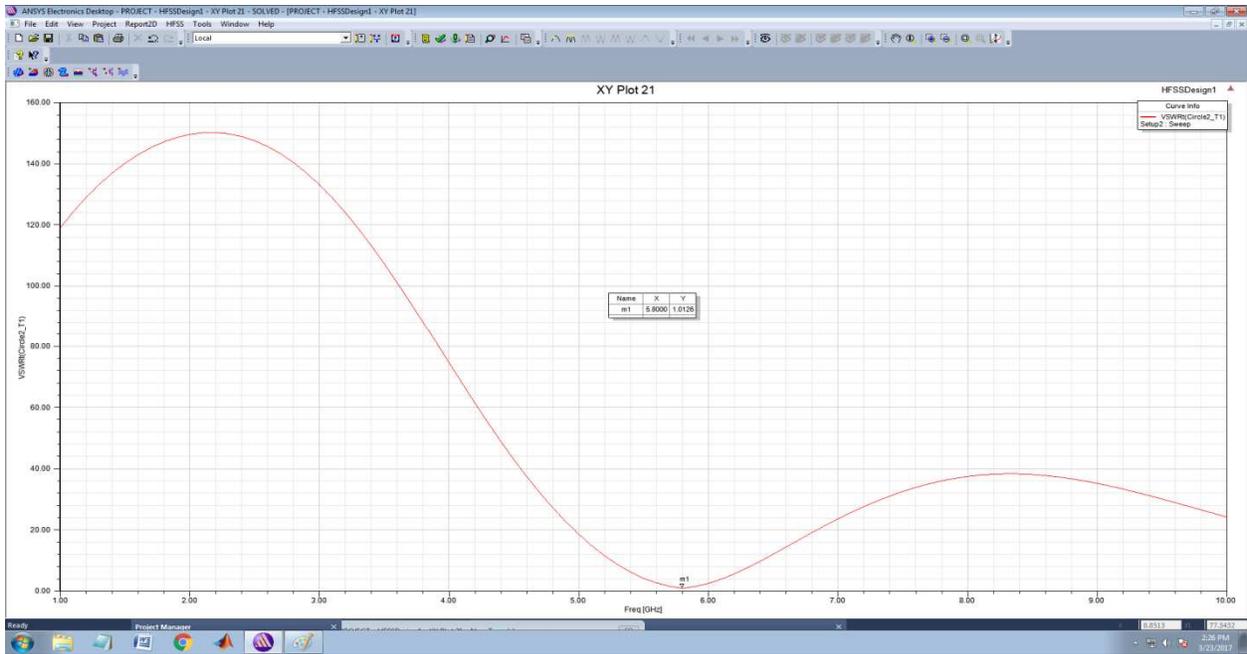
4. SIMULATION RESULTS OF ANTENNA

4.1. FR4 SUBSTRATE WITHOUT EBG

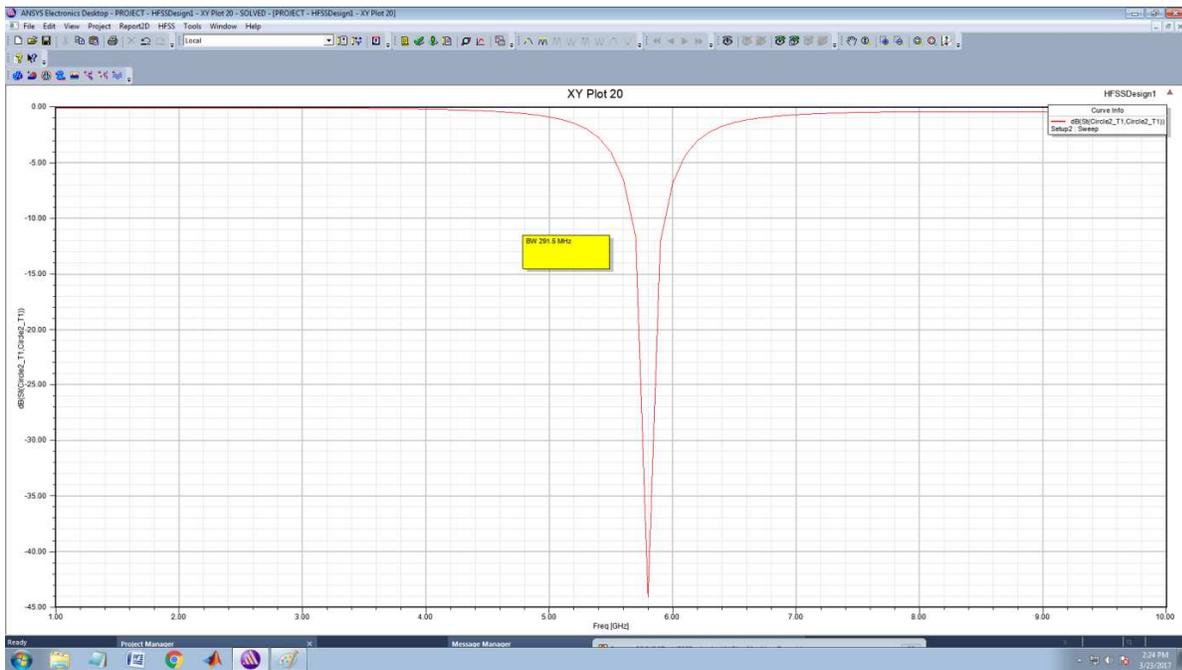
4.1.1. RETURN LOSS (S11)



