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Performance Comparison between U Slotted and Dumbbell Slotted Shaped Rectangular Patch Antenna

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ABSTRACT: A probe-fed, slotted Rectangular microstrip patch antenna has been proposed. The gain enhancement has been achieved by suitable cutting slots in the rectangular patch using probe feeding technique. We have found the optimum feed point giving desired results. The electromagnetic simulation of the proposed antenna has been carried out using IE3D software. The analysis of performance will be based on changing the geometry of the patch and the obtained results are compared especially in Return loss, VSWR, antenna efficiency and radiation pattern.

KEYWORDS: slotted microstrip patch antenna, gain enhancement, antenna efficiency.

I.INTRODUCTION

The rapid growth in communication technology in last few decades has led to the development of different types of microstrip patch antennas with different attractive features like low profile, light weight, simple and inexpensive manufacturing procedure using printed circuit technology and compatibility with monolithic microwave integrated circuit (MMIC). These properties make it suitable for different applications like Missile Technology, Satellite and Mobile Communications, Global Positioning System, Remote Sensing, etc. In-spite of their numerous advantages, microstrip antenna has low operational bandwidth, which puts constraints in using them in a number of applications like the case where operating frequency may be varied. Any wireless communication needs high gain and if the bandwidth of the antenna is also increased along with the gain it will be an additional advantage, though enhancing both gain as well as bandwidth at a same time is a challenging task.

In year 1981, Derneryd and Karlsson reported a foam-supported broadband Microstrip antenna and showed a bandwidth of 15%. In 1982, Dong and Sengupta demonstrated experimentally a new class of broadband Microstrip antennas. They found the VSWR less than two in the frequency range from 8 to 11 GHz. Kumar and Gupta , in 1983, proposed new configurations for obtaining broader bandwidth by using coupled multiple resonators and experimentally obtained bandwidths for four edges, gap coupled and directly coupled antennas, 25.8% and 24.0%, respectively. Also, in the beginning of 1985, they analyzed directly coupled multiple resonators by Green's function approach and their theoretical results were in good agreement with the experimental results. Lee *et al*., in 1987, experimentally demonstrated a two-layer electromagnetically coupled rectangular patch antenna with 13% bandwidth for 0.0505 cm air gap. In 1988, Bhattacharyya and Shafai described broadband operation in annular ring antenna and the theoretical results were also verified experimentally. Assailly *et al*., in 1989, proposed a broadband stacked square patch antenna and showed a bandwidth of 14.4%. In 1990, Watkins and Usual experimentally proposed broadband coaxial-fed disk antennas and achieved 17% bandwidth. Further, bandwidth improvement of 80% over conventional Microstrip patches was achieved by circularly shaped modified patches. The proposed compact broadband Microstrip antenna by Aanandan *et al*.showed a bandwidth eight times that of a conventional patch antenna of same size.

In 1991, Tulintseff *et al*. proposed an analysis technique for a probe-fed stacked circular Microstrip antenna with a wide bandwidth and dual frequency operations. In 1992, Revankar and Kumar's investigations on a three-layer stacked circular Microstrip antenna array reported a 20% impedance bandwidth. In 1994, Legay and Safai presented a new stacked Microstrip antenna, which provided bandwidth of 25%.In 1995, Huynh and Lee demonstrated a coaxially-fed

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single-layer single-patch with a U-shaped slot and achieved 10-40% impedance bandwidth.In 1996, Deepukumar *et al*. presented a peripherally fed broadband circular Microstrip antenna, which also exhibited polarization diversity with feed location. In 1997, Legay and Shafai proposed a novel self-matching wideband feed network for Microstrip arrays. They suggested it useful to broaden the impedance bandwidth. In the year 1998, Huang *et al*. demonstrated that loading the patch by a high-permittivity superstrate and a 1 ohm resistor, the operating bandwidth could be more than six times that of a conventional patch antenna. In June 1999, Clenet *et al*. presented the theoretical and simulation investigations of a coaxial fed U-slot Microstrip antenna stacked with a rectangular patch and achieved about 44.7% impedance bandwidth.Further, in 2000, Ooi and Shen presented a novel E-shaped Microstrip patch antenna for broadband operation. In 2001, Yang *et al*.'s E-shaped patch antenna showed a 32.3% impedance bandwidth.In 2001, Wong and Hsu proposed a broadband rectangular patch antenna with a pair of wide slits and obtained 24% bandwidth. In the same year, Meshram and Vishvakarma reported a gap-coupled rectangular patch antenna with 30% impedance bandwidth.

