COMPARISON BETWEEN RECTANGULAR, CIRCULAR AND TRIANGULAR MICROSTRIP PATCH ANTENNA

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Abstract—Modern Wireless communication Systems require low profile, lightweight, high gain and simple structure antennas to assure reliability, mobility, and high efficiency. A patch antenna is very simple in construction using a conventional Microstrip fabrication technique. It consists of a patch of metallization on a grounded dielectric substrate. They are low profile, lightweight antennas, most suitable for aerospace and mobile applications. Patch antennas have matured considerably during last years and many of their limitations have been overcome. The conducting patch can take any shape, but rectangular configurations are the most commonly used. In our study we are interested in rectangular, circular and triangular patch antenna designs. The objective of this research is to analysis the results of different patches.

Index Terms: HFSS tool, patch antenna.

I. INTRODUCTION

Antenna is like Eye and Ear of any radio system. A system without antenna won't have ability to transmit or receive to its full capacity. Antenna is the system which receives the radio signal and converts it into small voltage and when transmitting it converts voltage into radio signal which is electromagnetic wave. An Antenna is a reciprocal device i.e. same device can work on a frequency in both directions. Antenna is extremely important component for success of a radio system. So much rests on antenna. Antenna is the component which gives direction to the signal if needed. [1]

Microstrip antenna is one of the types of antennas. A Microstrip Antenna (MSA) in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. MSAs are also known as "patch antennas" or "printed antennas" or "planar antennas". Microstrip or patch antennas are becoming increasingly useful because they are low (paper-thin) profile, planar configuration and conformal structured, structurally robust and light weight, there is ease of fabrication using printed-circuit technology, both Linear and circular (left or right-handed) polarizations is possible (useful for frequency - reuse), they are compatible with modular designs; hence solid state components can be added directly into the microstrip antenna substrate, they are easily integrable with the circuits; feed lines and matching networks, it is easy to achieve dual-frequency performance, arrays can be easily created to increase directivity, they can be easily mounted on space vehicles, missiles and satellites without major alterations and also they are compatible with MMIC designs. Every element is having some limitations so does MSAs have, which are: Low radiation efficiency, small bandwidth, practical limitations on the maximum gain, poor polarization purity, low power handling capability, poor isolation between the feed and the radiating element, possibility of excitation of surface waves, spurious radiation from feeds, junctions and surface waves, high performance arrays require complex feed systems [2].

To fabricate an antenna, first we select the frequency of operation, the substrate used and the thickness of the substrate. The shape of the antenna is determined and then from these selections, the dimensions of the substrate and patch are calculated. The antenna is first designed and simulated in software. After obtaining the desired results, the actual fabrication process starts. Here, HFSS software is used for simulation. Different shapes of the patch are considered for obtaining the best results and the same is concluded.

Microstrip patch antenna has several applications. Some of these applications are discussed as below: Mobile and satellite communication application, Global Positioning System applications, Worldwide Interoperability for Microwave Access (WiMax), Radar Application, Rectenna Application, Telemedicine Application, Medicinal applications of patch. [3]

II. EXPERIMENTAL

2.1 Design of Microstrip Patch Antenna

Design involves the determination of dimensions of the patch from the knowledge of resonant frequency in Hz.

Firstly we have taken length of patch as 32mm, breadth as 30mm and then its area is equated to area of circle and corresponding radius is calculated. Radius is calculated as 17.4mm.

The simulation is performed on HFSS software. HFSS is high frequency structure simulator it is high performance full wave electromagnetic field simulator 3D volumetric passive device modelling that takes advantages of familiar Microsoft Windows graphical user interface .it integrates simulation, visualization ,solid modelling and automaton in easy to learn environment. Typical uses of HFSS are: package modelling, PCB board modelling, EMC/EMI, antenna mobile communications, connectors, waveguide, filters. HFSS uses a numerical technique called the finite element method. This is procedure where a structure is subdivided into many smaller subsections called finite element. The finite element used by HFSS is tetrahedral and entire collection of tetrahedral is called mesh. Solution is found for the fields within the finite element and these fields are interrelated so that Maxwell's equations are satisfied across inter element yielding. Yielding a field solution for the entire original structure. Once the field solution has found the s matrix solution is determined. [4]

2.2 Simulations

- After designing the single band linearly Polarized Micro Strip antenna the simulations are performed.
- Firstly, Validation check is performed to observe warnings and errors if any in the design,
- Next, the setup is assigned to the antenna, which includes operating frequency band 2.60-2.85 GHz sweep in the range 1-4 GHz with 0.01 GHz step.
- Results for return loss, VSWR, gain and parameters of antenna are obtained from the generate report section of HFSS tool.

Boundaries and excitations of the Microstrip antenna Boundaries

Perfect E: Patch, Ground

Radiating only: Air (except bottom face)

Excitation: Wave port (port 1)

III. SIMULATION AND ITS RESULTS

equations

Dimensions of Rectangular Patch Antenna

Calculation of Width (W):

The width of the micro strip patch antenna is given by the equation

$$W = \frac{c}{2fo\sqrt{\frac{(\epsilon_r+1)}{2}}}$$

On substituting, $C = 3 \times 10^{11}$mm/sec fo = 2.72GHz, ε_r=2.94

W=30mm

Calculation of Effective Length (L_{eff}):

The calculation of effective length of the micro strip patch antenna is given by the equation

$$L_{eff} = \frac{c}{2fo\sqrt{\epsilon_{reff}}}$$

$C = 3 \times 10^{11}$m/sec ,fo= 2.72GHz, ε_{reff}= 2.60

L_{eff}= 34mm

3.1 Simulation results of Rectangular Patch Antenna

The figures give the shape, return loss, VSWR, gain, various parameters of the rectangular Microstrip antenna. Values of parameters are given below.