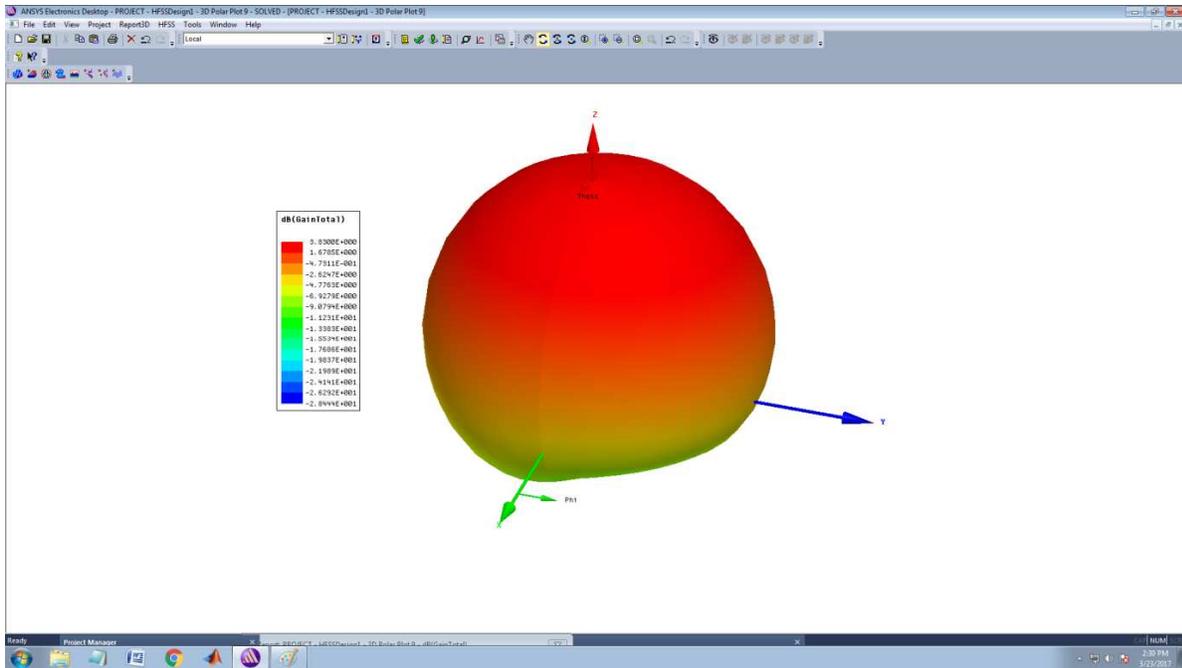
4.1.2. VSWR



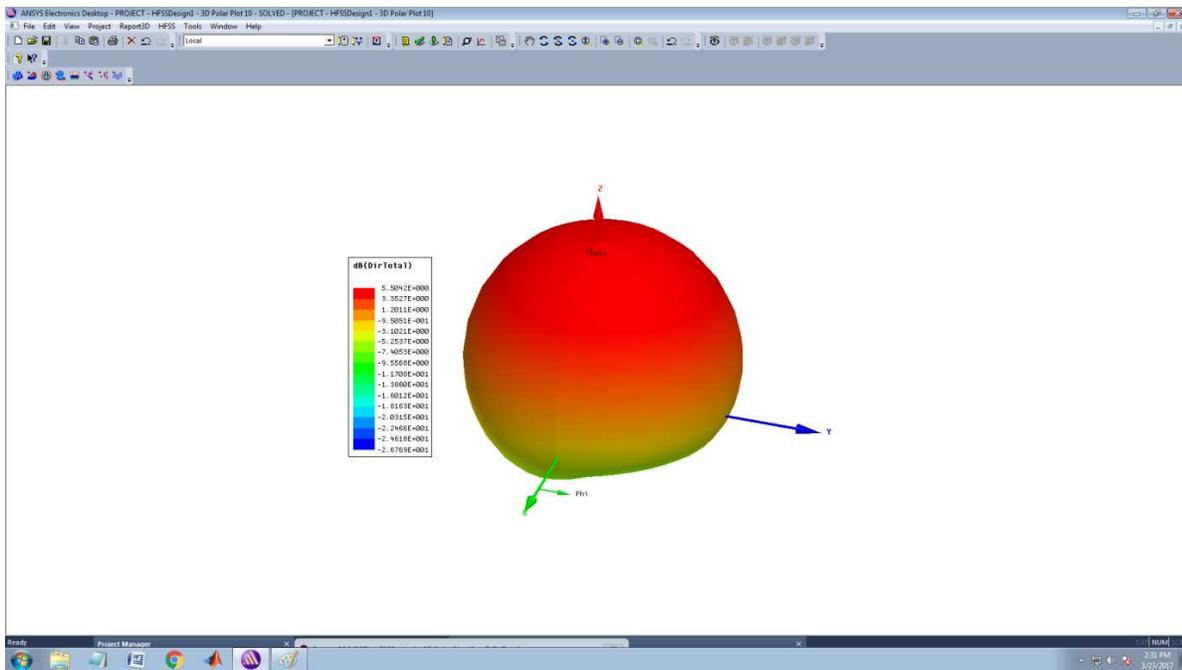
4.1.3. BANDWIDTH



4.1.4 GAIN

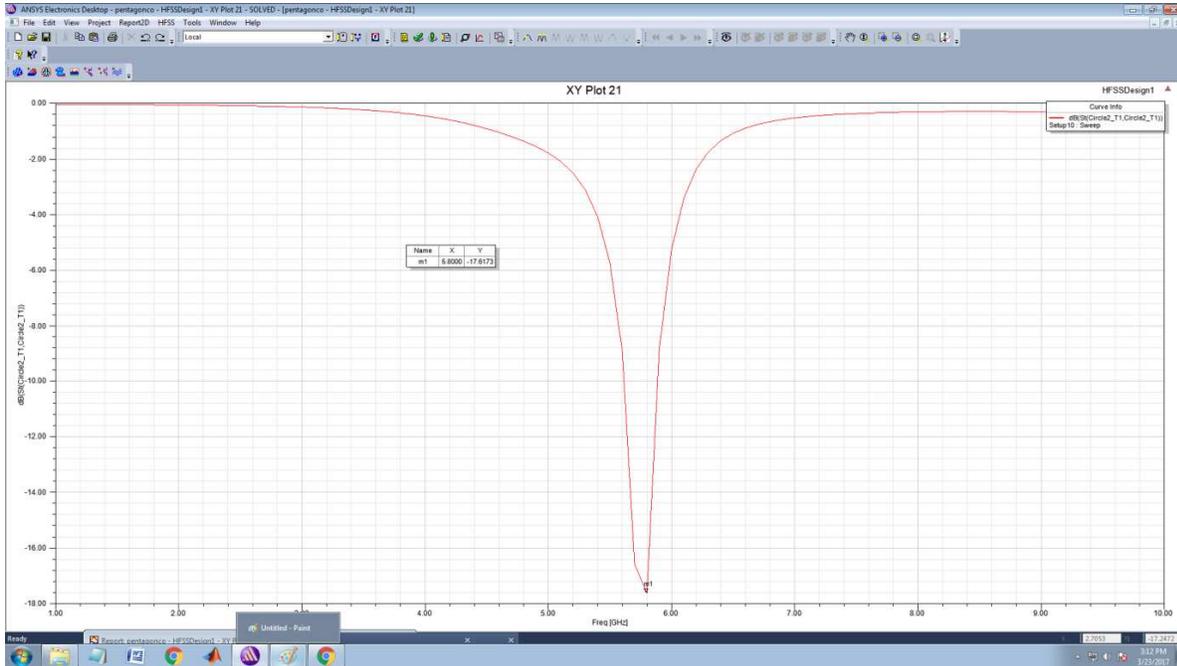


