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DESIGN AND SIMULATION OF RHOMBUS SHAPED MICROSTRIP PATCH ANTENNA USING HFSS

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ABSTRACT

In this paper, a rhombus shaped microstrip patch antenna is studied and the results are simulated using HFSS simulator at an operating frequency of 2.3 GHz. Microstrip Patch Antennas are low profile antennas, conformable to planar and non-planar surfaces, simple and easy to manufacture using modern printed circuit technology, mechanically robust when mounted on rigid surfaces and when the particular patch shape and size are selected; they are very versatile in terms of resonant frequency, polarization, pattern and impedance . HFSS is a commercial finite element method solver for electromagnetic structures from Ansys. The results are analyzed and discussed in terms of return loss, radiation pattern,3D polar plot , gain. The return loss comes out to be -6.4dB for the designed antenna. The length of the antenna is nearly half wavelength in the dielectric; it is a very critical parameter, which governs the resonant frequency of the antenna.

KEYWORDS: *Microstrip, Antenna, microwave, HFSS.*

I. INTRODUCTION

Microstrip antennas have profound applications especially in the field of medical, military, mobile and satellite communications. Their utilization has become diverse because of their small size and light weight. Rapid and cost effective fabrication is especially important when it comes to the prototyping of antennas for their performance evaluation. As wireless applications require more and more bandwidth, the demand for wideband antennas operating at higher frequencies becomes inevitable. Inherently microstrip antennas have narrow bandwidth and low efficiency and their performance greatly depends on the substrate parameters i.e. its dielectric constant, uniformity and loss tangent. In this regard several comparative studies have been performed e.g. in a Current study investigated the use of FR-4 substrate for microstrip antennas at 2.3 GHz. FR-4 has been chosen for this study because of its low cost and convenient availability hence can be used for microstrip antenna array prototyping. Microstrip patch antennas are attractive for their well-known efficient features such as compatibility with monolithic microwave integrated circuits (MMIC), light weight, less fragile, low profile etc. Because of these applications of the microstrip patch antenna, a new motivation is evolved for research and development on indigenous solutions that overcome the bandwidth limitations of the patch antennas. In applications in which bandwidth enhancement is required for the operation of two separate sub bands, an appropriate alternative to the broadening of the total bandwidth is represented by dual-frequency microstrip antenna, which exhibits a dual-resonant behavior in a single radiating element. In this paper, a rhombus shaped patch antenna is presented which is simulated using HFSS software. The results are discussed. The frequency of operation is chosen so as to ease the fabrication process. The shape is better as compared to square shape as it occupies lesser area with same length of edges.

II. BACKGROUND

.Microstrip patch antennas are attractive for their well-known efficient features such as compatibility with monolithic microwave integrated circuits (MMIC), light weight, less fragile, low profile etc. The main disadvantage associated with microstrip patch antennas is the narrow bandwidth, which is due to the resonant characteristics of the patch structure. But on the other hand modern communication systems, such as those for wireless local area networks (WLAN), as well as emerging applications such as satellite links (vehicular, GPS,etc.) often require antennas with low cost and compactness, thus requiring planar technology. Due to the light weight of the microstrip patch antennas, they are appropriate for the systems to be mounted on the airborne platforms such as synthetic aperture radars (SAR) and scatterometers. Because of these applications of the microstrip patch antenna, a new motivation is evolved for research and development on indigenous solutions that overcome the bandwidth limitations of the patch antennas. In applications in which bandwidth enhancement is required for the operation of two separate sub bands, an appropriate alternative to the broadening of the total bandwidth is represented by dual-frequency microstrip antenna, which exhibits a dual-resonant behavior in a single radiating element. Till date researches involve patches of rectangle, triangle, square, and fractals. Rhombus shape is chosen as it gives long edges with smaller area.

III. ANTENNA STRUCTURE AND HARDWARE

Figure 1 shows the proposed antenna design. A microstrip patch antenna consists of a conducting ground plane(here copper is used), a dielectric substrate (FR4-epoxy, ε_r=4.4), and a patch of same conducting material. The patch is etched using printed circuit technique.

