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# Design & Analysis of Hexagonal Patch Antenna at 1.8GHz for L-Band

Maneesh Rajput[1], Prof. Satyendra Swarnkar[2]

[1,2]Department of Electronics & Communication, C.S.E. Jhansi, Uttar Pradesh, INDIA

**ABSTRACT**

**In this paper, we designed a hexagonal shape patch antenna for L-band application. After designing the antenna on 1.8GHz (L-band), we study and analyzed the results of both simulated & measured. For L-band, we uses the dielectric substrate 4.2, loss tangent .0012 and having the substrate height 2mm. The patch and ground plane dimension's are same for both the antennas (i.e hardware base & software base ). The designed antenna on IE3d software at 1.8GHz (L-band) frequency showing the bandwidth 52% having return loss -22dB while the designed antenna on hard ware base at 1.8GHz frequency showing the bandwidth 43.9% having return loss -27dB. All the other respective results i.e., VSWR, gain, directivity, efficiency and 3D-radiation pattern for software design are shown.**

***Keywords-*** Hexagonal Patch antenna, ie3d software, bandwidth, gain, directivity and vswr.

## I. INTRODUCTION

Printed planar microstrip patch antennas [1] are getting popular for modern communication system due to their features which includes compact size, low cost and ease of fabrication. An extensive work on simple microstrip geometries including rectangular, circular and triangular shaped structures have been reported [2]. The advantages of patch antennas are that they radiate with moderately high gain in a direction perpendicular to the substrate and can be fabricated in a low cost PCB. Bandwidth and efficiency of a Microstrip antenna depends upon many factors for e.g. patch size, shape, substrate thickness, dielectric constant of substrate, feed point type and its location, etc. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable for higher bandwidth, better efficiency and better radiation [3-5]. Circular or rectangular microstrip patch has been modified for some applications to other shapes. Hexagonal shape microstrip antenna has smaller size compared to the square and circular microstrip antennas for a given frequency. The small size is an important requirement for portable communication equipments [6-9]. Coaxial probe feed is used to feed the antenna. Moreover thick substrate properties are used for improvement of proposed antenna. IE3d software is used to carry out the results. IE3d software is a fully featured software package for electromagnetic analysis and design in the high frequency range.

## II. ANTENNA DESIGN AND LAYOUT

The length and width of rectangular patch antenna are calculated from below equations. Where c is the velocity of light, $\varepsilon_r$ is the dielectric constant of substrate.

1: **Calculation of the Width (*W* ):** The width of the Microstrip patch antenna is given by equation as:

$$W = \frac{c}{2f_o\sqrt{\frac{\varepsilon_r + 1}{2}}}$$

2: **Calculation of Effective dielectric constant ($\varepsilon_{reff}$ ):** The following equation gives the effective dielectric constant as:

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{12h}{W}\right)^{-\frac{1}{2}}$$

3: **Calculation of the Effective length ($L_{eff}$ ):** The following equation gives the effective length as:

$$Le = L + 2\Delta L$$

4: **Calculation of the length extension ($\Delta L$ ):** The following equation gives the length extension as:

$$\Delta L = \frac{h}{\sqrt{\varepsilon_r}}$$

5: **Calculation of actual length of patch (L ):** The actual length is obtained by the following equation-

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{re}}} - 2\Delta L$$

6: **Calculation of the ground plane dimensions ( $L_g$ and $W_g$ ):** Ideally the ground plane is assumed of infinite size in length and width but it is practically

impossible to make a such infinite size ground plane, so to calculate the length and width of a ground plane followings equations are given as:

$L_g = L + 6h$

$W_g = W + 6h$

7: **Determination of feed point location ($X_f$ , $Y_f$):** A coaxial probe type feed is to be used in this design.The center of the patch is taken as the origin and the feed point location is given by the co-ordinates ($X_f$ , $Y_f$) from the origin. The feed point must be located at that point on the patch, where the input impedance is 50 ohms for the resonant frequency. Hence, a trial and error method is used to locate the feed point. For different locations of the feed point, the return loss (R.L) is compared and that feed point is selected where the R.L is most negative.