II.ANTENNA GEOMETRY AND DESIGN

The proposed antenna structures are designed by cutting a U shaped and dumbbell shaped slots of fixed dimensions. Cutting of these slots in antenna increases the current path which increases current intensity as a result efficiency is increased and desired parameters are obtained. Start off by calculating basic equation of typical rectangular patch and then convert its equivalent area to a Rectangular form. The Essential parameters of these Rectangular microstrip patch antennas are characterized by length (L) = 27.90 mm, width (W) = 33.88 mm, and the dimensions of ground plane (L x W) having 38.70 mm x 44.68 mm.

The rectangular microstrip patch antenna designed on one side of glass/epoxy structure with substrate relative permittivity (ε_r) = 2.2, height from the ground plane (d) = 1.8 mm and loss tangent (tanδ) = 0.0009. Design is being calculated taking frequency 3.5GHz and it is shown in figure (1). The steps are as followed.

Step 1: Calculation of the width (*W*):

The width of the Microstrip patch antenna is given as:

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

Substituting c = 3.00e+008 m/s, ε_r = 2.2 and fo = 3.5 GHz,
We get w **= 0.03388 m = 33.88 mm**

Step 2: Calculation of Effective dielectric constant (ε_{reff}**)**:

The effective dielectric constant is:

$$\varepsilon_{reff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1+12\frac{h}{W}\right]^{-\frac{1}{2}}$$

Substituting εr = 2.2, W = 33.88 mm and h = 1.8 mm we get:

ε_{reff} = **2.0688**

Step 3: Calculation of the Effective length (L_{eff}**):**

The effective length is:

$$L_{eff} = \frac{c}{2f_o\sqrt{\varepsilon_{reff}}}$$

Substituting $\varepsilon reff$ = 2.0688, c = 3.00e+008 m/s and fo = 3.5 GHz we get:

L_{eff} = 0.02979 m = 29.79 mm

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Step 4: Calculation of the length extension (ΔL):

The length extension is:

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

Substituting $\varepsilon reff$ = 2.0688, W = 33.88 mm and h = 1.8 mm we get:

ΔL = **0.94 mm**

Step 5: Calculation of actual length of patch (L):

The actual length is obtained by:

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

Substituting L_{eff} = 29.79 mm and ΔL = 0.94 mm we get:

L = **27.90 mm**

Step 6: Calculation of the ground plane dimensions (L_g and W_g):

The transmission line model is applicable to infinite ground planes only. However, for practical considerations, it is essential to have a finite ground plane. It has been shown by [9] that similar results for finite and infinite ground plane can be obtained if the size of the ground plane is greater than the patch dimensions by approximately six times the substrate thickness all around
The periphery. Hence, for this design, the ground plane dimensions would be given as:

***Lg* = 6*h* + L = 6(1.8) + 27.90 = 38.70 mm, *Wg* = 6*h* + W = 6(1.8) + 33.88 = 44.68 mm**

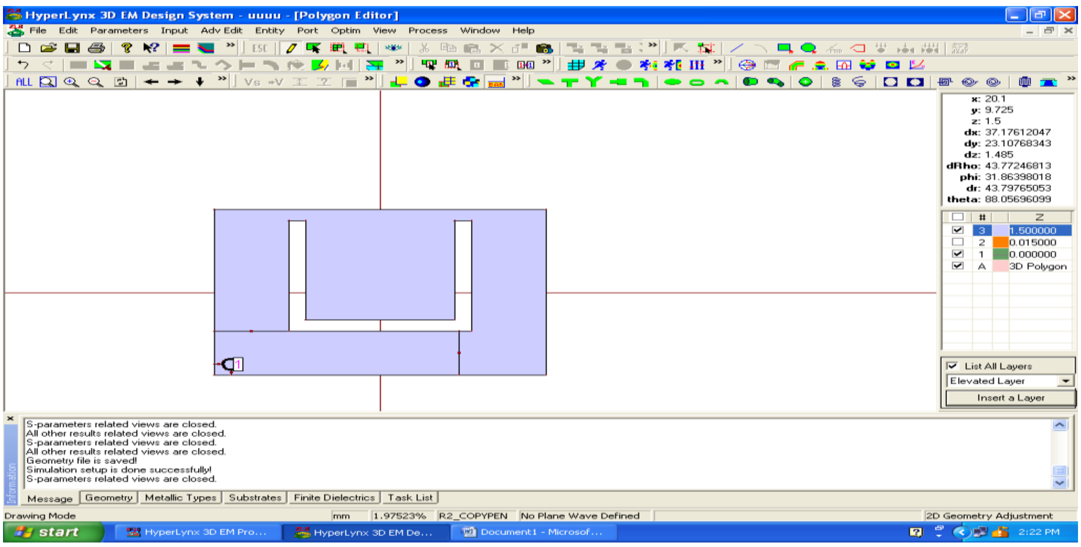

Fig. 1 Proposed Rectangular Patch with U shaped slotted.