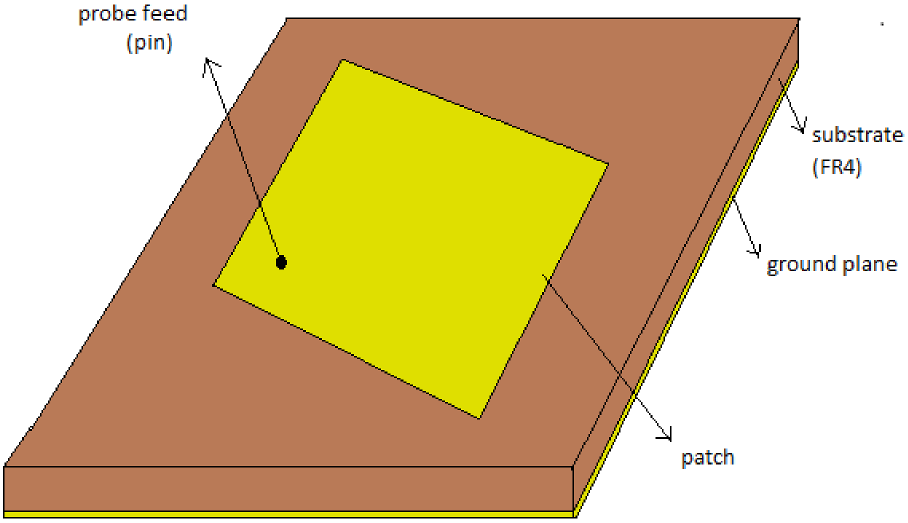

Fig. 1. Proposed antenna design.

The geometry of the antenna is calculated using the following formulae and taking operating frequency as 2.3 GHz.

$$W = c/(2f_0\sqrt{(\varepsilon r + 1)/2}$$

$$\varepsilon_{reff} = (\varepsilon_r + 1)/2 + (\varepsilon_r - 1)/2[1+12h/W]^{-1/2}$$

$$L_{reff} = c/(2f_0\sqrt{\varepsilon reff})$$

$$\Delta L = 0.412h(\varepsilon_{reff} + 0.3)((W/h)+0.264)(\varepsilon_{reff} - 0.258)(W/h + 0.8)$$

$$L = L_{eff} - 2\,\Delta L$$

$$L_g = 6h + L$$

$$W_g = 6h + W$$

Where,
f_o= operating frequency= 2.3 GHz.
c= speed of light= $3X10^8$ m/s.
ε_r= dielectric constant oof the substrate.= 4.4.

W= width of patch.
L= length of patch.
h= height of substrate= 1.6mm.
ε_{reff}= effective diectric constant.
L_{eff}= effective length of the patch.
ΔL= length extension.
W_g= width of ground plane.
L_g= length of groung plane.
On solving, W=39.76mm, L_{eff}=32.3mm, ΔL= 0.7392mm, L=30.82mm, L_g=40.42mm, W_g=49.36mm.
The patch is created as shown in figure 2.

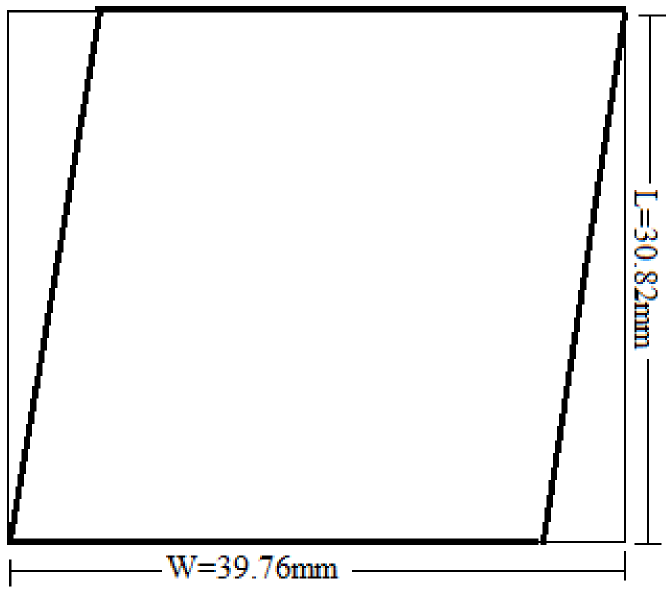

Fig. 2. Dimensions of the patch.