Return loss	=	-13.48 dB
VSWR	=	1.53
Gain	=	2.3
Radiation efficiency	=	99%

The dimensions used to design the patch antenna are approximate values and are almost near to the calculated values

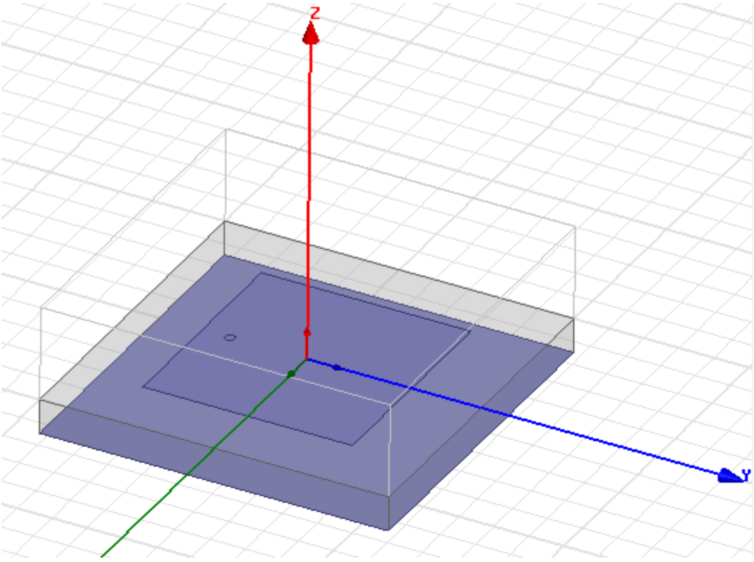

Fig 1: Rectangular patch antenna

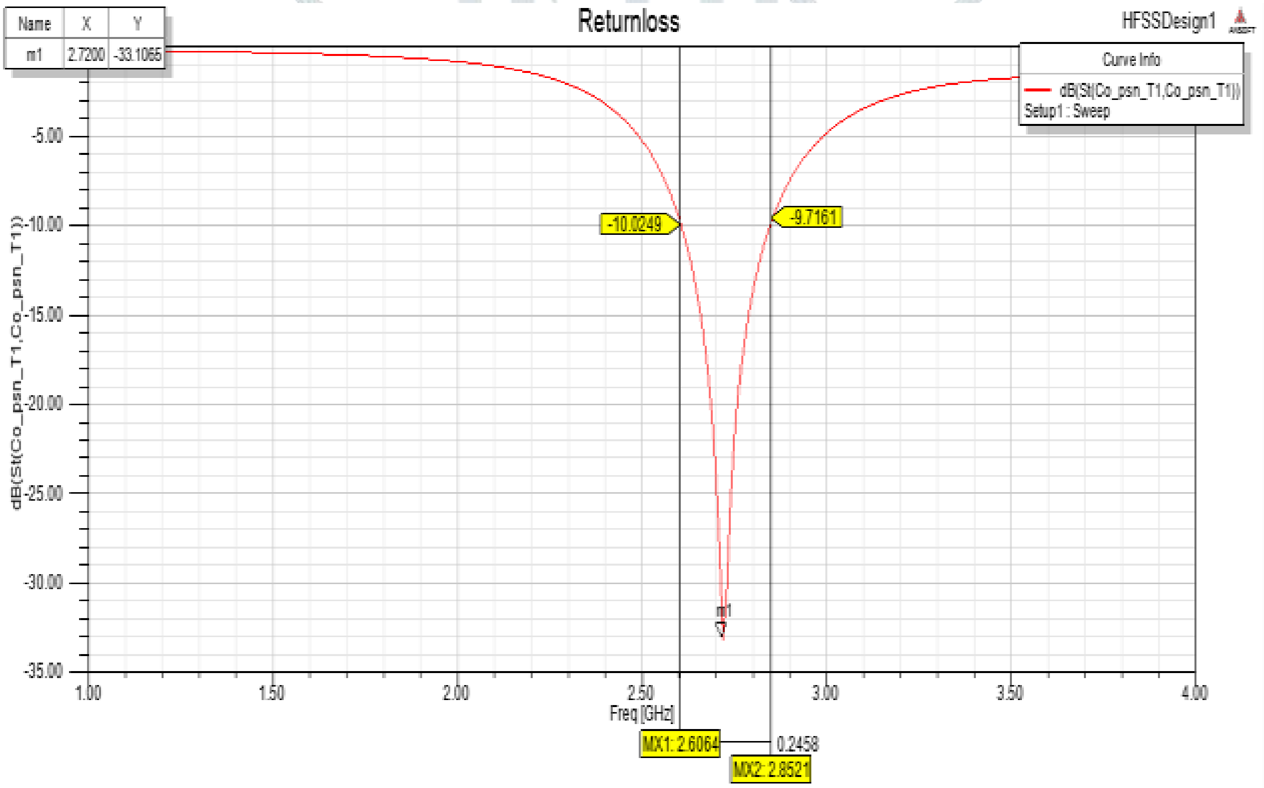

Fig 2: S_{11} Graph for designed rectangular patch antenna

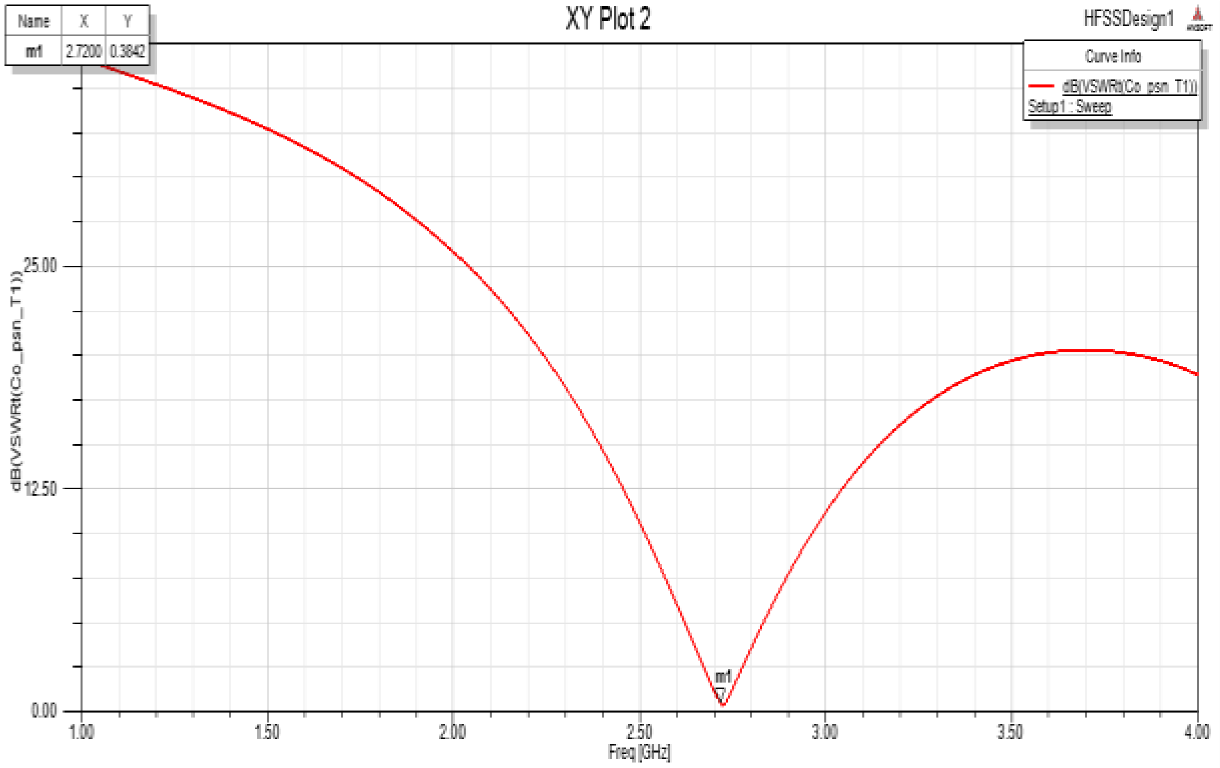

Fig3: VSWR graph for designed rectangular patch antenna

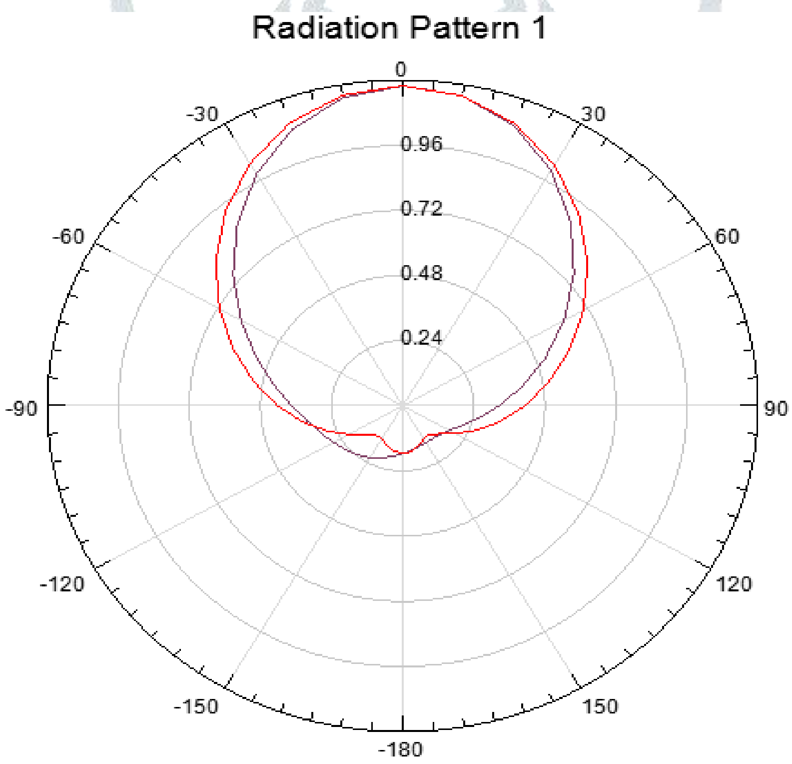

Fig 4: Radiation pattern for designed rectangular patch antenna

Inputs

Setup Name: Infinite Sphere1

Solution: LastAdaptive

Array Setup: None

Intrinsic Variation: Freq='2.72GHz'

Design Variation: brea='32mm' bread='30mm' f

Antenna Parameters:

Quantity	Value	Units
Max U	0.0018403	W/sr
Peak Directivity	2.4107	
Peak Gain	2.3882	
Peak Realized Gain	2.2856	
Radiated Power	0.0095934	W
Accepted Power	0.0096837	W
Incident Power	0.010118	W
Radiation Efficiency	0.99067	
Front to Back Ratio	44.838	
Decay Factor	0	

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Fig 5: Parameters of designed rectangular patch antenna

equations

Radius of Circular Patch Antenna

$$r = \frac{1.8412}{2\pi f\sqrt{\varepsilon_r\sqrt{\mu_o\varepsilon_o}}}$$

Where, f = 2.72 GHz, $\varepsilon_r = 2.94$, $\mu_o = 1.25 \times 10^{-6}$, $\varepsilon_o = 8.85 \times 10^{-12}$

r = 18.8mm

3.2 Simulation results of Circular Patch Antenna

The figures 5.6 - 5.10 give the shape, return loss, VSWR, gain, various parameters of the rectangular Microstrip antenna. Values of parameters are given below.