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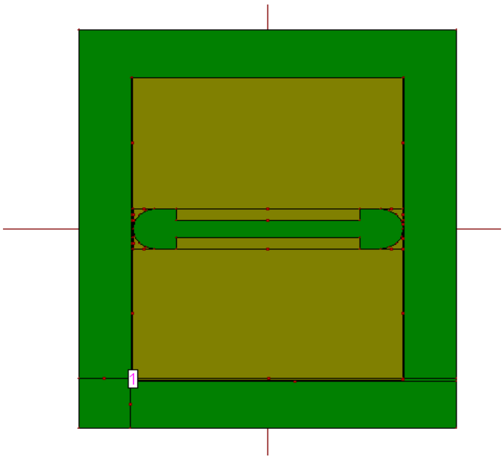

Fig. 2 Proposed Rectangular Patch with Dumbbell shaped slotted.

For U slot and for dumbbell slot the simulated radiation pattern in 3D are shown in figure 3 and figure 4 respectively.

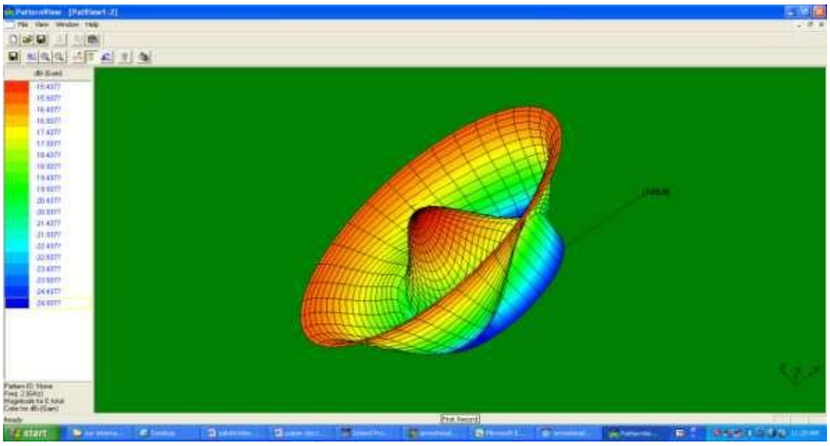

Fig. 3 Radiation pattern in 3D of the Patch Antenna with U shaped.

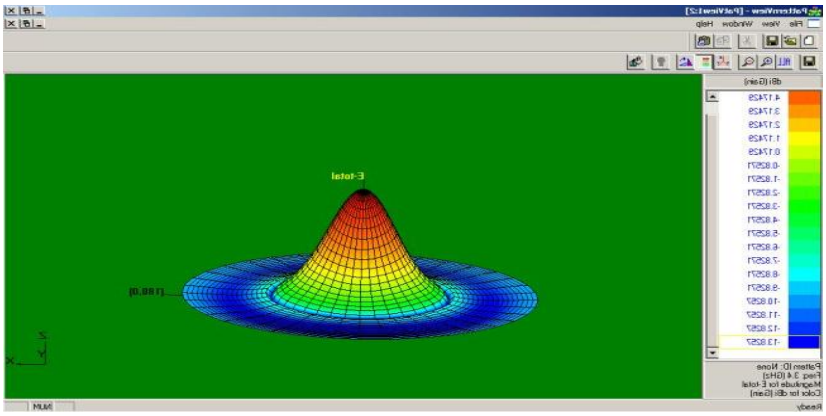

Fig. 4 Radiation pattern in 3D of the Patch Antenna with Dumb bell shaped.

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III.RESULT ANALYSIS

The simulation of micro-strip patch antenna is carried out using IE3D simulation software. The VSWR indicates the mismatch between the antenna and the transmission line. For perfect matching the VSWR value should be close to unity. In this design the VSWR is 1.04 for U slot and 1.05 at 3.5 GHz frequency for dumbbell slot. For U slot and for dumbbell slot The simulated radiation pattern in 3D are shown in figure 3 and figure 4 respectively, the return loss graph is shown in figure 5 and figure 6,the total field gain & frequency is shown in figure 7 and figure 8, The VSWR graph for U slotted rectangular patch antenna and dumbbell slot are shown in figure 9 and figure 10 respectively , the return loss is -31.33 db for U slot and -30.43 dB for dumbbell slot , the gain for U slot is 7.57db and for dumbbell slot it is equal to 7.05 db at resonant frequency 3.5 GHz.

