# Study of Compact and Wideband Microstrip U-Slot Patch Antenna with DGS for Satellite Application

Rammohan Mudgal[#1], Laxmi Shrivastava[*2]

[#] *Electronics & communication, Madhav Institute of Technology & Science*
*Gwlior-474005,India*

[1]rammohan977@gmail.com

[2]lselex@yahoo.com

*Abstract* — ***Microstrip patch antennas are used in many wireless communication applications. This paper proposes the use of a patch antenna with U-shaped slot and ground with reduced dimension having DGS(Defected Ground Structure.) to achieve wideband application with very low return loss. The objective of this paper is to design, construct and fabricate microstrip antennas suitable for satellite application that centred at frequency 6.3GHz. The antenna must operate within the band of 6.3GHz band. This band is currently being used in military applications. The antenna is proposed to be used as a transmitting as well as receiving antenna in wireless network and the mentioned applications. A thick substrate with finite ground dimensions broadens the bandwidth of the antenna. The proposed antenna reduced the return loss as well as increases the bandwidth of the antenna*** *without increasing substrate height with the help of DGS.*

*Keywords*— **Wideband Antenna, Patch Antenna, DGS,CST, Satellite.**

## I. INTRODUCTION

Now a day's patch antenna with high permittivity material substrate is used for wireless networking application. Modern life depends so much on wireless technologies that one can no longer afford to be off-line for long, even during flights.. In particular, the U-slot patch [1] enable a single patch single layer microstrip antenna to attain over 30% impedance bandwidth. The use of DGS and reduced dimension of ground plane is the main reason for achieving wide impedance bandwidth. In this context, the present study investigated the possibility of designing a wireless antenna catering to applications at 5.5-6.49GHz, making use of typical panel materials employed in such an environment. A wide-band antenna with frequency 5.5-6.49GHz (about 1 GHz bandwidth) bands would meet the requirements for all the above applications. Microstrip patch antenna is widely considered to be suitable for many wireless applications, even though it usually has a narrow bandwidth [1]. The microstrip patch is inherently a narrow-band structure and a larger thickness of the grounded substrate helps in increasing its bandwidth [3]. But limited ground plane size is an essential requirement for its compactness as well as compatibility with the mobile wireless equipments. However, the bandwidth and the size of an antenna are generally conflicting properties i.e. improvement of one of the characteristics normally results in degradation of the other. To overcome these researchers such as slotting, DGS, use of dielectric substrate of high permittivity [4] etc. The other method to miniaturize the microstrip antenna is to modify its geometry using irises [5] or folded structures [6-7] based on the perturbation effect [8]. Defected ground structure (DGS), where the ground plane metal of the microstrip antenna design is modified intentionally in order to enhance the performance [9-10]. The name for this technique simply means that a "Defect" has been etched off in the ground plane, which disturbs the shield current distribution in the ground plane and influences the input impedance as well as current flow of the antenna. A defect in the ground plane causes to increase in effective capacitance and inductance. DGS may have various shaped slot like U-shaped slot, E-shaped slot, L-shaped slot, I-shaped slot etc. which helps to improve resonant bandwidth. Different types of antennas works in different frequency bands such as L-band ranges between 1-2GHz, S-band ranges between 2-4GHz, C-band ranges between 4-8 GHz and X-band ranges between 8-12 GHz etc. Each of these frequency bands has different working applications. Similarly proposed antenna finds its application in C-band such as in satellite communications, Wi-Fi etc. In this paper work, the design incorporates random shaped Defected Ground Structure in ground plane, which disturbs shielded current distribution in ground plane [11-12]. drawbacks and to improve antenna characteristics, different techniques have been used.

## II. ANTENNA DESIGN PROCEDURE

The geometry of a single patch antenna using u-slot with Defected Ground Structure feed by microstrip feed line can be shown in Figure 1. The patch antenna is constructed on same dielectric substrate. The patch antenna is realized on FR 4 substrate and having a relative permittivity ( $\varepsilon_r$) = 4.4, substrate of thickness (***h***) = 1.6 mm and loss tangent (***tan***δ) = 0.09 and the microstrip feed line is realized on the same *substrate layer*.

