Slotted Rectangle Patch with Defective Ground Structure Antenna Operating at 10.72 GHz with Gain 8.1421 db and Bandwidth 731.9 MHz

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Abstract— Simple rectangular patch antenna structure resonates at 5.18 GHz and slotted Rectangular Patch with DGS structure resonates at 10.76 GHz is designed. The height of substrate in both cases remains 1.77 mm and material of substrate is RT/Duriod 5880 with 2.2 Dielectric Constant. The E plane and H plane radiation pattern of both cases are discussed. Bandwidth of simple rectangular patch is 227.3 MHz & Return loss is – 40 db and bandwidth of Slotted Rectangle Patch Antenna with DSG antenna is 731.9 MHz & Return loss is -26.1291 db.

Keywords: Simple rectangular patch, Defective Ground Structure (DGS), Coaxial Probe Feeding, HFSS

I. INTRODUCTION

Microstrip antenna is an ideal choice for wireless communication due to low profile, light weight, conformal shaping, low cost ,simplicity of manufacturing and easy integration to circuit [1].However, conventional microstrip patch antenna suffers from very narrow bandwidth, typically about 5% bandwidth with respect to central frequency. In recent years, there is a need for more compact antennas due to rapid decrease in size of personal communication devices. As communication devices become smaller due to greater integration of electronics, the antenna becomes a significantly larger part of the overall package volume. This results in a demand for similar reductions in antenna size. In addition to this, low profile antenna designs are also important for fixed wireless application. The microstrip antennas used in a wide range of applications from communication systems to satellite and biomedical applications. There are numerous and well known method to increase the bandwidth of antennas, including increase of substrate thickness, the use of low dielectric substrate [2]. Due to evaluation of wireless communication, many high performance mobile devices are developed which require efficient mean of communication i.e. it should have low return loss & high bandwidth. For good antenna performance a thick dielectric substrate with low dielectric constant is desirable and this provides improved efficiency (as much as 90%), improved bandwidth (up to 35%). However, such a construction leads to a larger antenna size. In order to miniaturization methods, these are slot on the patch, dielectric substrate of high permittivity [3], DGS at the ground plane.

II. DESIGN PRINCIPLES

A. *For Rectangular patch antenna:*

We can calculate the dimension of rectangular patch antenna by using some mathematical formulation, before the we know basic three fundamental terms value that are Frequency of operation (f_O) Dielectric constant of the substrate (ε_r) and Height of dielectric substrate (h) and these play an important role in calculation of width (W) and length (L) of patch [4]. The steps for calculation of patch dimension are as follows:

Step 1: The width of patch is calculated by following expression:

$$W = \frac{c_o}{2f_r}\sqrt{\frac{2}{\epsilon_r + 1}}, c_o \text{ is speed of light}$$

Step 2: Due to fringing field effect the Effective Dielectric Coefficient (ε_{reff}) and Effective Length (ΔL) is calculated by following expression:

$$\epsilon_{reff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-1/2}$$

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

Step 3: The actual length of patch is calculated by the following expression:

$$L = \frac{c_o}{2f_r\sqrt{\epsilon_{reff}}} - 2\Delta L$$

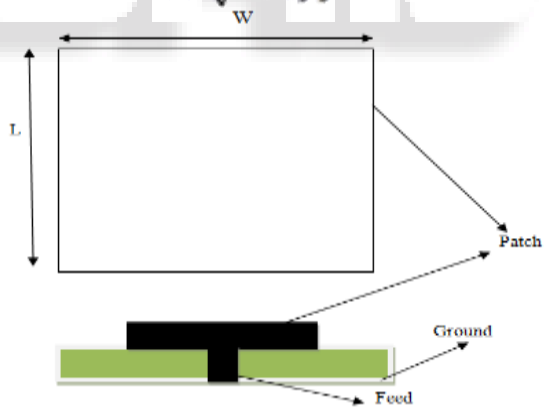

Fig.1: Top and Side View of Simple Rectangular Patch Antenna

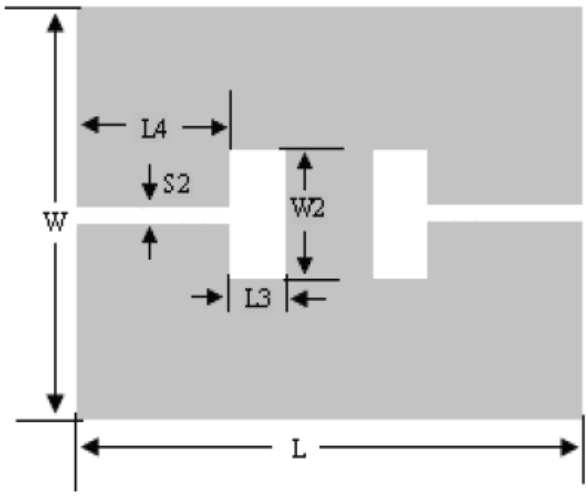

Fig.2: Top view of Slotted Rectangular Patch

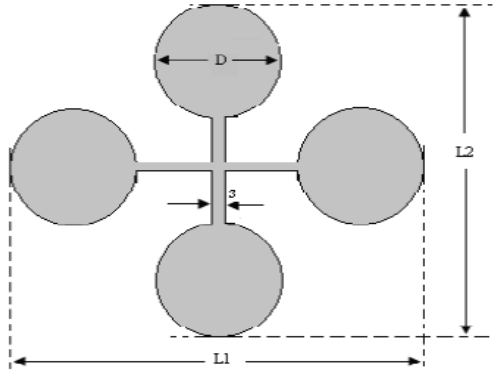

Fig.3: DGS Arrangement

III. USED PARAMETERS

The parameters used in this design are shown in Table 1. The arrangement of DGS which is used in design is as shown in Figure 3 [5].

Table 1: Used Parameter

Parameter	Value
h	1.77 mm
ε_r	2.2
L	24 mm
W	18 mm
D	11 mm
s	2 mm
L1	32 mm
L2	34 mm
L3	3 mm
L4	7 mm
W2	6 mm
S2	1 mm

IV. DESIGN AND SIMULATION RESULT

For the design and simulation of Simple Rectangle Patch Antenna (resonate at 5.18 GHz) and Slotted Rectangular Patch with DSG Antenna (resonate at 10.72 GHz) we use the HFSS Software and shown in Figure 4 Figure 5 respectively, the parameter use in this design are shown in Table 1. In Simple Rectangle Patch Antenna and Slotted Rectangular Patch with DSG Antenna the feeding points are 0.-4, 0 and 0, 0, 0 respectively. Table 2 shows the simulated results of both designs. The design, return loss, gain, E plane and H plane and VSWR of both proposed antennas are shown in Figure 4 to Figure 13.

Table 2: Simulated Results

Parameter	Simple Rectangular Patch Antenna	Slotted Rectangular Patch with DGS Antenna
Operating Freq. (f_o)	5.18 GHz	10.72 GHz
Return Losses	-40 db	-26.1291 db
Bandwidth	227.3 MHz	731.9 MHz
Gain	6.3355 db	8.1421db
VSWR	1.1229	1.1039