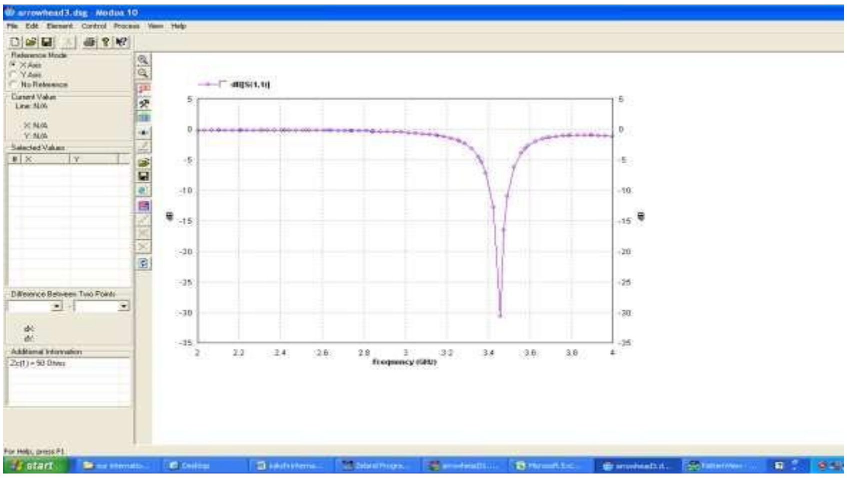

Fig. 5 Return Loss of the Patch Antenna with U Shaped slotted

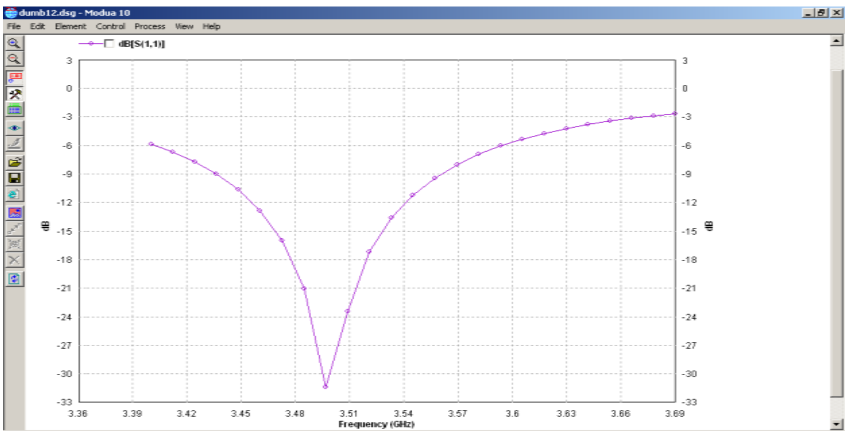

Fig. 6 Return Loss of the Patch Antenna with dumb bell Shaped slotted

The field gain and frequency obtained for both the shaped antenna are shown in figure 7 and figure 8.

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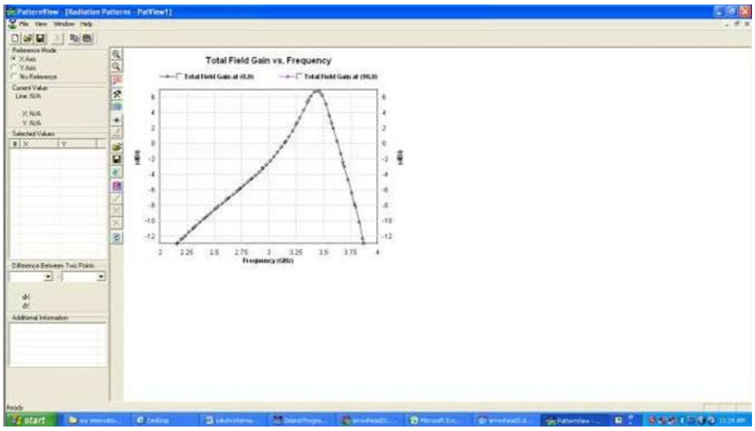

Fig. 7 Total field gain & frequency of patch antenna with U shaped.