IV. ANTENNA DESIGN ON HFSS

Figure 3 shows the designed antenna on the HFSS window. The coordinates of the patch are chosen so as to nearly meet the necessary dimensions. The coordinates (in mm) are (14.15, -10); (14.15, 20); (-14.15, 10); (-14.15, -20).

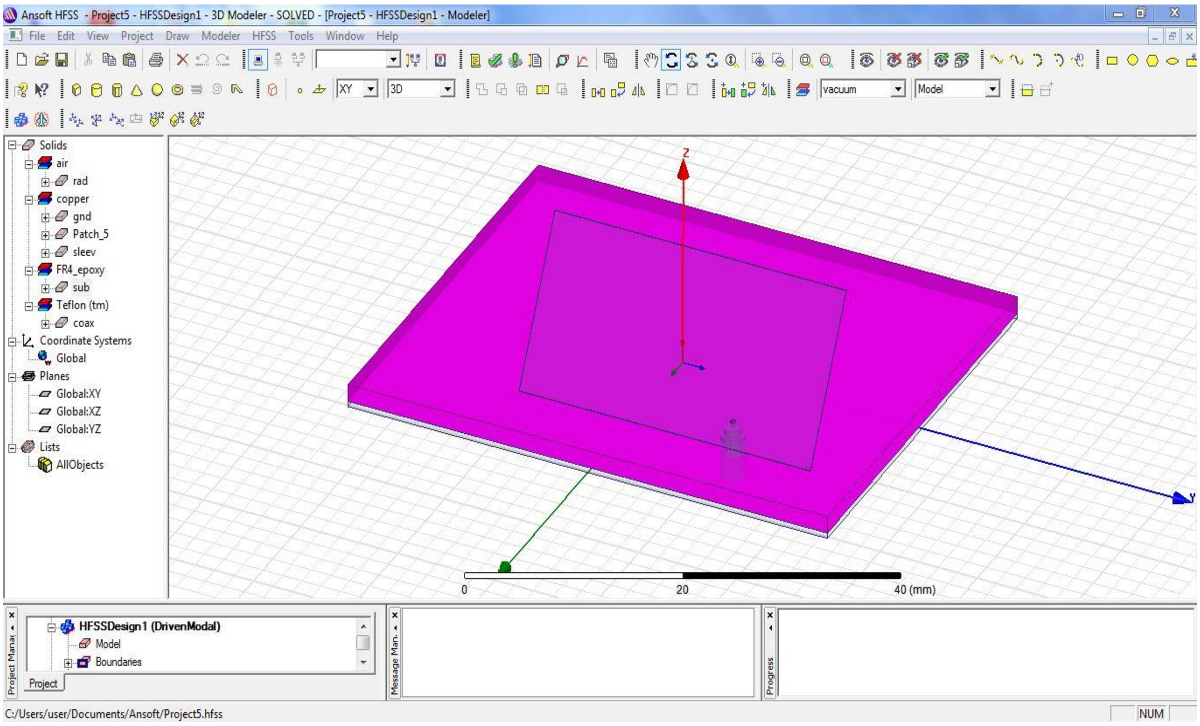

Fig. 3. 3D Model of the proposed antenna on HFSS.

The model is surrounded by a box of air to get radiation. The box is assigned a radiation boundary. The patch open faces as well as the ground open faces are assigned perfect E boundaries. The setup is assigned a waveport with coordinates (10, 10) at the pin and coaxial cable with input impedence 50Ω. The analysis setup is driven at 2.3 GHz frequency and sweep over 1-3 GHz.

V. RESULT AND ANALYSIS

5.1 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 extreme parameter as it shows the antenna's directivity as well as gain at various points in space. Fig. 4 shows the 2D radiation pattern, and fig. 5 shows the 3D radiation pattern with gain.