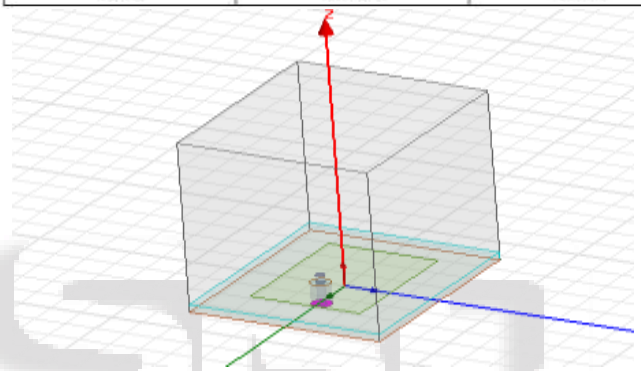

Fig.4: Design of Simple Rectangle Patch Antenna

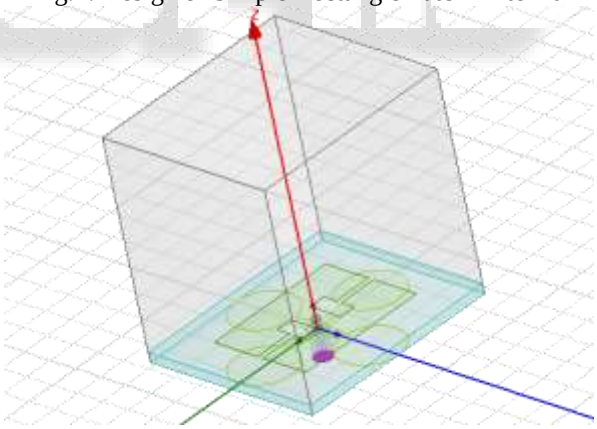

Fig.5: Design of Slotted Rectangle Patch Antenna with Defective Ground

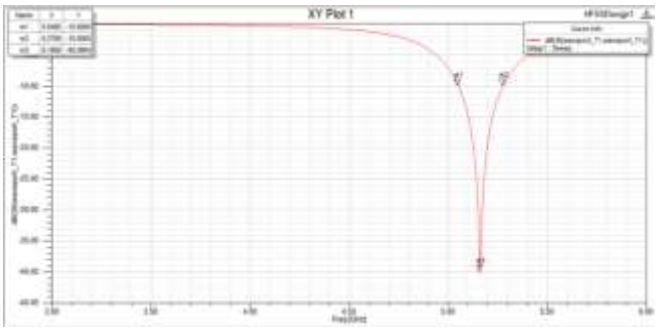

Fig.6: Return Losses of Simple Rectangle Patch

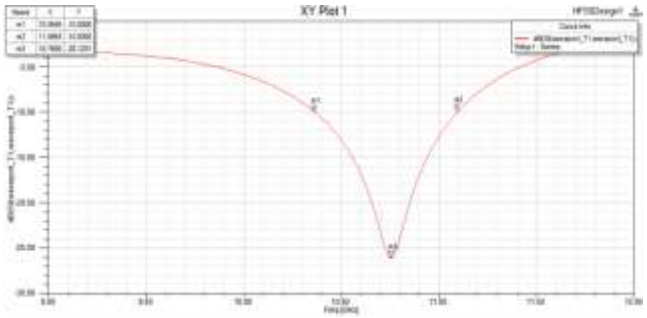

Fig.7: Return Losses of Slotted Rectangle Patch Antenna with Defective Ground

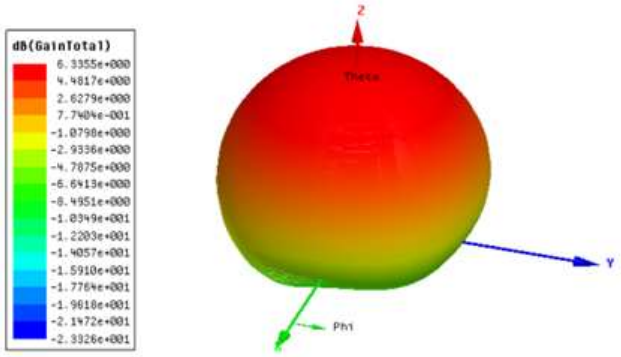

Fig.8: Gain of Simple Rectangle Patch Antenna

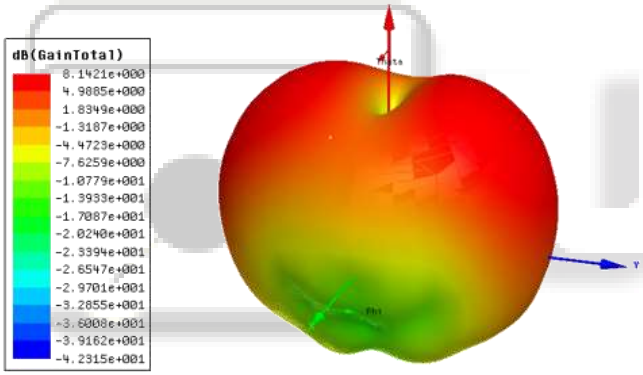

Fig.9: Gain of Slotted Rectangle Patch Antenna with Defective Ground

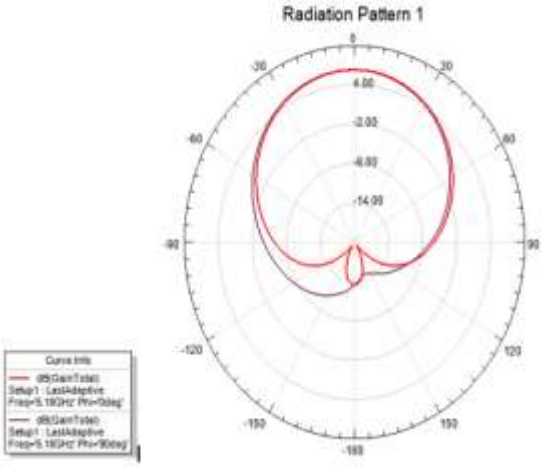

Fig.10: E plane and H plane Radiation Pattern of Simple Rectangle Patch Antenna

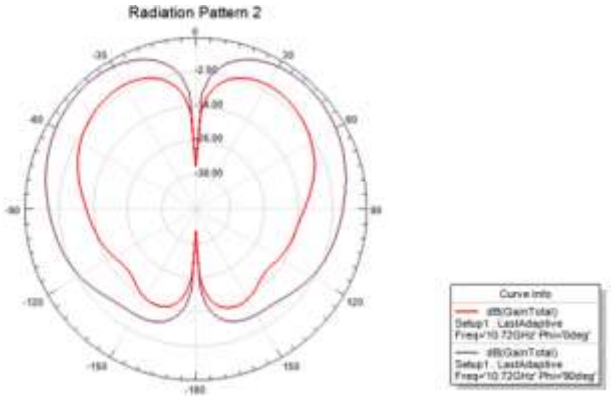

Fig.11: E plane and H plane Radiation Pattern of Slotted Rectangle Patch Antenna with Defective Ground

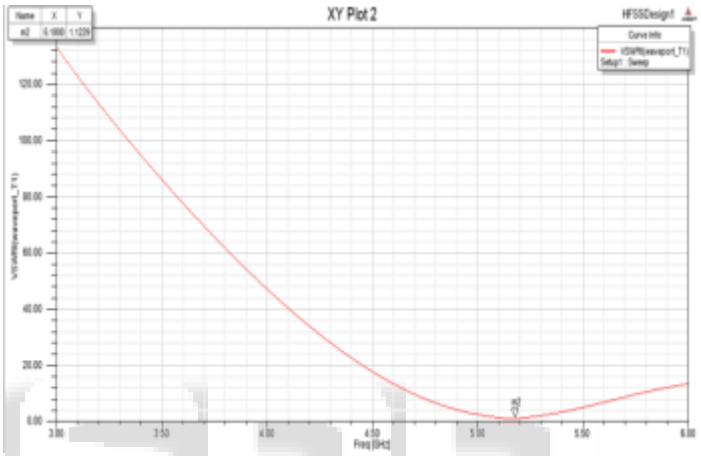

Fig.12: VSWR of Simple Rectangle Patch Antenna

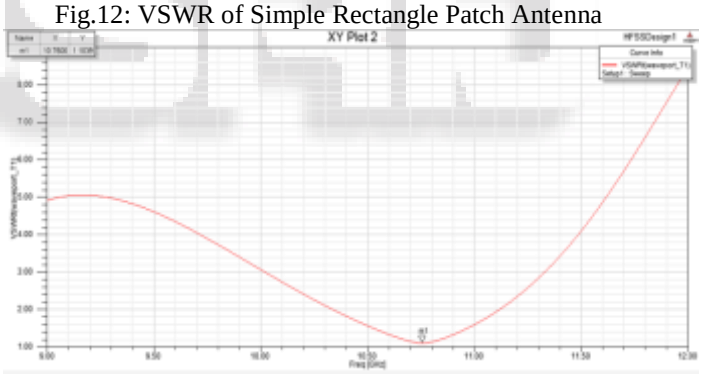

Fig.13: VSWR of Slotted Rectangle Patch Antenna with Defective Ground Antenna

V. CONCLUSION