Return loss	=	-33.1 dB
VSWR	=	0.38
Gain	=	2.38

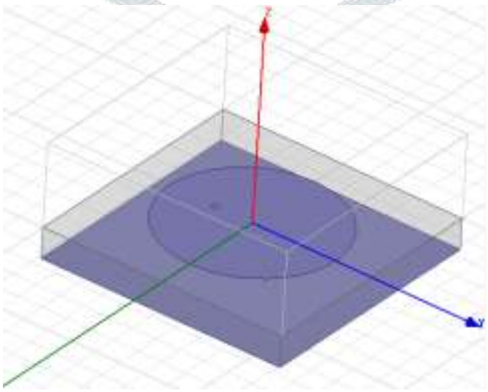


Fig 6: Circular Patch Antenna

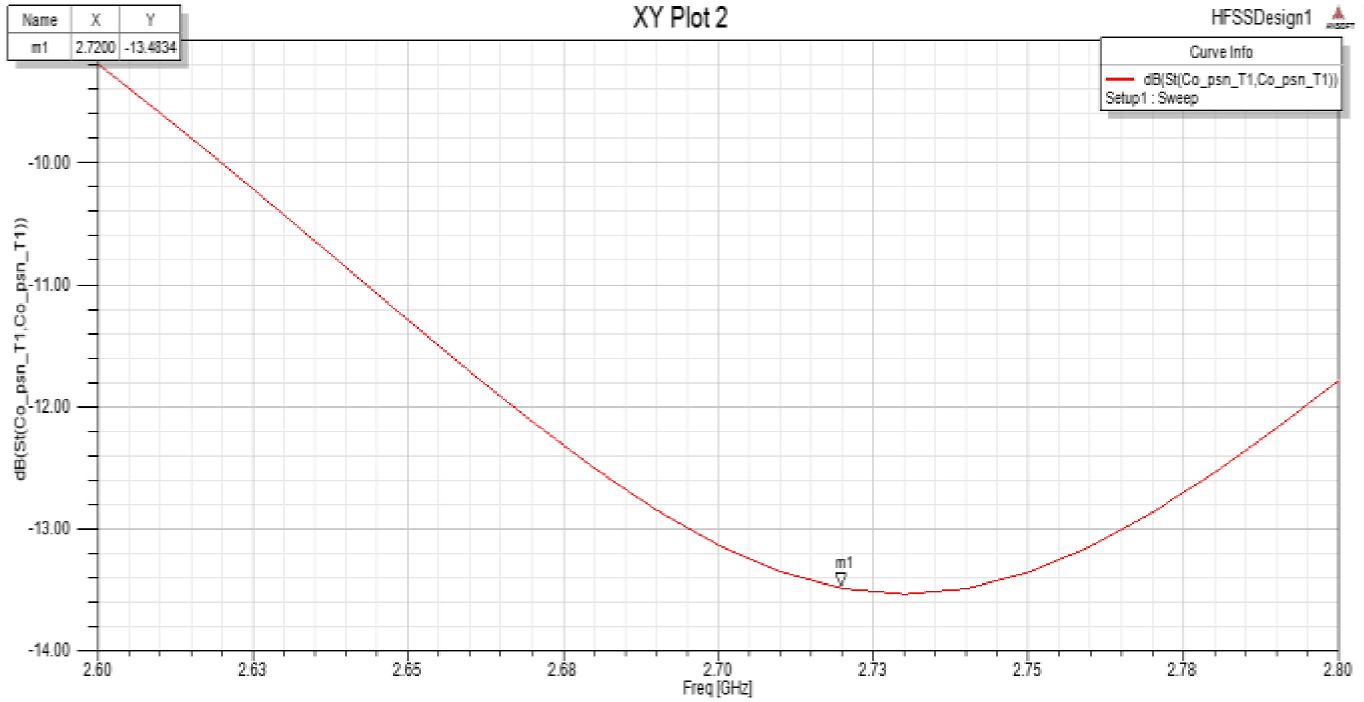


Fig 7: S_{11} Graph for designed circular patch antenna