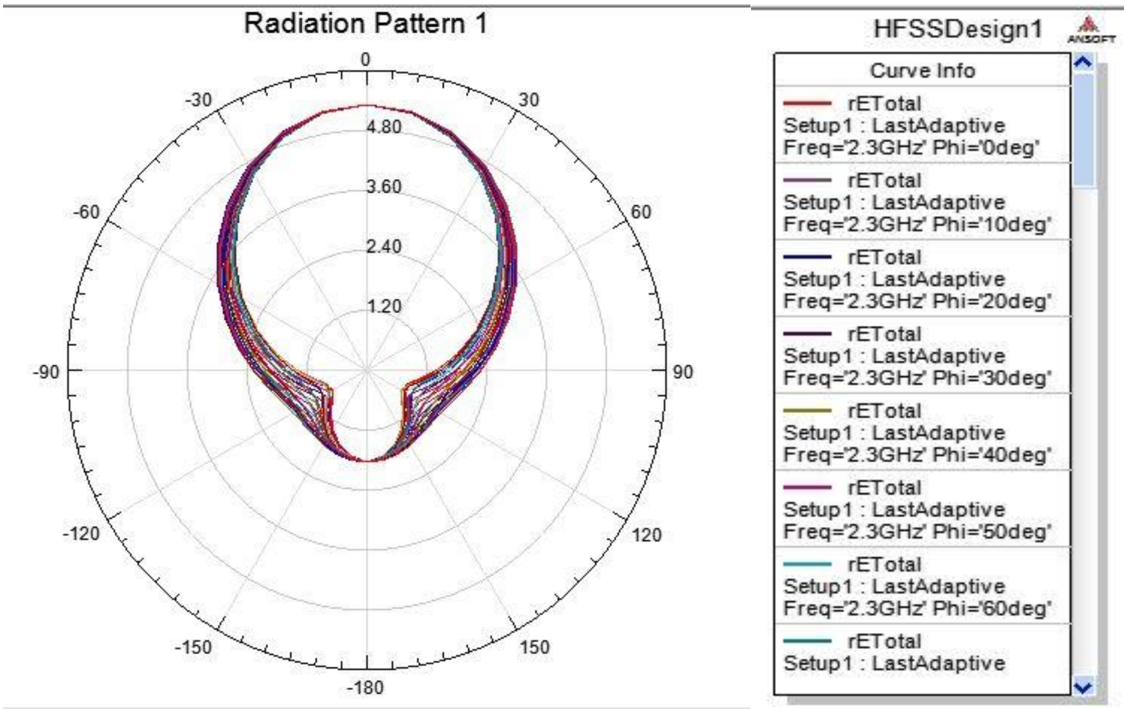

FIG. 4. 2D RADIATION PATTERN (POLAR PLOT).

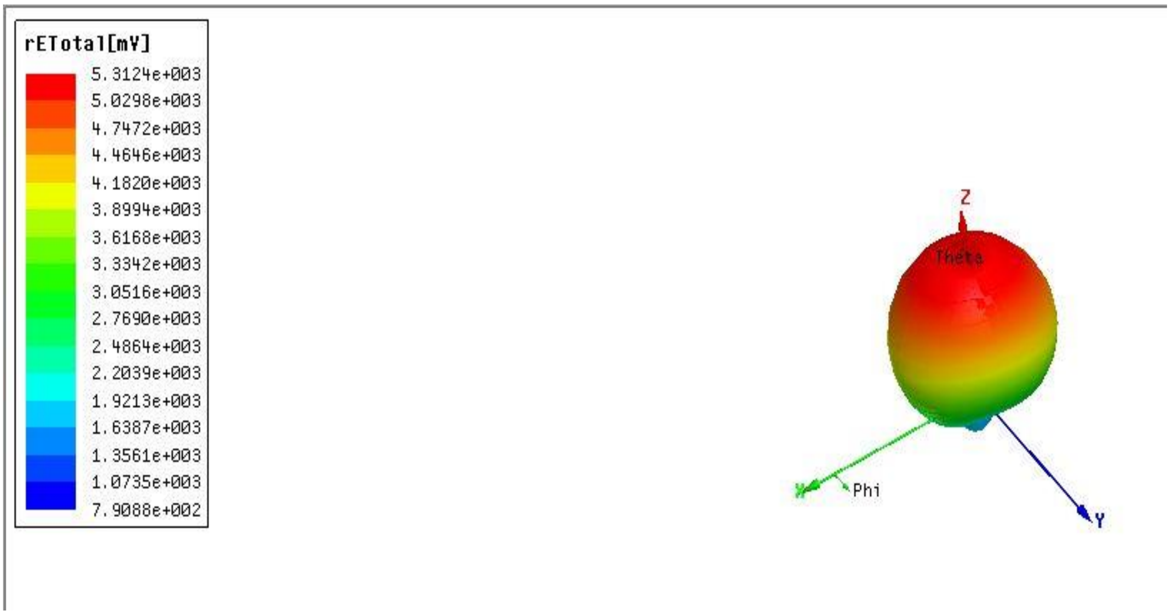

FIG. 5. 3D RADIATION PATTERN.