**Table 1. Proposed antenna Design parameters**

| Design of Micro strip patch antenna | Design on Software base antenna | Design on Hardware base antenna |
|---|---|---|
| Name of Pattern | Hexagonal | Hexagonal |
| Frequency of Operation (GHz) | 1.8 | 1.8 |
| Dielectric constant of substrate | 4.2 | 4.2 |
| Loss tangent | .0012 | .0012 |
| Height of the dielectric substrate (mm) | 2mm | 2mm |
| Feeding method (Probe feeding) | Point (x=25.9,y=6.2 ) | Point (x=25.9,y=6.2 ) |
| Width of the ground ($W_g$) | 64mm | 64mm |
| Length of the ground ($L_g$) | 52mm | 52mm |
| Width of the patch ($W_p$) | 52mm | 52mm |
| Length of the patch ($L_p$) | 40mm | 40mm |

## Antenna Design on IE3d software

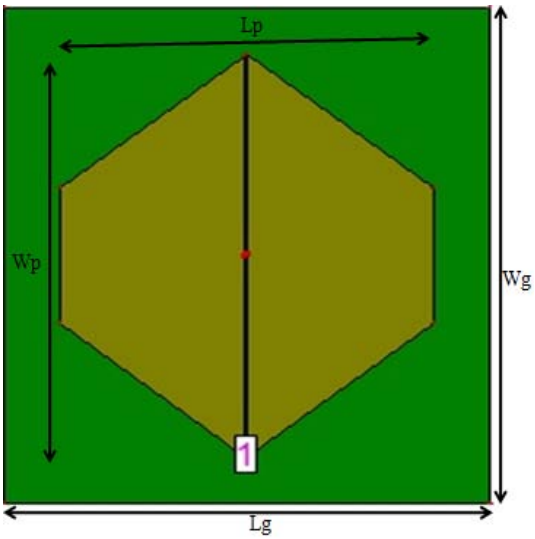


**Figure no.1**- software base design

## Antenna Design on Hardware

**Figure no.2** – Hardware base design

## III. RESULTS OF SIMULATED & MEASURED DESIGN

After simulating the proposed antenna design on IE3d simulator, we get various results. All these various results are shown below. Firstly we shown & discuss all the results of proposed antenna design on IE3d software and then we shown & discuss all the results of proposed antenna design on hardware.