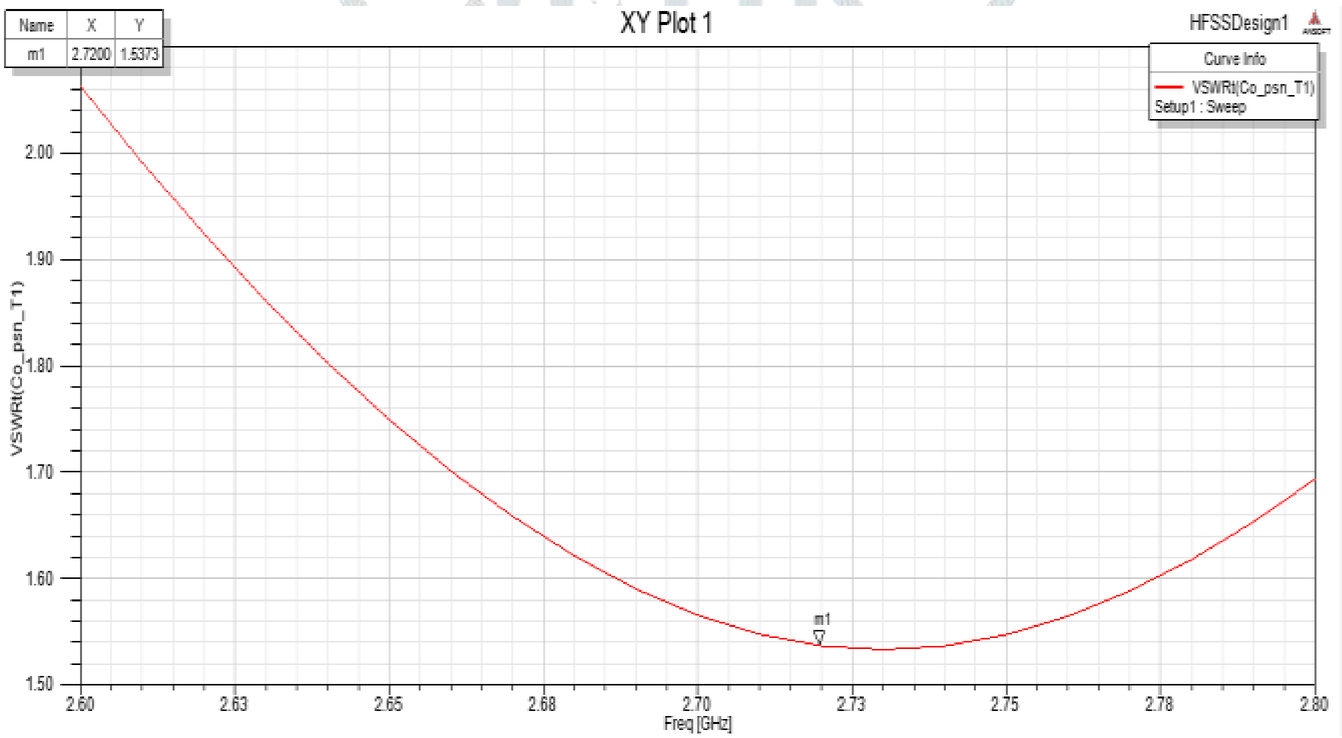


Fig 8: VSWR graph for circular patch antenna

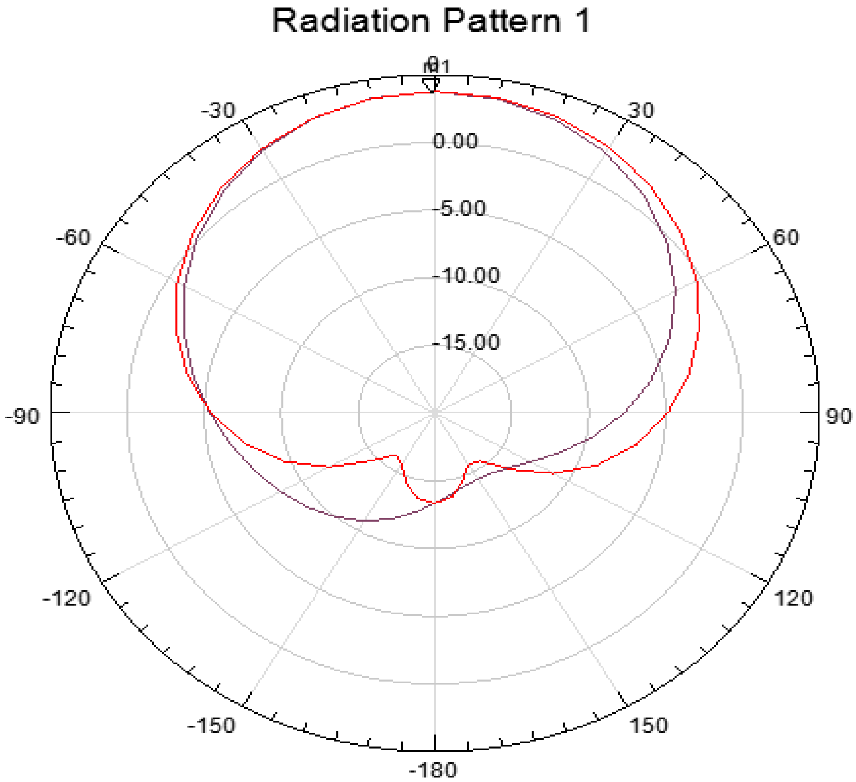
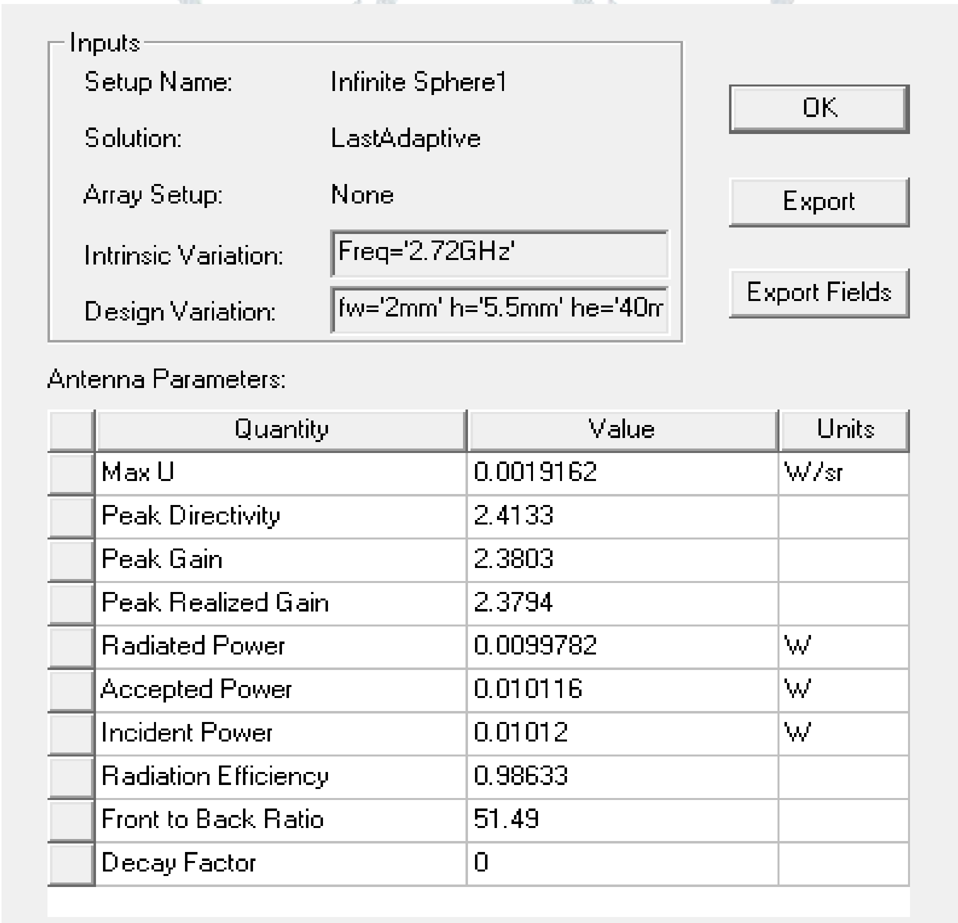