5.2 RETURN LOSS

Microstrip and coaxially fed patch antennas are commonly used in various types of smart antenna systems. In order for any given antenna to operate efficiently, the maximum transfer of power must take place between the feeding system and the antenna. Return Loss is a parameter similar to the *VSWR* which indicates the amount of power that is lost to the load and does not return as a reflection. Fig.6. shows the best value of return loss after optimization which is about -6.4 dB. Fig. 7 shows the 3D image of the same. The value of return loss should be minimum in order to minimize the reflection wave and able to maximize the transmitting power thus operating the antenna with the better performance.

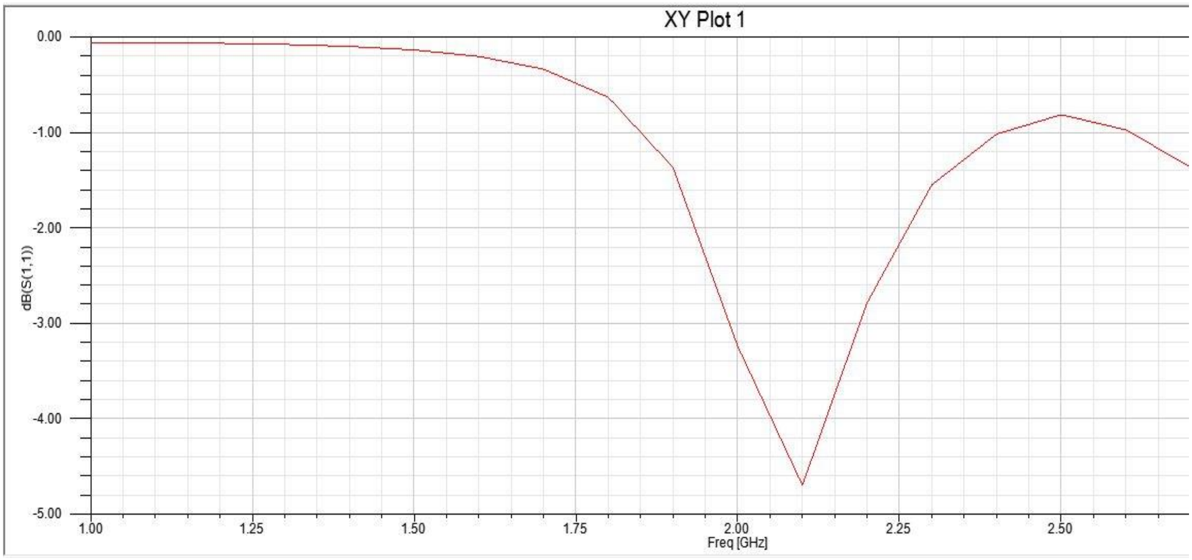

FIG. 6. Frequency VS Return Loss.