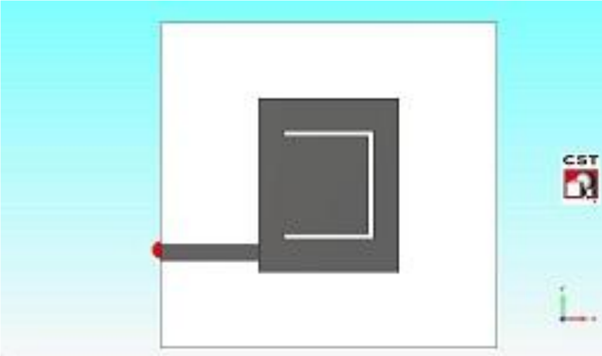


Fig 1.1: front view of proposed Antenna

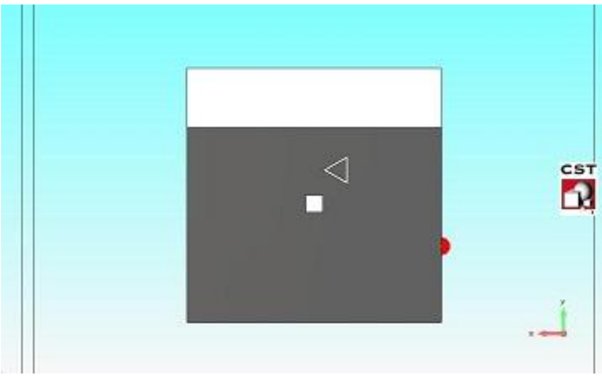


Fig.1.2: Ground plane with DGS of proposed Antenna

## III. RESULTS AND DISCUSSION

### *A. Return Loss and Bandwith*

S11 represents how much power is reflected from the antenna, and hence is known as the reflection coefficient. The bandwidth of the antenna can be calculated from return loss versus frequency plot at -10 dB.

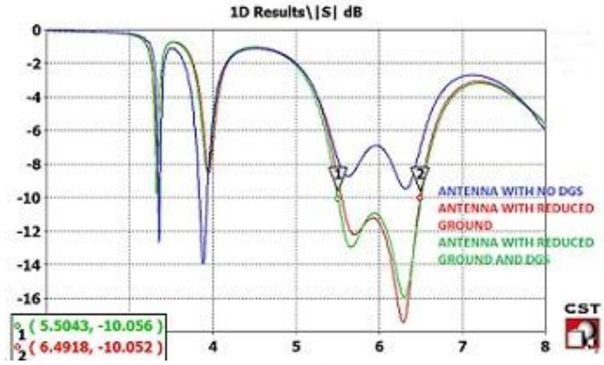


Fig. 2: Return Loss of all Antennas Geometry

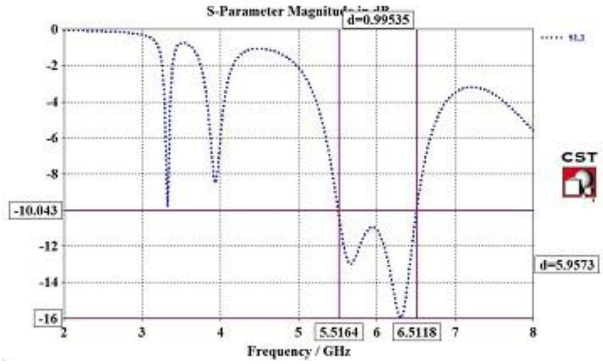


Fig.3: Bandwith of Proposed Antenna

### *B. Voltage Standing Wave Ration(VSWR)*

VSWR is a measure of how well matched antenna is to the cable impedance. A perfectly matched antenna would have a VSWR of 1:1. This indicates how much power is reflected back or transferred into a cable. VSWR obtained from the simulation of DGS antenna is 1.37 which is approximately equals to 1:1 as shown in Fig. 4. This shows the perfectly matching of an antenna with the port.