4.1.5. DIRECTIVITY

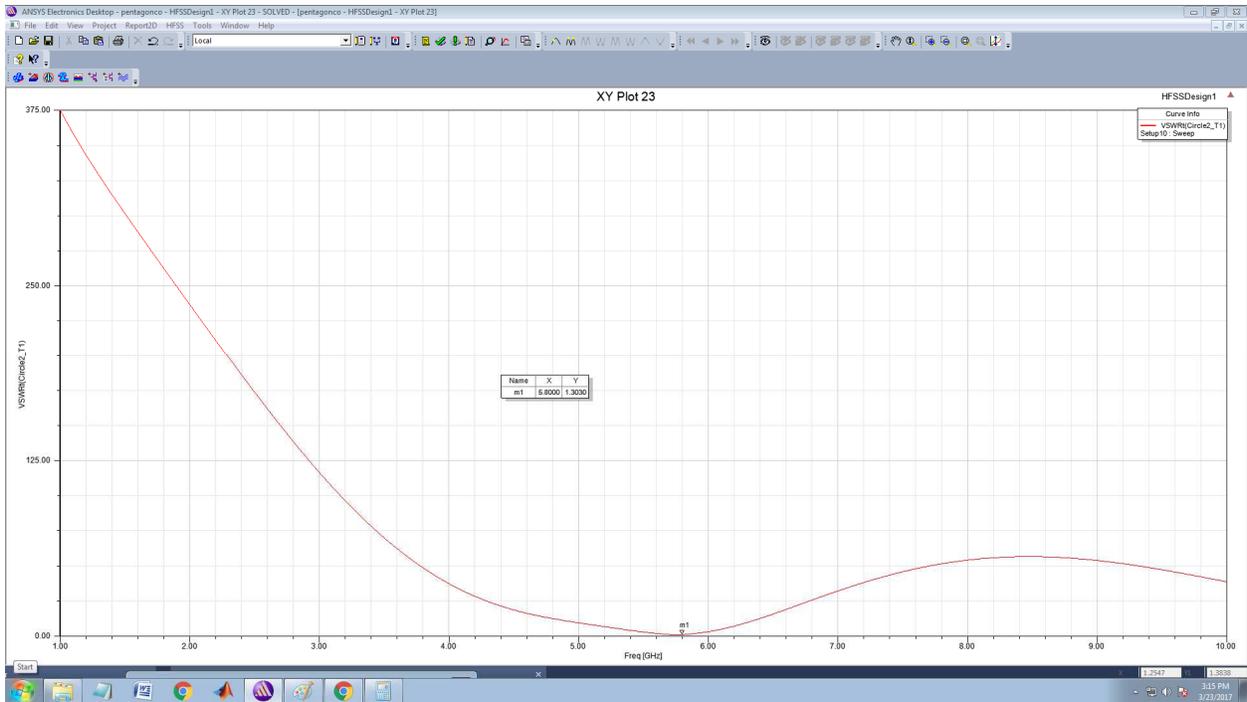


4.2. ROGER SUBSTRATE WITHOUT EBG

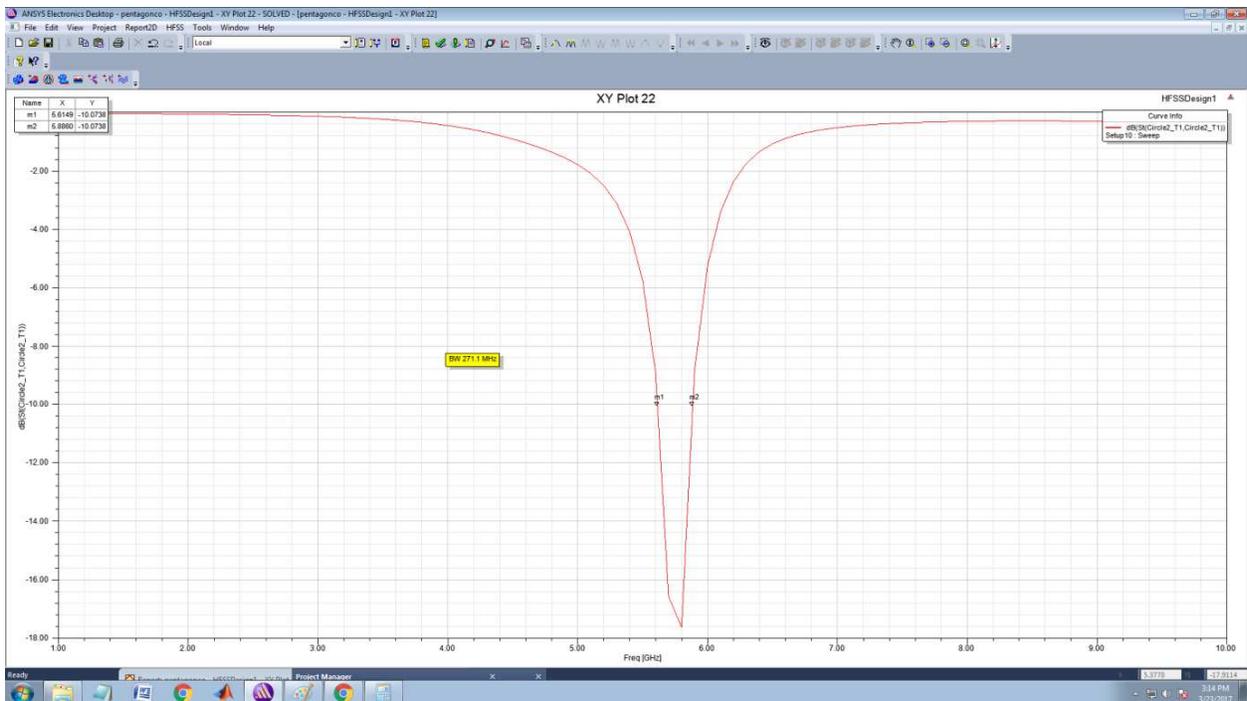
4.2.1. RETURN LOSS (S11)