## Simulation results using IE3d Software

(A) Return Loss Vs Frequency-

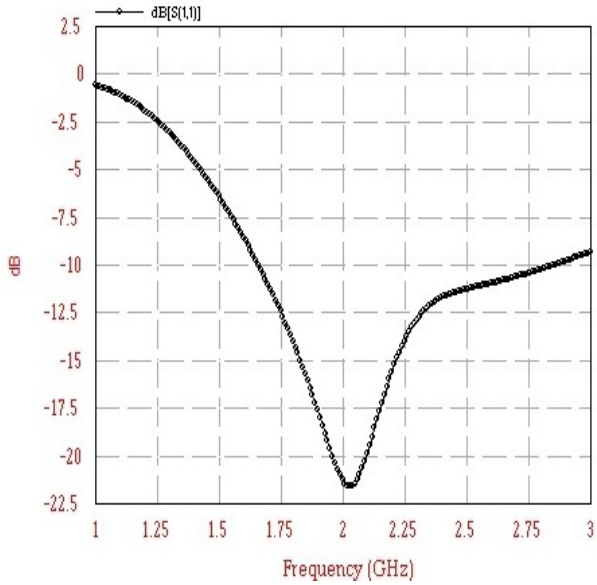


**Figure no.3-** Frequency Return Loss

(B) Frequency Vs VSWR -

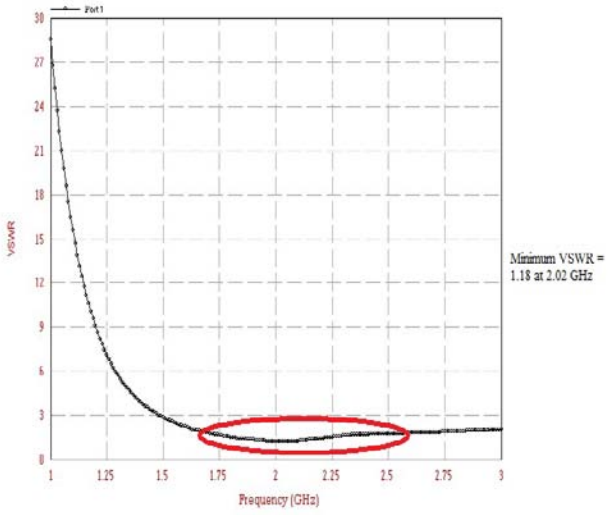


**Figure no.4**- Frequency Vs VSWR

(C) Gain Vs Frequency –

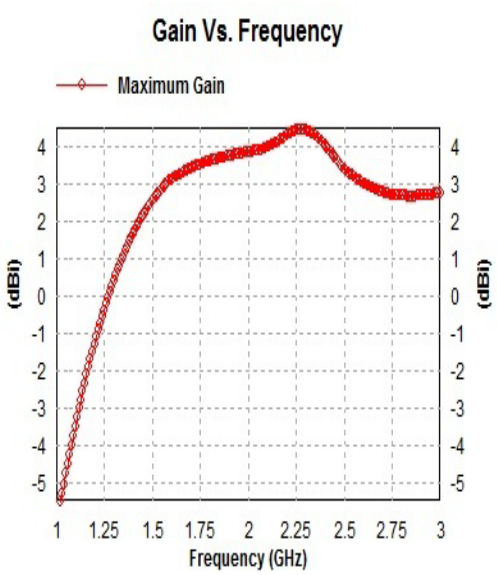


**Figure no.5** - Gain Vs Frequency

(D) Directivity Vs Frequency-

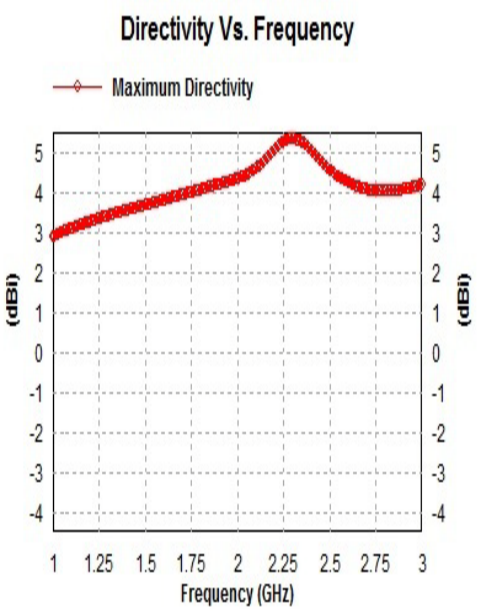


**Figure no.6** - Directivity Vs Frequency

(E) Efficiency Vs Frequency –

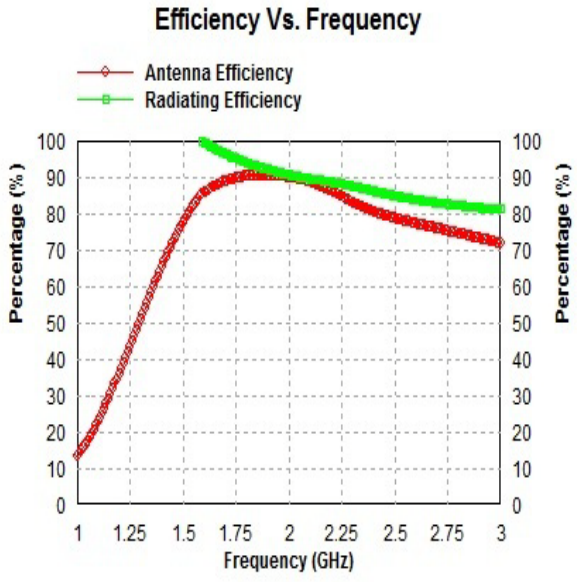


**Figure no.7** - Efficiency Vs Frequency

(F) Radiation Pattern –

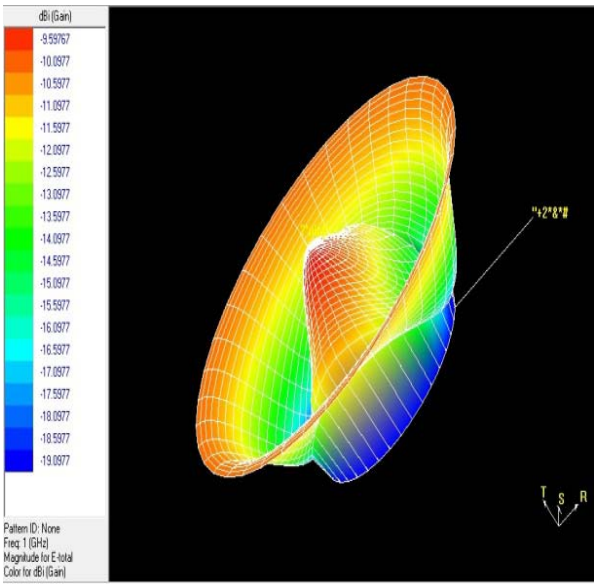


**Figure no.8** - 3D View of radiation pattern

(G) 3D View –

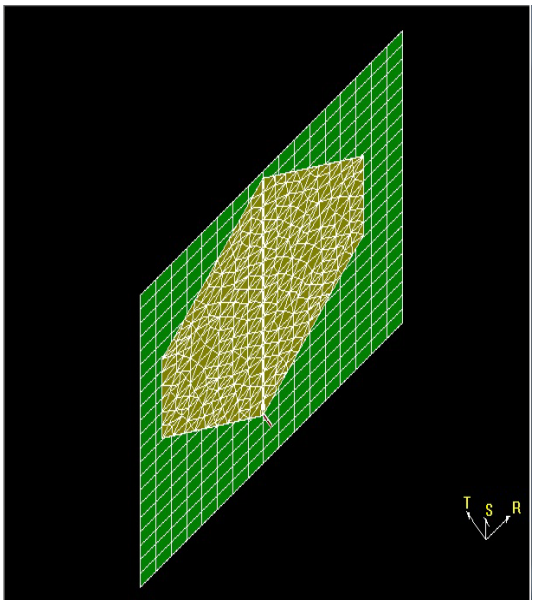


**Figure no.9** -3D View

(H) SmithChart-

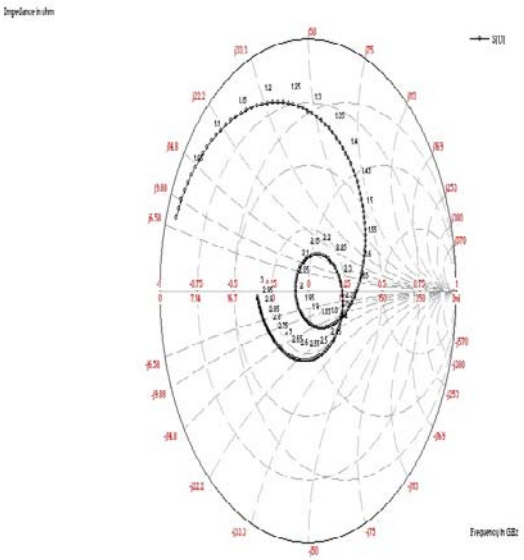

**Figure no.10**- Smith Chart

## Measured result of hardware based antenna design

(A) Return Loss Vs Frequency