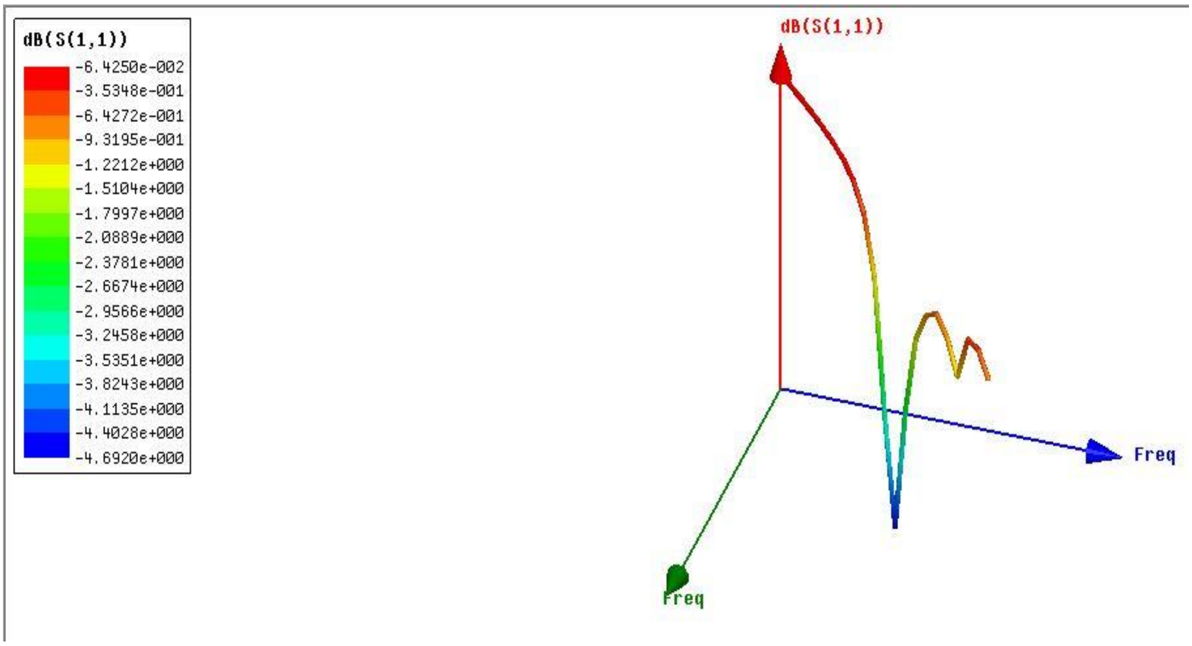

FIG. 7. . Frequency VS Return Loss (3D).

5.3 GAIN

Gain is not a quantity which can be defined in terms of a physical quantity such as the Watt or the Ohm, but it is a dimensionless ratio. Gain is given in reference to a standard antenna. The two most common reference antennas are the isotropic antenna and the resonant half-wave dipole antenna.

The method of measuring gain by comparing the antenna under test against a known standard antenna, which has a calibrated gain, is technically known as a gain transfer technique. Gain representation using HFSS is shown in fig. 8. The gain of the proposed antenna is about 5.425 dB.

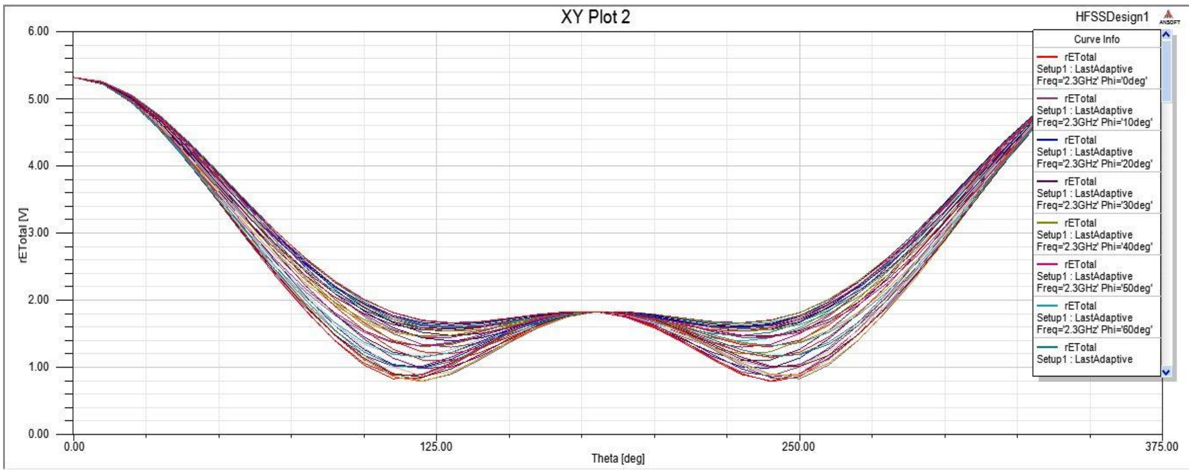

Fig. 8. Gain Plot.

VI. CONCLUSION

This paper presents a rhombus shaped microstrip patch antenna, simulated using HFSS software. The results are analyzed. The shape gives a better result keeping in view the size reduction of rhombus as compared to a square of same edges. Research is going on to further optimize the parameters so as to obtain even better results. The simulation tools play a big role in such design procedures and researches. The aim is to maximize the radiation efficiency in the required direction while minimizing it in the back and side lobes.

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