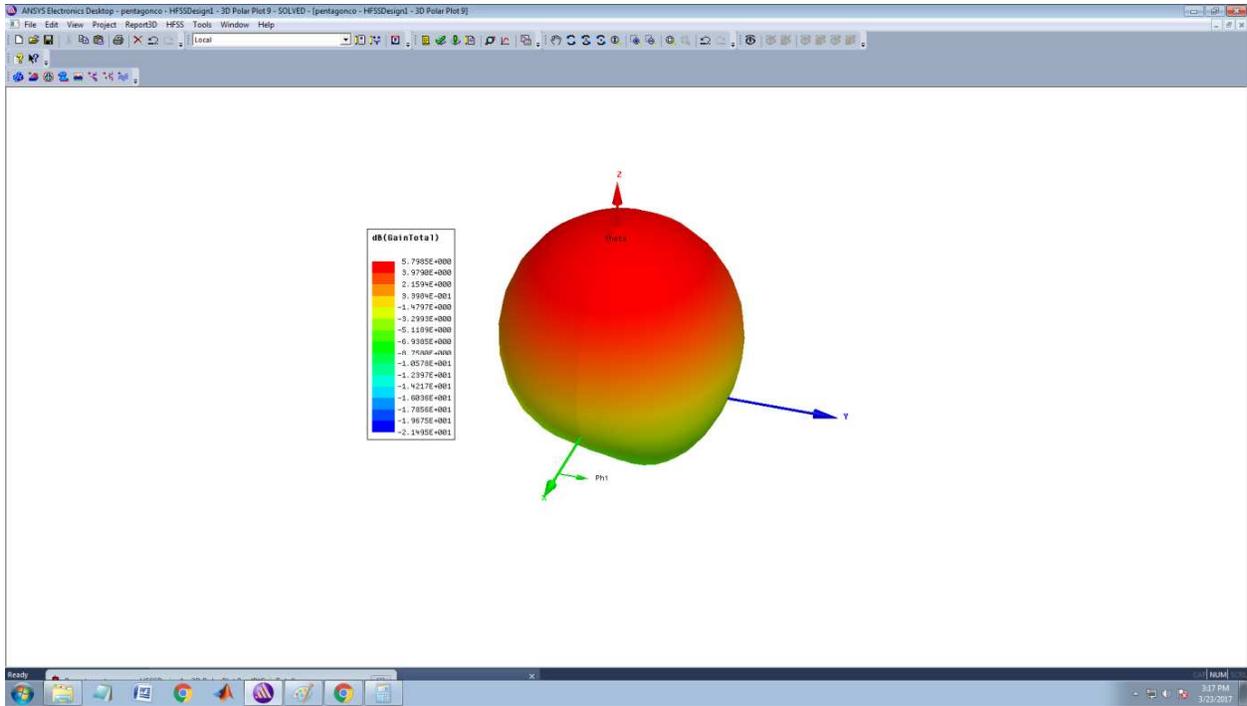
4.2.2. VSWR



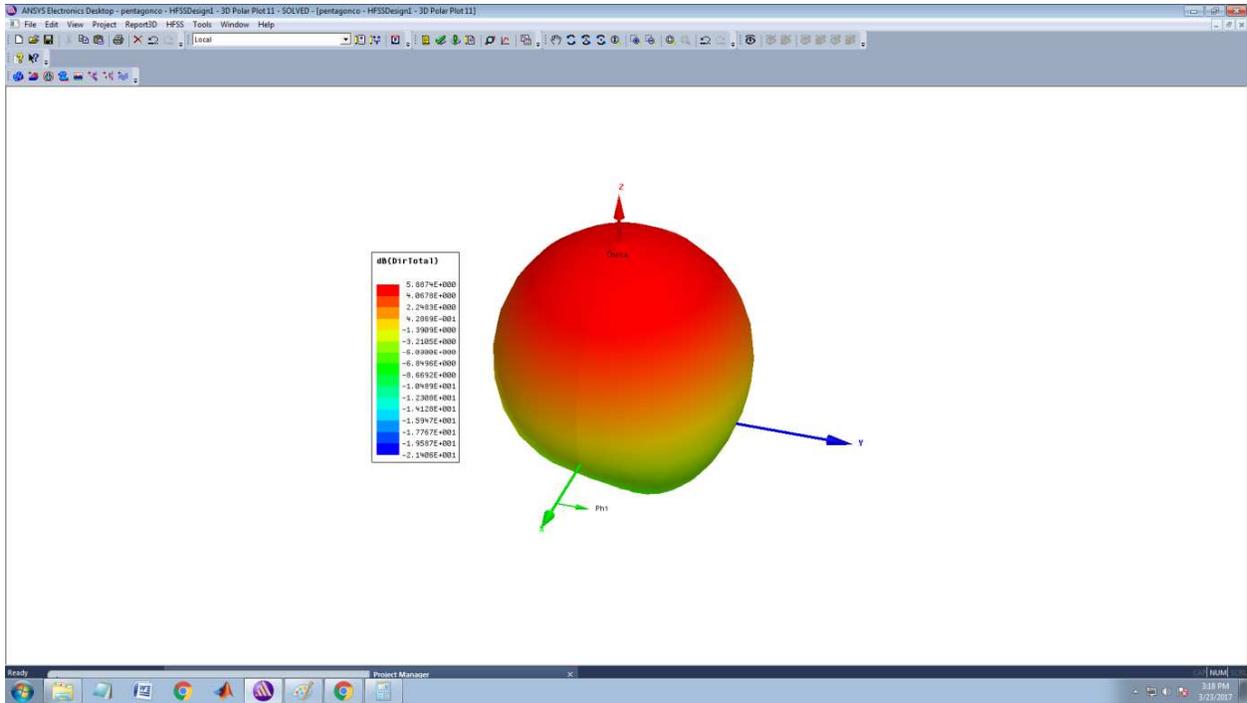
4.2.3. BANDWIDTH



4.2.4. GAIN

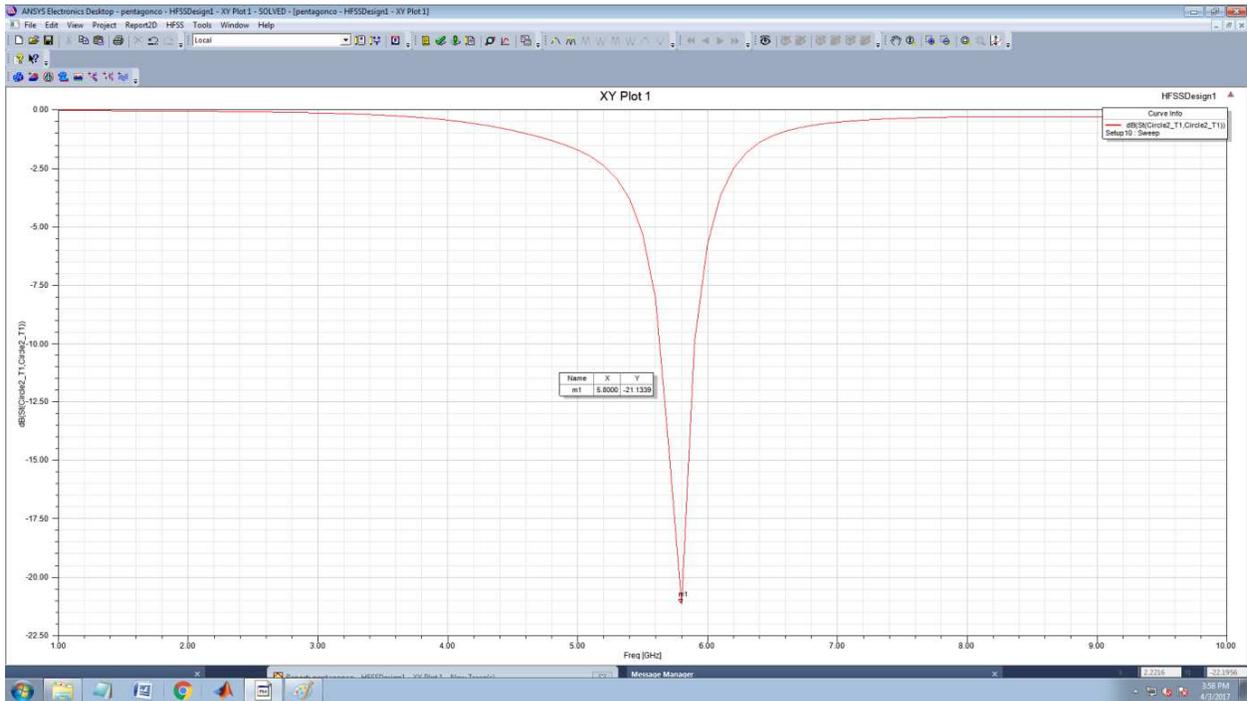