Fig 9: Radiation Pattern of designed circular patch antenna



Inputs

Setup Name: Infinite Sphere1

Solution: LastAdaptive

Array Setup: None

Intrinsic Variation: Freq='2.72GHz'

Design Variation: fw='2mm' h='5.5mm' he='40m

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Antenna Parameters:

Quantity	Value	Units
Max U	0.0019162	W/sr
Peak Directivity	2.4133	
Peak Gain	2.3803	
Peak Realized Gain	2.3794	
Radiated Power	0.0099782	W
Accepted Power	0.010116	W
Incident Power	0.01012	W
Radiation Efficiency	0.98633	
Front to Back Ratio	51.49	
Decay Factor	0	

Fig 10: Parameters of designed circular patch antenna

equations

Radius of Circular Patch Antenna

The equilateral triangular patch has a side length ‘S’ and printed on a substrate of thickness ‘h’ with relative dielectric constant ‘$\in_r$’.
The resonant frequency of ETMA with side length S is given as

$$f_{mn} = \frac{2c\sqrt{m^2 + n^2 + mn}}{3S_e\sqrt{\in_0}}$$

Where, S_e is the effective side length given by,

$$S_e = S + \frac{h}{\sqrt{\in_e}}$$

Where, $\in_e$ is the effective dielectric constant given by,

$$\in_e = \frac{\in_r + 1}{2} + \frac{\in_r - 1}{2}\left[1 + \frac{10h}{\frac{S}{2}}\right]^{\frac{-1}{2}}$$

Where, h is the height of the dielectric substrate and $\in_r$ is the dielectric constant.
Therefore, we obtain the side as 45mm.

3.3 Simulation results of Triangular Patch Antenna

The figures give the shape; return loss, VSWR, gain, various parameters of the rectangular microstrip antenna. Values of parameters are given below.