Design of Simple Rectangular Patch Antenna and Slotted Rectangular Patch with DGS is carried out in this work. Here we see that when we place slot on rectangular patch and by using the DGS (two bumble shape) in place of simple ground plane the bandwidth, gain and VSWR of antenna get improved as compare to Simple Rectangular Patch Antenna.

REFERENCES

[1] W.He, R.Jin, and J.Gerg, "E-shape patch with wideband & circular polarization for millimeter wave communication" ,IEEE Trans. Antenna Propag. , vol 56,no 3,pp 893-895,2008.
[2] K L Lau, K.M Luk and K.L Lee, "Design of Circularly-Polarized Vertical Patch Antenna," IEEE Trans. Antenna Propag. , vol 54,no 3,pp 1332- 1335,2006
[3] T.K. Lo and Y.Hwang, Microstrip antannas of very higy permittivity for personal communications, 1997 Asia Pacific Microwave Conference, pp. 253-256
[4] Constantine A. Balanis, "Antenna Theory: Analysis and Design, 3rd Edition," John Wiley and Sons, Inc. Hoboken, New Jersey 2005.
[5] Mrinmoy Chakraborty, Biswarup Rana, P.P. Sarkarc, Achintya Das, "Design and Analysis of a Compact Rectangular Microstrip Antenna with slots using Defective Ground Structure" Elsevier, SciVrese ScienceDirect, Procedia Technology 4 (2012) 411 – 416
[6] HFSS Tutorial prepared by Dr. Otman El Mrabet,2005-2006.
[7] Ansoft High Frequency Structure Simulator v 11, "Getting Started with HFSS".