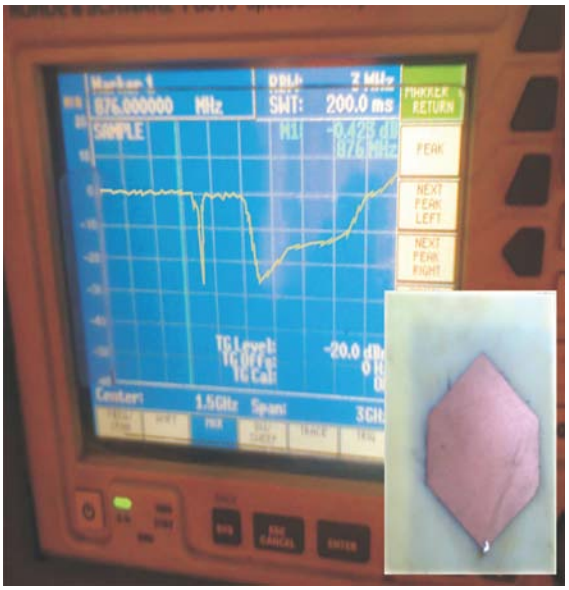


**Figure no.11**- Frequency Vs Return Loss

## IV. CONCLUSION

Microstrip antennas have become a rapidly growing area of research. Their potential applications are limitless, because of their light weight, compact size, and ease of manufacturing.

In our paper, we have design and analyzed the Hexa Shape Microstrip Patch antenna on 1.8GHz (L-band) having patch length, Lp = 40mm & patch width, Wp = 52mm. The proposed antenna designs have been analyzed between 1GHz to 3GHz. The proposed antenna is designed on a GLASS EPOXY Substrate dielectric constant 4.2, loss tangent .0012. The comparison of both the results at 1.8GHz (L-band) are shown below in the tabular form-

| Antenna Design | Bandwidth (%) | Return Loss (dB) |
|---|---|---|
| Software Based Design | 52 | -22 |
| Hardware Based Design | 43.9 | -27 |

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