Return loss	=	-33.1 dB
VSWR	=	0.38
Gain	=	2.38

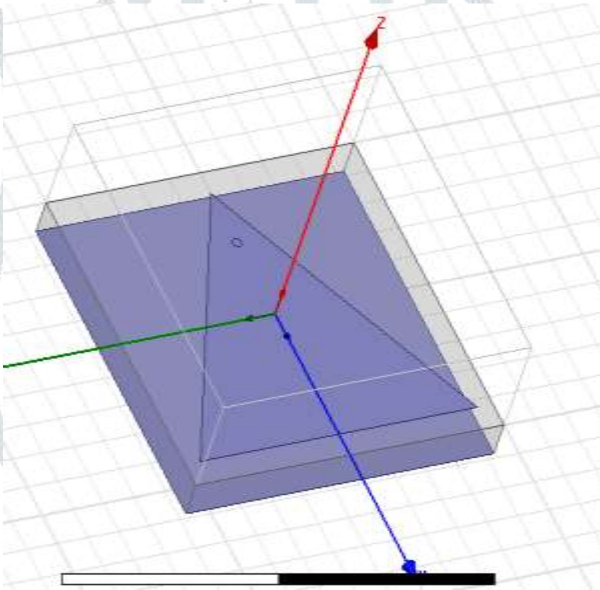

Fig 11: Triangular Patch Antenna

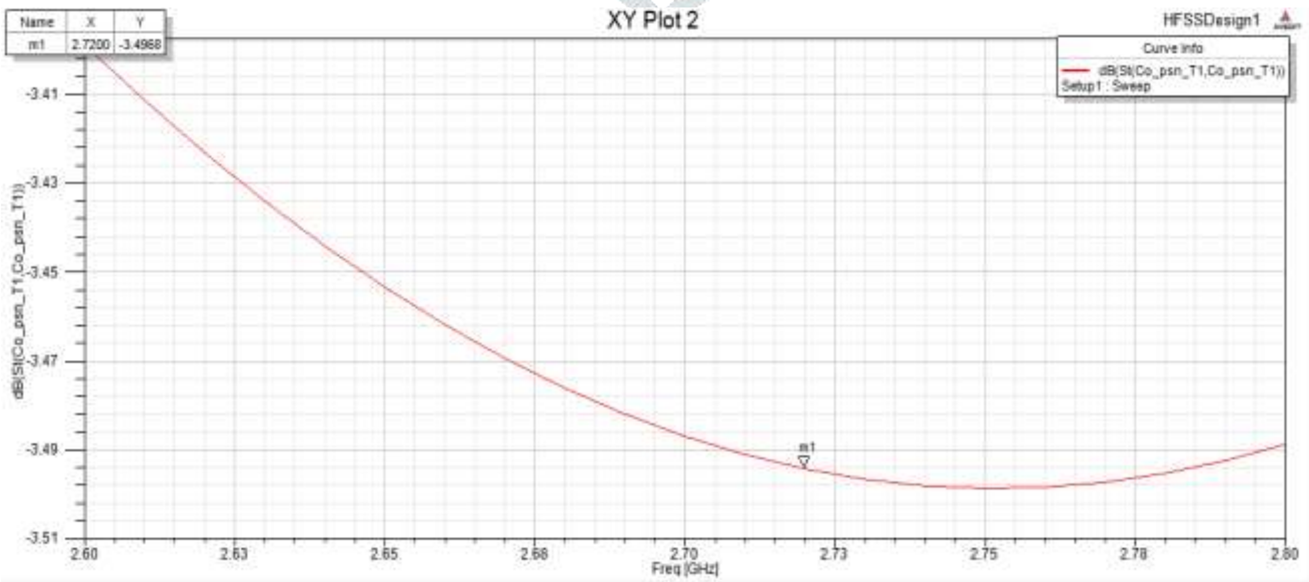

Fig 12: S_{11} Graph for designed triangular patch antenna

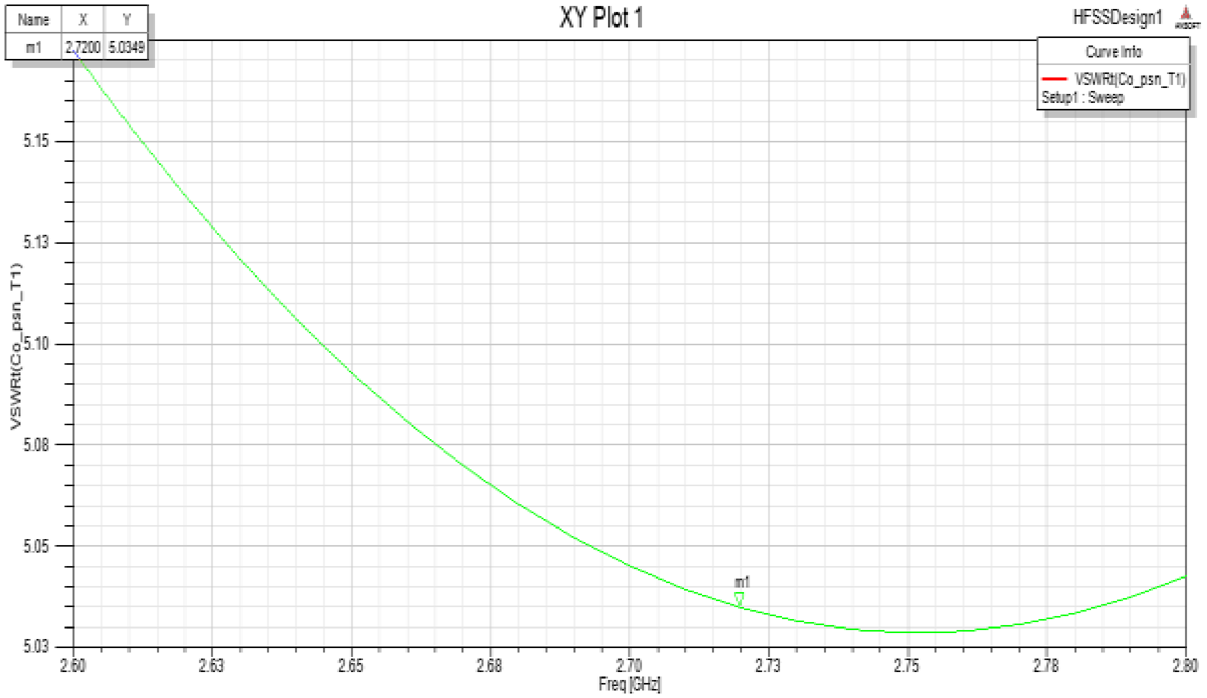

Fig 13: VSWR graph for triangular patch antenna

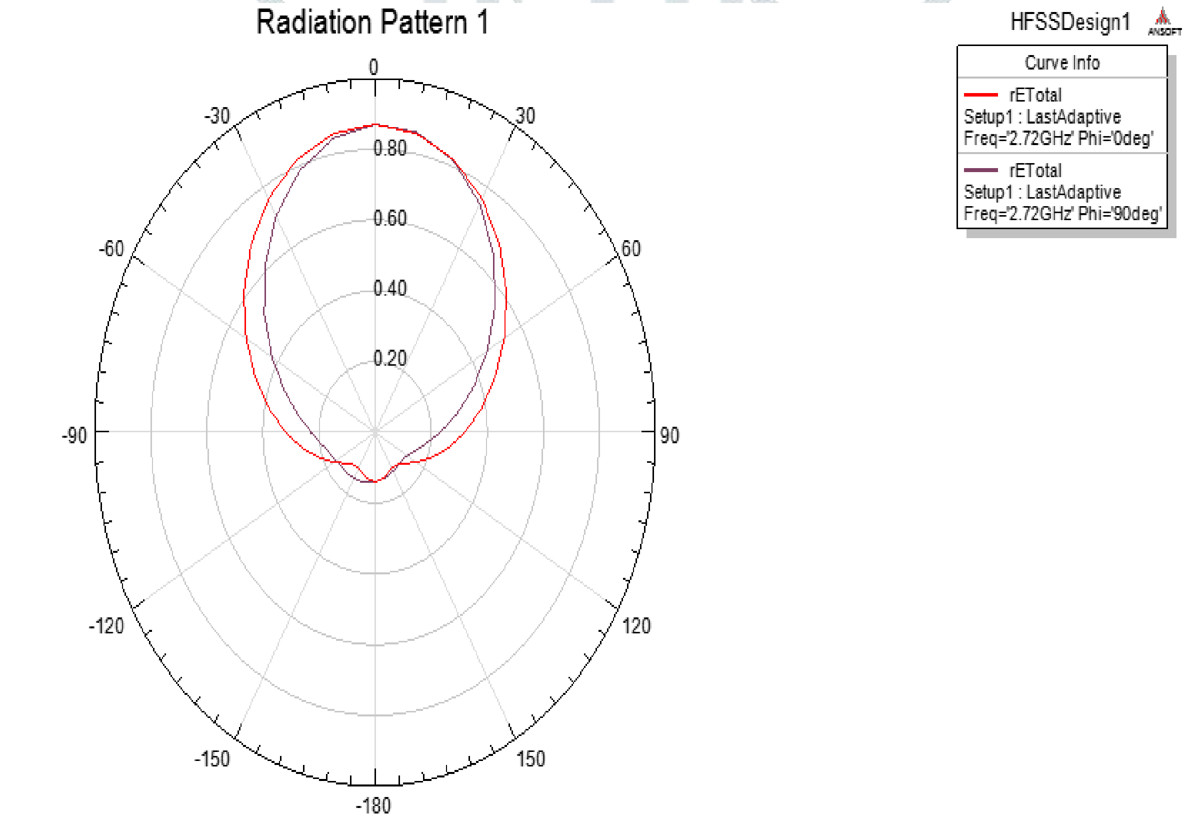

Fig 14: Radiation Pattern of designed triangular patch antenna

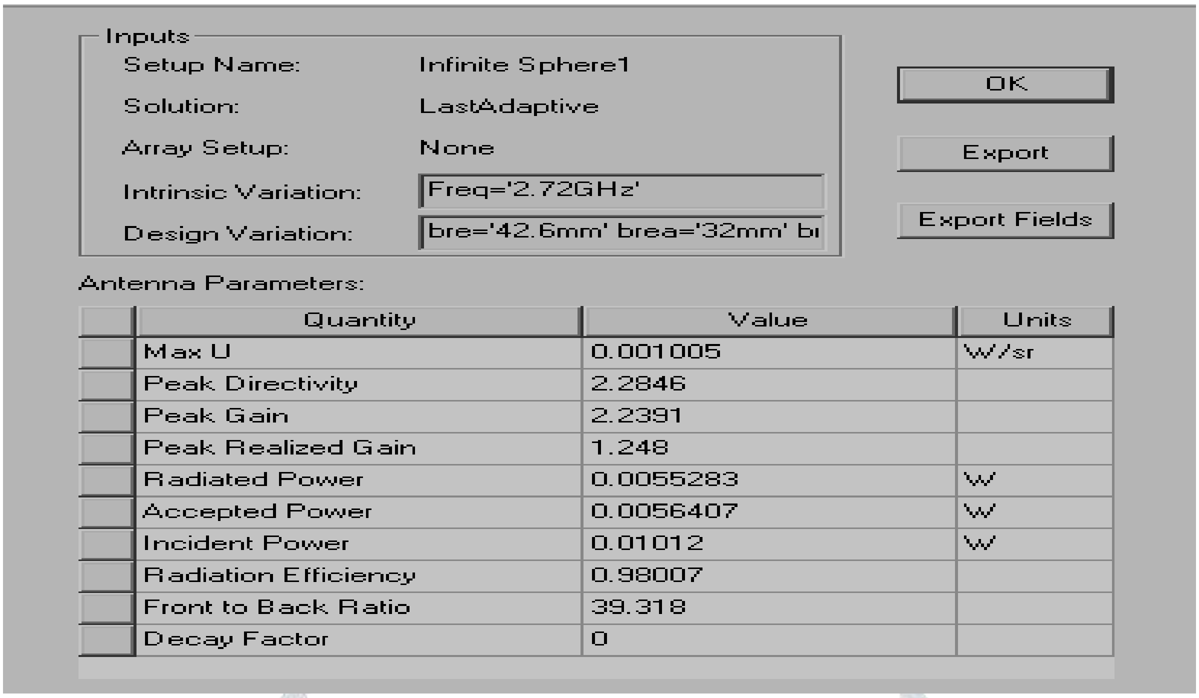

Fig 15: Parameters of designed triangular patch antenna

IV. ANALYSIS AND COMPARISION

Firstly microstrip antenna with rectangular shape has been considered and simulated. This is done by calculating length and breadth of the antenna using specified formulae. The performance of the antenna has been evaluated using results. After this, antenna has been designed for circular shape. Approximate radius of circular patch antenna is obtained by using the specified equation. The simulation is done for the circular patch and results of both the antennas are compared. Finally conclusion may be given as circular patch is more appropriate in terms of optimized parameters. The table gives the comparison of rectangular and circular patch antennas.

Table 1: Comparison of various parameters of designed rectangular, circular and triangular patch antenna

Parameter	**Rectangular Mm**	**Circular Mm**	**Triangle Mm**
Dimensions (mm)	L=32, B=30	R=17.4	B=45, H=42.6
S11 (dB)	-13.5	-33	-3.49
VSWR (dB)	1.52	0.70	5.03
Feed Position (mm)	0,-11,0	0,-7.74,0	0 ,-12.6 ,-5.5
Directivity (dB)	2.4	2.4	2.28
Gain (dB)	2.38	2.38	2.23

V. CONCLUSION

This letter presents the design and performance of rectangular, circular, triangular patches on dielectric substrates. The designed antenna presents much improved impedance and directivity and larger gain. These improved parameters are achieved without much increase in the thickness of the structure. The significant improvement in the directivity, HPBW is the main achievement of the proposed work. In several modern-day wireless and satellite communication systems, circularly polarized radiations with higher axial ratio bandwidth are desired, and this antenna may prove to be a useful structure for these systems. We have also used frequency 