4.2.5. DIRECTIVITY

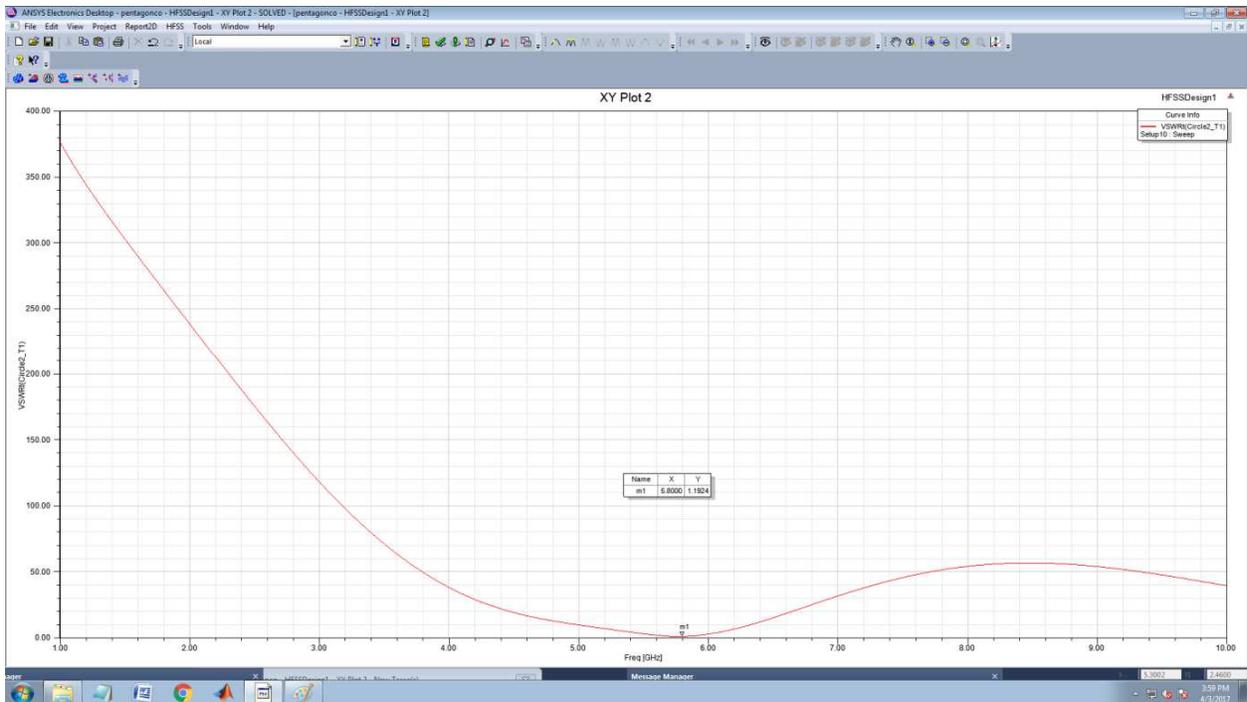


4.3. ANTENNA WITH EBG (FR4 SUBSTRATE)

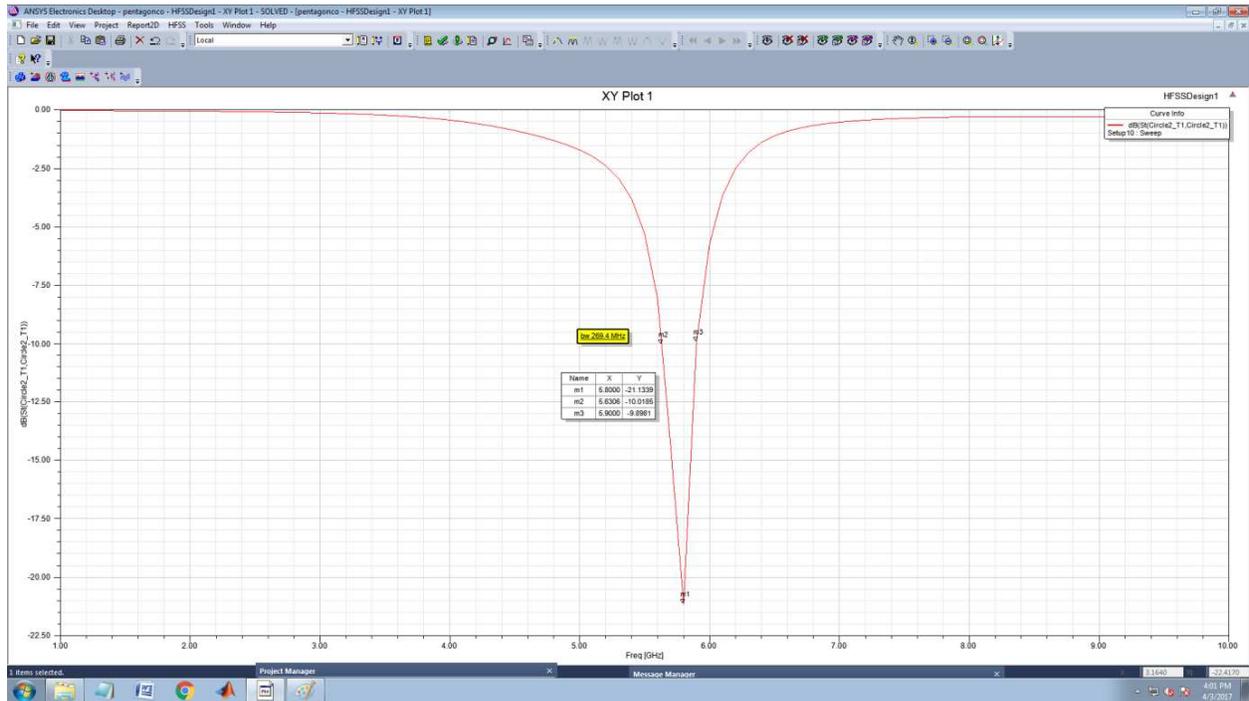
4.3.1. RETURN LOSS (S11)