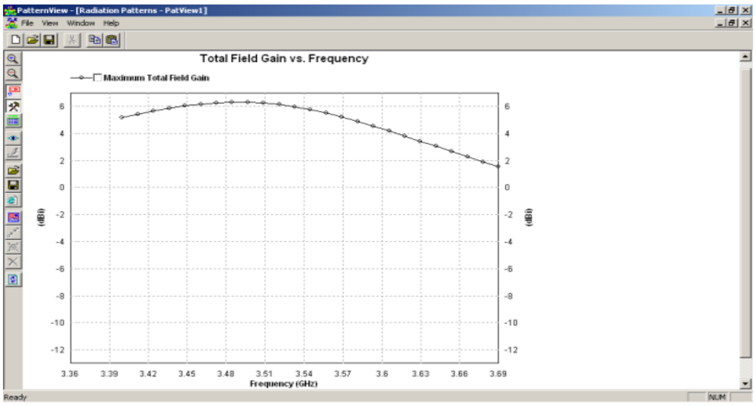

Fig. 8 Total field gain & frequency patch antenna with dumbbell shaped.

The VSWR graph for U slotted rectangular patch antenna and dumbbell slot are shown in figure 9 and figure 10 respectively.

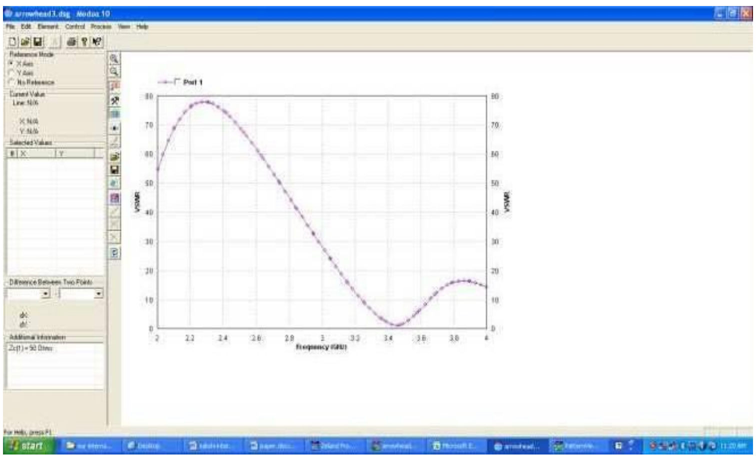

Fig. 9 VSWR of the Rectangular Microstrip Antenna with U shaped.

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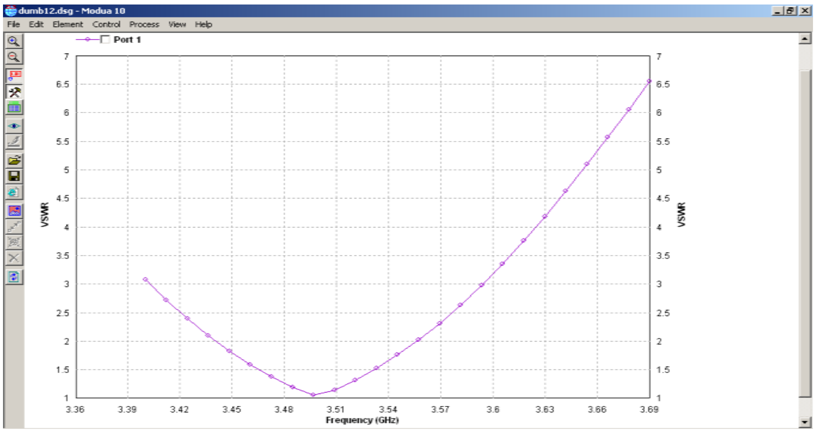

Fig. 10 VSWR of the Rectangular Microstrip Antenna with dumb bell shaped.

Geometry (Rectangular Patch)	***Return loss*** (dBi)	***Gain*** (dBi)	***VSWR***
Modified: arrow head shaped slotted	-31.33	7.57	1.04
Modified : dumbbell shaped slotted	-30.43	7.05	1.05

Table 1 Comparison of parameters between modified antenna geometries.

IV.CONCLUSION

This paper has described the different geometries of rectangular patch antenna used to investigate the effects of antenna parameters. The parameters return loss, VSWR, antenna efficiency and radiation pattern of antenna as a function of frequency is measured in simulated result as shown in table 1. From the detailed experimental study it is good to see that the return loss has a negative value in both the cases which states that the losses are minimum during the transmission. In the U slot patch the Return loss is -31.33 dB and gain is 7.57 db in coaxial feed technique. For the Design with dumbbell slot the return loss is equal to -30.43dB and gain is 7.05 db. If we have comparison between U slotted patch and dumbbell slotted patch antenna performance then U slotted patch gives the better results than dumbbell slotted patch.

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