2.72GHz for calculation of parameters of rectangular, circular, triangular patches. From the above tables we conclude that circular patch antenna is more effective than rectangular and circular patch in terms of VSWR, radiation pattern and directivity .So for getting better results the value of dielectric constant should be low. Circular patch is always useful for all the application where compact antennas are required. It should be light weight and should have circular polarization. This antenna is always useful in several wireless and satellite applications.

VI. FUTURE SCOPE

From the Equation of the Rectangular manual calculation of all parameter is complex. By the use of the GUI this can be easy to calculate it. The Effect of the Changes in input parameter on radiation pattern can be easily analyzed by the use of GUI. As mentioned in results by changes in the material of the patch physical parameter of the Microstrip Patch is changes, this will be help designer to determine the antenna performance and make necessary adjustment before fabrication. In thesis different dielectric constants are used for a single frequency operation.[5] By keeping the frequency constant calculation of gain, directivity, HPBW, char. Impedance, is done. A further study can be look into the design of a microstrip patch antenna array operating at UHF frequency. This will further improved the antenna with very directive characteristics or very high gains to meet the demands for long distance communication as well as providing a fixed beam of specified shape (shape beam) or a beam that scans in response to system stimulus. One of the applications is to use a UHF microstrip antenna array for Synthetic Aperture radar onboard an aerial platform. There are many antenna design simulator like, MATLAB is very challenging as it will take very complex programming to achieve the desire results and it is very time consuming. However, this can be easily solved by using RF simulation software like Zealand IE3D and HFSS. If future work is to be carried out, it is recommended to use this advance software for the initial design and simulation and should there be facilities.

VII. ACKNOWLEDGMENT

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