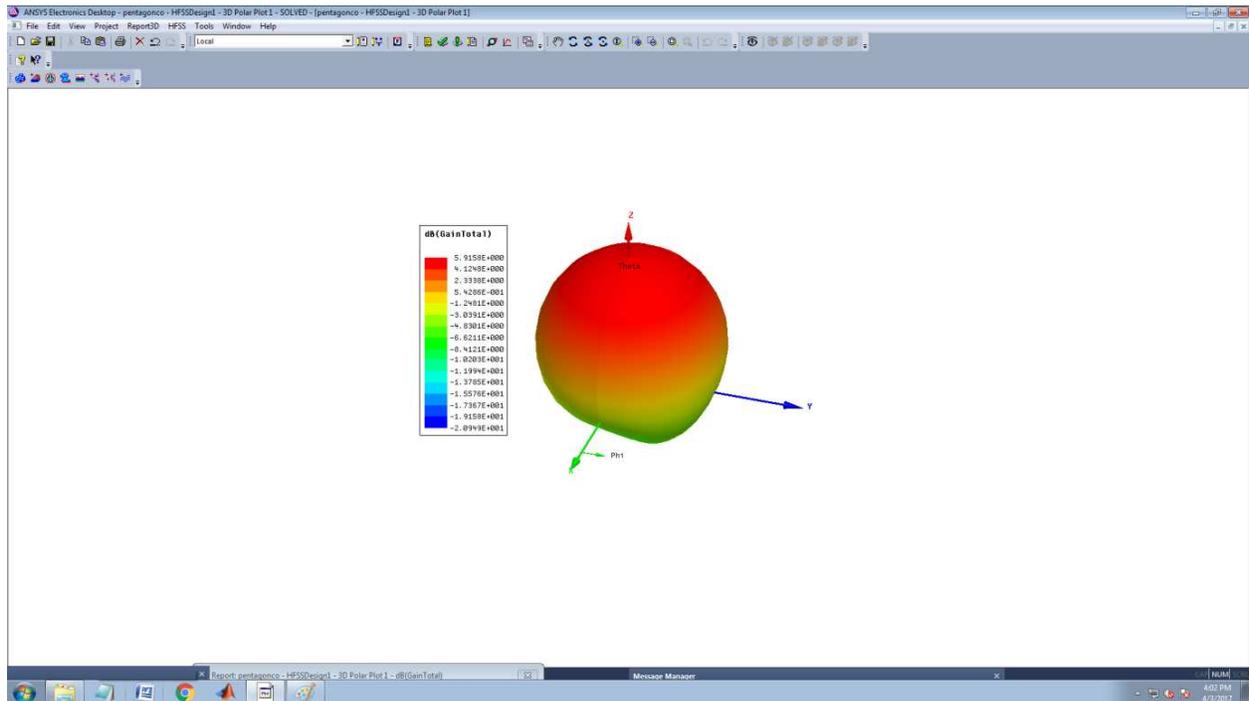
4.3.2. VSWR



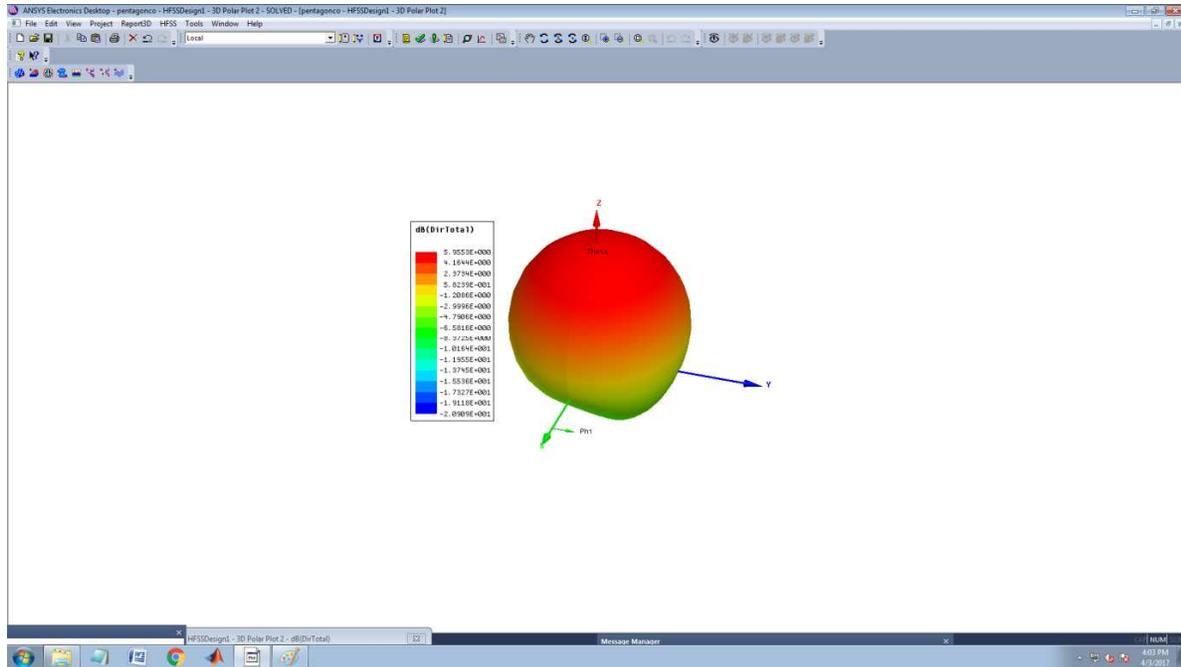
4.3.3. BANDWIDTH



4.3.4. GAIN



4.3.5. DIRECTIVITY



4.4. COMPARISON OF RESULTS

PARAMETERS OBTAINED	FR4 SUBSTRATE WITHOUT EBG	FR4 SUBSTRATE WITH EBG	ROGER SUBSTRATE WITHOUT EBG
RETURN LOSS	-44.03dB	-21.13dB	-17.62dB
VSWR	1.0126	1.1924	1.3030
BANDWIDTH	286.3 MHz	269.4MHz	271.1 MHz
GAIN	3.3dB	5.91dB	5.78dB
DIRECTIVITY	5.5dB	5.95dB	5.8dB

Table 4.1. Comparison of results

5. FABRICATION

5.1. ANTENNA DESIGN AND SIMULATION

During the past four decades, microstrip antennas have attracted a great deal of attention due to their low profile, ease of fabrication, low cost, and conformability. In this work, the antenna is chosen to operate at a resonant frequency of 5.8 GHz since this band is very common and widely used for WLAN applications. The transmission line model is used for calculating the dimensions of the patch. Three essential parameters, frequency of operation (f_0), height of dielectric substrate (h) and dielectric constant of the substrate, must be selected appropriately to design a microstrip patch antenna.