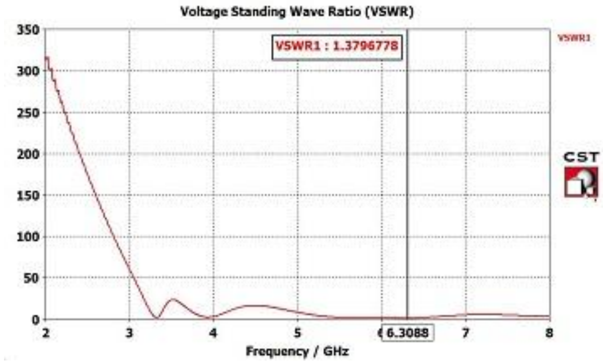


Fig.4: VSWR Graph

### *C. Smith Chart*

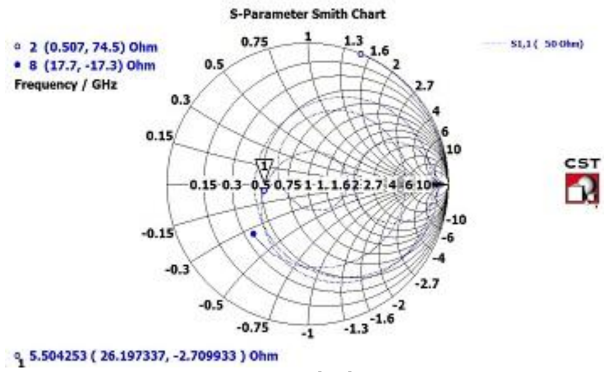


Fig.5:Smith Chart

### *D. Directivity*

Directivity of a non-isotropic antenna is equal to the ratio of its radiation intensity in a given direction over that of an isotropic antenna.

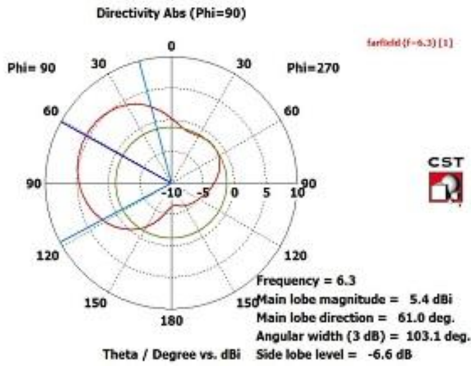


Fig.6:Polar Plot of Proposed Antenna for Directivity

*E. Gain*

Gain of an antenna is the ratio of the maximum radiation intensity in a particular direction from the test antenna to the maximum radiation intensity from reference antenna, when same input power is applied to both antennas.

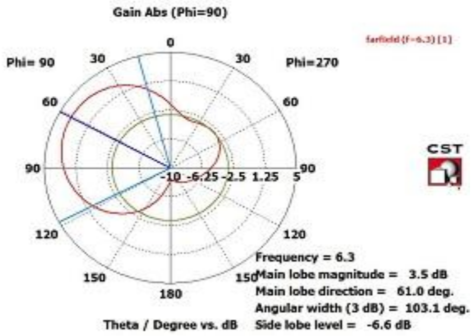


Fig.7 Polar Plot of Proposed Antenna for Gain

## IV. DESIGN FORMULAS TO CALCULATE DIMENSIONS

The width of the rectangular MSA is given by [14]:

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

Effective dielectric constant is given as [2]:

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

The length extension is given as [2]:

$$\Delta L = 0.41h\frac{\varepsilon_{eff}+0.3}{\varepsilon_{eff}-0.258}\times\frac{\left(\frac{w}{h}+0.264\right)}{\left(\frac{w}{h}+0.8\right)} \quad (3)$$

The actual length is given by [2]:

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} - 2\ \Delta L \quad (4)$$

The length and the width of the ground plane are given by[14]:

$$L_g = 6h + L \quad (5)$$
$$W_g = 6h + W \quad (6)$$

**TABLE.1 :Design Specifications of Final Antenna**

| Sr. No. | Specifications | Dimensions (mm)/Volume |
|---|---|---|
| 1. | Ground | 30×23×0.038 |
| 2. | Substrate | 30×30×1.6 |
| 3. | Patch | 12.5×16 |
| 4. | Feed | 8.75×1.5 |
| 5. | Permittivity of substrate material | 4.4 |

## V. CONCLUSION

This paper proposed a rectangular shaped patch with u-slot antenna for sattelite applications in this paper, a comprehensive review has been given of the u-slot patch antenna. Although, this antenna is best known for its wideband characteristics. This antenna is applicable for the satellite application which is centered at frequency 6.3GHz. This antenna gives the good results in Satellite applications.

## REFERENCES

[1] V.Ratna Bhargavi,P.Poorna Priya,K.Pavan Kumar, Dr.Habibulla Khan, “ *Gain Enhancement of V-slotted Triangular Shape Microstrip Patch Antenna for WiMax Applications*” *International Journal of Engineering Research and Applications (IJERA), vol. 2, issue 3*, May-Jun 2012, pp.1187-1193

[2] Indra Surjati, Yuli KN and Yuliastuti, “ *Increasing Bandwidth Dual Frequency Triangular Microstrip Antenna For wimax Application” International Journal of Electrical & Computer Sciences IJECS-IJENS Vol: 10 No: 06*, 2010.

[3] M. T. Islam, M. N. Shakib, N. Misran and T. S. Sun, “Broadband Microstrip Patch Antenna,” *European Journal of Scientific Research,* vol. 27, no. 2, pp. 174-180, 2009

[4] T.K. Lo and Y.Hwang, “Microstrip antannas of very high permittivity for personal communications”,1997 Asia Pacific Microwave Conference, pp. 253-256.

[5] J.S. Seo and J.M. Woo, “Miniaturizaation of microstrip antenna using iris,” Electron Lett., vol.40 no. 12, pp.718-719,Jun.2004.

[6] K.L.Wong, Compact and Broadband Microstrip antennas. New York: Wiley-Interscience,2002, p.5.

[7] H. M. Heo and J. M. Woo, “Miniaturization of microstrip antenna using folded structure,” in *Proc. Int. Symp. Antennas Propag.*, endai,Japan, Aug. 2004, pp. 985–988.

[8] R. F. Harrington*, Time-Harmonic Electromagnetic Fields*. Piscataway, NJ: IEEE Press, 2001.

[9] Naftali Herscovici, “A Wide-Band Single Layer Patch Antenna”, *IEEE Transactions on Antennas and Propagation,* 46, (4), pp. 471-474, 1998

[10] H. Liu, Z. Li, and X. Sun, “Compact defected ground structure in microstrip technology,” *Electron. Lett.*, Vol. 41, No. 3, pp.132-134, 2005.

 

[11] Arya, A.K. Kartikeyan, M.V., Patnaik, A., "Efficiency enhancement of microstrip patch antennas with Defected Ground Structure," IEEE proc. Recent Advanced in Microwave theory and applications (MICROWAVE-08), pp.729–731 November 2008.

[12] F. Y. Zulkifli, E. T. Rahardjo, and D. Hartanto, " Mutual Coupling Reduction using Dumbbell Defected Ground Structure for Multiband Microstrip antenna array" Progress In Electromagnetics Research Letters, Vol. 13, 29-40, 2010

[13] Constantine A. Balanis (John Wiley & Sons, Inc., Hoboken, New Jersey,2005). **antenna theory** analysis and design. [15] B. Vedaprabhu and K. J. Vinoy, *" An Integrated Wideband Multifunctional Antenna Using A Microstrip Patch With Two U-Slots" Progress In electromagnetics Research B, Vol. 22*, 221-235, 2010

 