The chosen substrate in this project is FR4 of a relative permittivity, ϵ_r , of 4.4 and thickness of 1.6 mm. The size of ground plane is 30 mm \times 30 mm. The feed point must be located where the input impedance is 50 ohms at the resonant frequency. The location of the feeding point is achieved by a trial-and-error method by selecting a distance 30% from the edge and moving in a small step to ($X_f = 1$ mm, $Y_f = 0.7$ mm), locate the optimum feed point where the S_{11} is minimum.

These antenna parameters are fed to simulation software based on the technique, Finite Element Method (FEM) formulation of Ansoft's High Frequency Structure Simulator (HFSS), which is chosen for validation purposes. The simulation results of softwares are compared to the measured ones.

For printed antennas designed using HFSS following are the steps for antenna fabrication

- Click Modeler in the Menu bar of HFSS and then click Export.
- Select the file type to be .dxf and provide name to the file and location.
- Then the dxf file can be opened using some CAD software or Corel Draw.

Follow the conventional PCB fabrication process i.e. screen printing, masking, etching etc.

After exporting the Gerber file of the simulated design to the printer, loading the substrate and adjusting the nozzles distances as discussed previously, the printing order is given to print the SNP-based square patch. Next, thermal curing is applied and feed is applied afterwards.

A coaxial feed is used to excite the microstrip antenna using a microdriller, silver paste, and soldering station to fix the 50 Ω ohm subminiature version A (SMA) port. The SMA is connected to the antenna by carefully drilling the antenna at the specified position.

The inner conductor of the coaxial cable is connected and soldered to the patch, and the outer conductor of the coaxial cable is soldered to the ground plane. The inner conductor of the SMA port is connected to the patch through the substrate using silver paste while the inner conductor of the SMA is soldered to the copper patch. For both patches, the SMA port is soldered to their ground plane.

5.2. SMA CONNECTOR

- SMA Connectors are coaxial RF connectors developed in the 1960s and SMA is the abbreviation of SubMiniature version A. SMA connectors have a 50 ohm impedance, 1/4-36 thread type coupling mechanism and this RF connector offers excellent electrical performance from 0 to 18 GHz.
- SMA connectors are available in various quality classes for different applications with different material options. Various SMA connectors are widely used in Vehicle Tracking System, Wireless LAN, WiMax, Telecommunication, Aero and precise testing instrumentation.



Fig 5.1. SMA connector

5.3. MATERIALS

5.3.1. FR4_EPOXY

FR-4 glass epoxy is a popular and versatile high-pressure thermoset plastic laminate grade with good strength to weight ratios. With near zero water absorption, FR-4 is most commonly used as an electrical insulator possessing considerable mechanical strength.

The material is known to retain its high mechanical values and electrical insulating qualities in both dry and humid conditions. These attributes, along with good fabrication characteristics, lend utility to this grade for a wide variety of electrical and mechanical applications.

"FR" stands for flame retardant, and denotes that safety of flammability of FR-4 is in compliance with the standard UL94V-0. FR-4 was created from the constituent materials (epoxy resin, woven glass fabric reinforcement, brominated flame retardant, etc.) by NEMA in 1968



Fig 5.2. FR4 _epoxy

NEMA is the regulating authority for FR-4 and other insulating laminate grades. Grade designations for glass epoxy laminates are: G10, G11, FR4, FR5 and FR6. Of these, FR4 is the grade most widely in use today. G-10, the predecessor to FR-4, lacks FR-4's self-extinguishing flammability characteristics. Hence, FR-4 has sincerely replaced G-10 in most applications.

5.3.2. ROGER RT/DUROID 5880

RT/ duroid® 5870 and 5880 glass microfiber reinforced PTFE composites are designed for exacting strip line and microstrip circuit applications. The randomly oriented microfibers result in exceptional dielectric constant uniformity.

The dielectric constant of RT/duroid 5870 and 5880 laminates is uniform from panel to panel and is constant over a wide frequency range. Its low dissipation factor extends the usefulness of RT/duroid 5870 and 5880 laminates to Ku-band and above.

RT/duroid 5870 and 5880 laminates are easily cut, sheared and machined to shape. They are resistant to all solvents and reagents, hot or cold, normally used in etching printed circuits or in plating edges and holes.

5.4. FABRICATION PROCESS

This antenna is fabricated using the Eleven Lab fabrication device. It involves three process.

1. Drilling
2. Milling
3. Routing



Fig 5.3. Eleven Lab Device

5.5. FABRICATED ANTENNA

FRONT VIEW

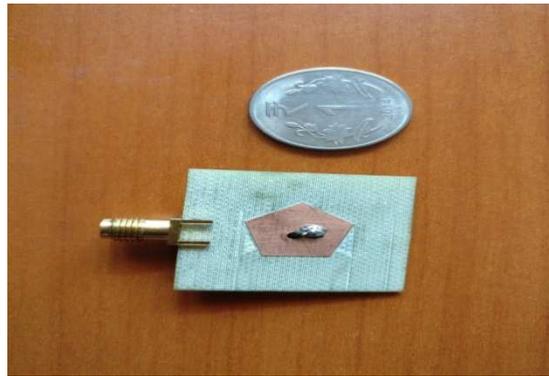


Fig 5.4. Front view of fabricated antenna

BACK VIEW

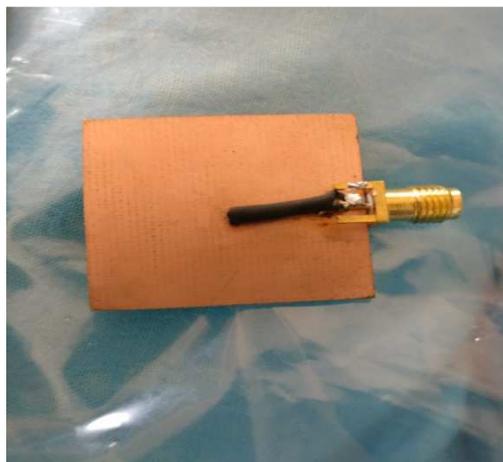


Fig 5.5. Back view of fabricated antenna

6. TESTING

6.1. NETWORK ANALYZER

A network analyzer is an instrument that measures the network parameters of electrical networks. Today, network analyzers commonly measure S-parameters because reflection and transmission of electrical networks are easy to measure at high frequencies. Here, the measurement of S11 and VSWR are performed using KEYSIGHT FieldFox Microwave Analyser N9915A (9 GHz)



Fig 6.1. Network analyser

6.2. KEY FEATURES AND FUNCTIONS OF N9915A

- 9 GHz maximum frequency.
- Carry the worlds most integrated handheld and microwave analyser. Standard model includes cable and antenna analyser.

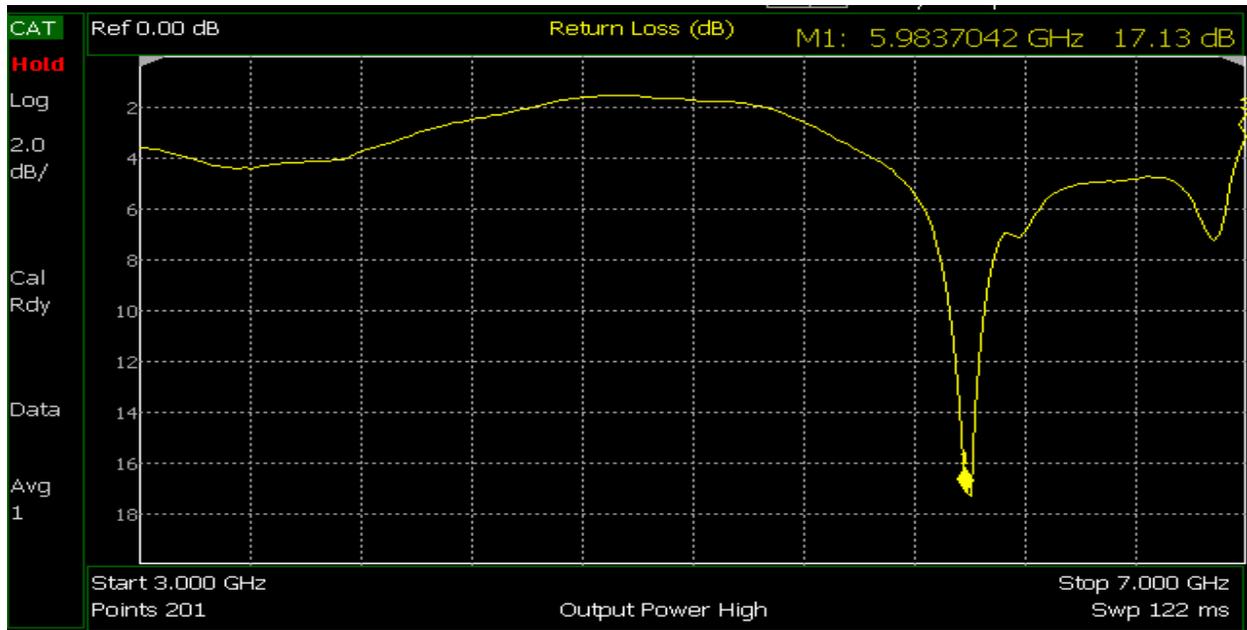
- Expand capabilities with optional VNA, spectrum analyser, built in power meter, vector volt meter and more.
- Save time by measuring DTF and TDR in the same sweep.
- Simultaneously measure all four S-parameters.
- Make accurate spectrum analyser measurements (± 0.5 dB) without needing warm up.
- Calibrate simply with quikCal
- Lightest all in one analyser at only 6.6 lb (3.0 kg)

6.3 . PRACTICAL RESULTS

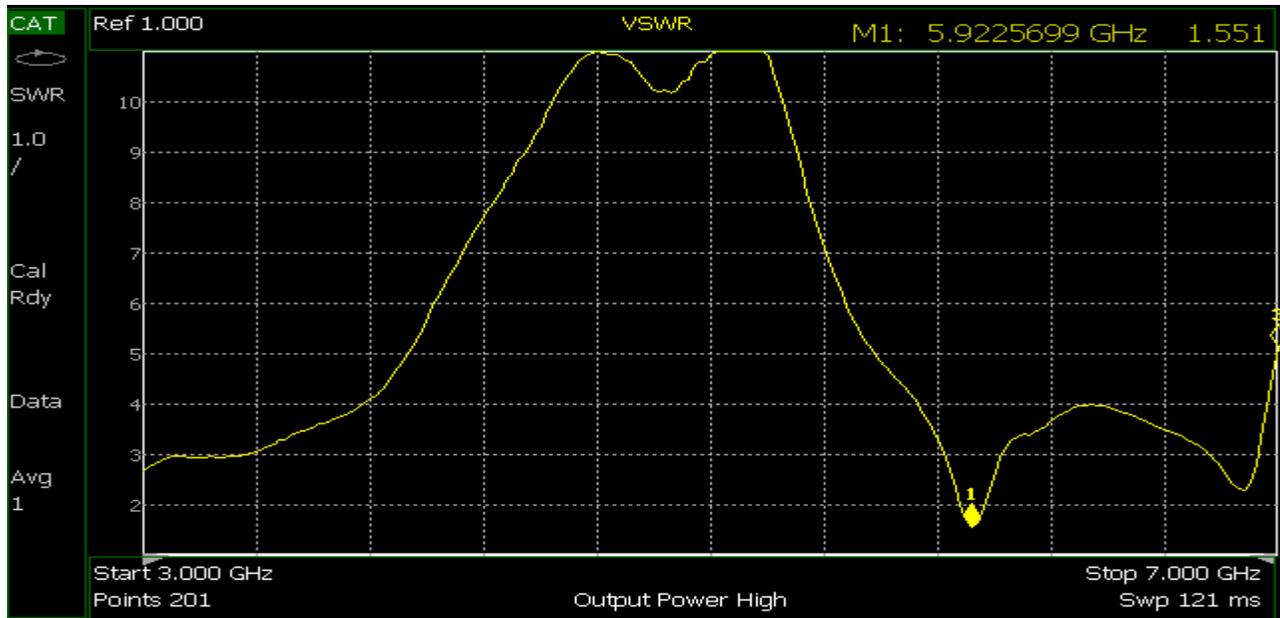
6.3.1. EXPERIMENTAL SETUP



6.3.2. RETURN LOSS



6.3.3. VSWR



7. CONCLUSION

The pentagon shaped patch antenna is designed to operate at 5.8 GHz with good return loss. The corresponding return loss is -44 dB and VSWR is 1.01 while the resulted gain is 3.8 dB. EBG structure has been successfully designed and incorporated with the designed antenna. After incorporating, the gain has been significantly increased to 5.9 dB. The proposed antenna is aggressive miniaturized to meet requirements of the wireless communication systems. It was concluded that the hardware and software results we obtained matched the theoretically predicted results.

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